

ISES CELEBRATES

SWC50



DEC 2020

TO NOV 2021

JOIN THE CENTURY OF SOLAR
A Year of Virtual Celebration

ISES SWC50
The Century of Solar

Stories and Vision

swc50.org



ACKNOWLEDGEMENTS

Undertaking the planning of any conference takes the commitment of many individuals and SWC50-The Century of Solar has been no exception. The people listed below have all provided their time, skills and knowledge in the development of this booklet, the virtual museum and the virtual conference held on 3rd and 4th December 2020. Without them this celebration will not be the success that we know it will be. As chairperson of the committee I thank them all very much and appreciate their contributions.

Planning for SWC50 commenced in 2018 with the formation of the international organising committee:

Arabella Liehr
Jenny McIntosh
Paulette Middleton
Fred Morse
Monica Oliphant
Dave Renné
Geoff Stapleton
Eicke Weber

In early 2020 Lawrence Kazmerski and Bernard McNelis were invited to join the committee to assist in planning the museum.

Originally the conference was to be held in Melbourne. Although the conference went virtual in March 2020, we still relied on important advice from the local committee:

Steve Blume
Geoff Bragg
Brian England
Renate Egan
Jenny Gregory
Ken Guthrie
Linda Koschier
Monica Oliphant
Kathleen Ryan
Geoff Stapleton

In addition to the international committee, these people assisted in the development of the highlights in history of ISES and the different solar technology applications.

ISES

Jenny Gregory,

PV

John Perlin

Solar Thermal

Ken Guthrie, Bill Beckman , Leon Bogers, Dean Clift, , Vasiliki Drosou, Jan-Olof Dalenbäck, Pedro Diaz, Alan Law, Graham Morrison, Daniel Mugnier, Karen Surridge, Drosou He Tao , Klaus Vajen and Werner Weiss

CSP

Luis Crespo, Belen Gallego, David Kearney, Greg Kolb, Terry Peterson, Hank Price

Architecture/Buildings

John Perlin, Maria Wall

PV in Developing Countries

Anil Cabraal, Mark Hankins, John Perlin, Neville Williams

The books and websites used in compiling the summaries are referenced in the booklet's bibliography section.

I also would like to thank Cathy Stapleton and Michael Stapleton for compiling the pioneers' material for inclusion in the booklet and the GSES graphics team and other GSES staff for assisting in publishing the final version of the booklet.

Geoff Stapleton
Chair, SWC50

PLATINUM PARTNERS OF SWC50



GOLD PARTNER OF SWC50



SUPPORTERS OF SWC50

INDUSTRY ASSOCIATION SUPPORTERS



MEDIA SUPPORTERS

ecogeneration



ASSOCIATE SUPPORTERS



TABLE OF CONTENT

Acknowledgements.....	I
Platinum Partners of SWC50.....	III
Gold Partner of SWC50.....	III
Supporters of SWC50.....	IV
Abbreviations.....	XIII
Foreword.....	XVI
SWC50 Booklet – A Century of Solar.....	XVI
1. Introduction.....	1
2. 1970 Solar World Congress.....	4
3. Overview of the Summaries.....	6
3.1 ISES.....	6
3.2 Photovoltaics (PV).....	6
3.3 Solar Thermal.....	7
3.4 Concentrating Solar Power (CSP).....	7
3.5 Solar Architecture and Buildings.....	7
3.6 Solar Energy for the Developing World.....	8
4. Pre 1950.....	10
4.1 PV Pre 1950.....	10
4.3 CSP Pre 1950.....	11
4.4 Solar Architecture Buildings Pre 1950.....	12
4.5 Research Pioneers Pre 1950.....	15
4.6 Industry Pioneers Pre 1950.....	18
5. 1950-1959.....	19
5.1 ISES 1950-1959.....	19
5.2 PV 1950-1959.....	22
5.3 Solar Thermal 1950-1959.....	23
5.4 Solar Architecture Buildings 1950-1959.....	24
5.5 Research Pioneers 1950-1959.....	25
5.6 Industry Pioneers 1950-1959.....	29
5.7 SWC Associate Supporter: American Solar Energy Society.....	31
5.8 SWC50 Supporter: Smart Energy Council.....	33
6. 1960-1969.....	35
6.1 ISES 1960-1969.....	35
6.2 SES Presidents 1964-1969.....	37
6.3 PV 1960-1969.....	38
6.4 Solar Thermal 1960-1969.....	39
6.5 Solar Architecture Buildings 1960-1969.....	39
6.6 Research Pioneers 1960-1969.....	40
6.7 Industry Pioneers 1960-1969.....	47
7. 1970-1979.....	53
7.1 ISES 1970-1979.....	53
7.2 ISES Presidents 1970-1979.....	58
7.3 PV 1970-1979.....	60
7.4 Solar Thermal 1970-1979.....	62
7.5 CSP 1970-1979.....	64

7.6 Solar Architecture Buildings 1970-1979	65
7.7 PV in Developing Countries 1970-1979.....	65
7.8 Research Pioneers 1970-1979	66
7.9 Industry Pioneers 1970-1979	101
7.10 SWC50 Platinum Partner: NREL.....	124
7.11 SWC50 Supporter: IEA SHC	126
7.12 SWC50 Supporter: RENEW	128
7.13 SWC50 Supporter: Solar Energy Industries Association	130
7.14 ISES Section: Brazil	131
7.15 ISES Institute Members: ZAE Bayern.....	133
8. 1980-1989	135
8.1 ISES 1980-1989	135
8.2 ISES Presidents 1980-1989.....	139
8.3 PV 1980-1989	140
8.4 Solar Thermal 1980-1989	143
8.5 CSP 1980-1989.....	145
8.6 Solar Architecture Buildings 1980-1989	145
8.7 PV in Developing Countries 1980-1989.....	146
8.8 Research Pioneers 1980-1989	148
8.9 Industry Pioneers 1980-1989	164
8.10 ISES Institute Member- SPF Insitute for Solar Technology	199
8.11 ISES National Section- Hungary.....	201
9. 1990-1999	203
9.1 ISES 1990-1999	203
9.2 ISES Presidents 1990-1999.....	215
9.3 PV 1990-1999	217
9.4 Solar Thermal1990-1999	222
9.5 CSP 1990-1999.....	224
9.6 Solar Architecture Buildings 1990-1999	224
9.7 PV in Developing Countries 1990-1999.....	225
9.8 Research Pioneers 1990-1995	229
9.9 Industry Pioneers 1990-1995.....	238
9.10 American Solar Energy Society Fellow	251
9.11 Individuals Involved with ISES National Sections	252
9.12 SWC50 Platinum Partner: GSES.....	259
9.13 SWC50 Supporter- Pacific Power Association.....	261
9.14 ISES Institute Members: Politecnico Di Torino.....	263
10. 2000-2009	265
10.1 ISES 2000-2009.....	265
10.2 ISES Presidents 2000-2009	271
10.3 PV 2000-2009.....	272
10.4 Solar Thermal 2000-2009.....	278
10.5 CSP 2000-2009	280
10.6 Solar Architecture Buildings 2000-2009	281
10.7 PV in Developing Countries 2000-2009	282
10.8 SWC50 Gold Partner: Smart Energy	286
10.9 SWC50 Supporter: ARE	288

10.10 SWC50 Supporter: APVI	290
10.11 SWC50 Supporter: WWEA	292
11. 2010-2019	294
11.1 ISES 2010-2019.....	294
11.2 ISES Presidents 2010-2019	300
11.3 ISES President 2020-2021	300
11.4 PV 2010-2019.....	301
11.5 Solar Thermal 2010-2020.....	305
11.6 CSP 2010-2021	307
11.7 Solar Architecture Buildings 2010-2019	309
11.8 PV in Developing Countries 2010-2019	310
11.9 SWC50 Supporter: Global Solar Council.....	317
11.10SWC50 Supporter: GWNET	319
11.10 SWC50 Supporter: SEIAPI.....	321
11.12 ISES Institute Member: The Australian Centre For Advanced Photovoltaics.....	323
12. The Future	324
12.1 Introduction	324
12.2 What are Some Pathways to 100% Renewables?	325
12.3 What is ISES' Position on the Key Elements of these Studies?	329
12.4 What Will Be the ISES' Role in Leading and Supporting the Renewable Energy Future?	330
12.5 References.....	331
13. Bibliography	332
14. Appendix 1 Program from 1970 Conference	334

LIST OF FIGURES

Figure 1: SWC 1970 Promotional Pamphlet.....	4
Figure 2: Farrington Daniels, a key figure in the establishment of AFASE, and the first SES President elected by the membership 1964 – 67.....	19
Figure 3: Harry Tabor with a flat-plate selective-surface steam generator at the “Sun at Work” exhibition at Phoenix in 1955.....	20
Figure 4: SOMAR pump (Italy) at “Sun at Work” exhibition at Phoenix in 1955.....	20
Figure 5: Solar cookers on display at the Phoenix “Sun at Work” exhibition, 1955.....	21
Figure 6: Drawing of Peter Lee’s winning design for the AFASE solar house competition.....	21
Figure 7: Roger Morse (Australia), Peter Glaser and Farrington Daniels (USA), the first three Presidents of SES elected by society membership.....	35
Figure 8: Frank Edlin, Farrington Daniels and Peter Glaser at Tempe meeting, 1967 Indian Section was formed.....	36
Figure 9: Farrington Daniels, President 1964-1967.....	37
Figure 10: Peter Glaser, President 1967-1969.....	38
Figure 11: Roger Morse (Australia), Jack Duffie (USA), Taro Hisada (Japan) and Julio Hirschmann (Chile) examine a solar water heater at Melbourne, 1970.....	53
Figure 12: Frank G. Hogg (Australia), Secretary-Treasurer of ISES from 1970 to 1985, and editor of ISES News.....	53
Figure 13: New design of Solar Energy, instituted by Andy Drumond, on right. Old cover design is on left.....	54
Figure 14: Membership Growth 1970-1980.....	54
Figure 15: Wall ReadCSIRO, Bill Charters Uni of Melbourne, Jack DuffieUniv of Wisconsin and Roger Morse CSIRO.....	55
Figure 16: The first board of China Solar Energy Society (1979, Xi’an, China).....	56
Figure 17: Roger Morse,.....	58
President 1969-1971.....	58
Figure 18: Jack Duffie,President 1971-1973.....	58
Figure 19: George Oscar Löf, President 1973-1975.....	58
Figure 20: William Klein, President 1975-1977.....	59
Figure 21: R.L. Datta, President 1977-1979.....	59
Figure 22: William Charters, President 1979-1981.....	59
Figure 23: Australian annual installed solar water panel capacity 1970-1979.....	62
Figure 24: Austrian annual installed solar water panel capacity 1970-1979.....	63
Figure 25: USA annual installed solar water panel capacity 1974-1979.....	63
Figure 26: Past Presidents sitting with the newly elected President in Perth. In the front row, left to right, are Wal Read, Harry Tabor, and Bill Charters and in the back row, Jack Duffie, Roger Morse, George Löf and Bill Klein.....	135
Figure 27: Wal Read and newly-elected President Bill Beckman with Horst Hörste (President of the German Section of ISES) pointing the way to the 1987 Hamburg Congress.....	136
Figure 28: A traditional ISES presentation: newly-elected President Lorriman with assembled Past Presidents Löf, Tabor, Datta, Beckman, Read and Corvi. 1989.....	137
Figure 29: Harry Tabor, President 1981-1983.....	139
Figure 30: Wal Read, President 1981-1983.....	139
Figure 31: William Beckman, President 1985-1987.....	139
Figure 32: Corrado Corvi, President 1987-1989.....	140
Figure 33: Doug Lorriman, President 1989-1991.....	140
Figure 34: Annual recorded installed solar water panels capacity 1980-1989.....	143
Figure 35: Survey on Energy, Environment & Development, Preliminary Conclusions and Recommendations March 1991.....	203
Figure 36: Debating energy policy in the UNCED Working Group 3, Geneva.....	203
Figure 37: Mike Nicklas (Vice President ISES), Maurizo Cumo (ISES Board member), Corrado Corvi (ISES Board member and chair ISES Italy) and Adolf Goetzberger (ISES President).....	204
Figure 38: Solar Energy Solutions for an Environmentally Sustainable World.....	204
Figure 39: Dr Leslie Jesch, President ISES-Europe, who became editor of SunWorld in 1992.....	205

Figure 40: Dr Nicola Pearsall, Northumbria University and ISES UK member, Brighton.....	205
Figure 41: Former US President Jimmy Carter on his acceptance of the first Karl Böer Medal.....	205
Figure 42 : Members of the international WSSP organising Committee. Adolf Goetzberger far left, Hubert Nacfaire (CEC) and Boris Berkovsky (UNESCO) centre front	206
Figure 43: Opening session of the World Solar Summit, with Boris Berkovsky seated far left with Philippe Chartier (Scientific Director ADEME) and Hubert Nacfaire far right.....	206
Figure 44: The ISES World Congress conference in Budapest was a huge success.....	206
Figure 45: The ISES 1995 calendar, starring pictures of the sun painted by children across Hungary	207
Figure 46: Summary panel, ISES NGO Summit NY.	207
Figure 47: Alison Patterson, Assistant Editor Sun at Work in Europe and member UK SES, promoting the first European SunDay	207
Figure 48 : ISES Board meeting, Cypress	208
Figure 49: Villa Tannheim in 2000. Transparent thermal insulation is just visible on the wall behind the ISES Flags.....	208
Figure 50: Villa Tannheim in 1920.....	208
Figure 51: Empowerment for Africa.....	209
Figure 52: The new Executive Director Burkhard Holder, Lord Mayor of Freiburg Rolf Böhme, and President Mike Nicklas at the opening of Villa Tannheim	209
Figure 53: HQ staff at the opening of Villa Tannheim	209
Figure 54: The retiring Australian HQ staff, 1995, in their offices at the Chisholm Institute of Technology in Caulfield, Victoria. Wal Read sits in front of Peg Bilston (left), another staff member and Barbara Rozen (right). Peg and Wal served ISES for 24 years at ISES HQ Melbourne.....	210
Figure 55: Some of the ISES solar women who met at the Congress.....	210
Figure 56: The Entrance to the EuroSun Conference at them newly opened Congress Centre, Freiburg (1996)	211
Figure 57: The oldest and youngest participants at EuroSun.....	211
Figure 58: Environment Minister Angela Merkel meeting ISES-Europe President Leslie Jesch (second from left), Fraunhofer SE Director Joachim Luther (second from right), and ISES Vice President David Mills (extreme right) (1996).....	211
Figure 59: Mrs Marta Weeks in 2003	212
Figure 60: After Dr Mary Archer's presntation on solar energy at the Royal Instite London, following the conference presntations.	212
Figure 61: Professor Adolf Goetzberger, President 1991-1993.....	215
Figure 62: Mike Nicklas, President 1993 – 1995	215
Figure 63 : Eduardo de Oliveira-Fernandes, President 1995 – 1997	215
Figure 64: David Mills, ISES President 1997 -1999.....	216
Figure 65: Cesare Silvi, President 1999 - 2001	216
Figure 66: Annual PV Installed Capacity (1993-1999).....	217
Figure 67: : Cumulative PV Installed Capacity (1992-1993).....	218
Figure 68: Annual recorded installed solar water panels capacity 1990-1999 broken down into ROW and China	222
Figure 69: Annual recorded installed solar water panels capacity 1990-1999 broken down into ETC and FPC.....	223
Figure 70: Access to Electricity 1990-1999	225
Figure 71: Estimated sales in solar modules in Kenya from 1986 to 2001.	226
a-Si: amorphous silicon modules, x-Si crystalline silicon modules	226
Figure 72: The Staff at ISES Headquarters in June 2001, at the time of Burkhard Holder's resignation due to ill health. Rian van Staden, fourth from the right, would become Executive Director and Christine Hornstein, 9th from the right, the Deputy Executive Director.....	265
Figure 73: Karl Böer speaking after receiving the Farrington Daniels Award (2003).....	266
Figure 74: Anna Grete Hestnes at Solar Cities in Daegu.....	266
Figure 75: ISES Board Meeting in Florida 2005	267
Figure 76: Christine Hornstein and Monica Oliphant.....	267
Figure 77: Four ISES Past Presidents Monica Oliphant, Anne Greta Hestnes, D Yogi Goswami and Dave Renne	269

Figure 78: Anne Grete Hestnes, President 2002 – 2003	271
Figure 79: Professor Yogi Goswani, President 2003 – 2005	271
Figure 80: Torben Esbensen, President 2006 – 2007	272
Figure 81: Monica Oliphant, President 2008 – 2009	272
Figure 82: Annual Installed Capacity	273
Figure 83: Cumulative PV Installed Capacity	274
Figure 84: Annual recorded installed solar water panel capacity 2000-2009 broken down into ETC and FPC.....	278
Figure 85: Annual recorded installed air heating panel capacity 2000-2009 for Canada and USA	279
Figure 86: Access to Electricity 2000-2009	282
Figure 87: Jennifer McIntosh.....	294
Figure 88: ISES Headquarters Staff as of 2020	297
Figure 89: Dave Renné , President 2010 – 2019.....	300
Figure 90: Klaus Vajen President 2020-2021.....	300
Figure 91: : Annual Installed PV Capacity	301
Figure 92: Cumulative Installed PV Capacity	302
Figure 93: Annual installed solar water panel capacity 2010-2018 broken down into ETC and FPC.....	305
Figure 94: Cumulative installed solar water panel capacity 2010-2018 broken down into ETC and FPC....	306
Figure 95: Annual installed air heating panel capacity 2010-2018 for Canada and USA.....	306
Figure 96: Access to Electricity 2010-2016.....	311
Figure 98: Estimated Annual Sales of Off-Grid Solar Lighting Systems	314
Figure 99: Conservative Estimate of the Number of People Worldwide Benefiting from Access to Electricity through Off-Grid Solar Devices	314
Figure 100: Installed Mini-Grids by Technology	315
Figure 101: Annual Cumulative Installed Mini-Grids in Sub-Saharan Africa	316
Figure 102: Annual Cumulative Installed Mini-Grids in Asia.....	316
Figure 103: The growth in capacity levels required to achieve expected electricity supply by 2050 under the Transforming Energy Scenario. Under these capacity levels, solar PV will contribute 25% of total electricity supply in 2050 (see ref. [1])	328
Figure 104: Shares of primary energy supply in 2015 and 2050 in the LUT/EWG analysis [3]	329

LIST OF TABLES

Table 1: Locations of SWC	2
Table 2: Officers of AFASE (1950-1959)	22
Table 3: Conferences and Meetings (1955-1959).....	22
Table 4: Officers of AFASE 1960-1963	36
Table 5: Officers of SES 1964-1969/70.....	36
Table 6: Conferences and Meetings 1965-1968.....	37
Table 7: Officers of SES 1970-1971	56
Table 8: Officers of ISES 1971-1979/80	57
Table 9: Conferences and Meetings 1970-1979	57
Table 10: Officers of ISES 1981-1991	137
Table 11: Conferences and Meetings 1981-1989.....	138
Table 12: Officers of ISES 1991-2001	213
Table 13: Conferences and Meetings 1991-1999.....	213
Table 14: Average Module Prices for Large and Small Orders	217
Table 15: Percentage of Total Annual PV Installed by IEA Member Countries (1993-1999)	218
Table 16: Breakdown of Solar Manufacturers in IEA Countries in 1999	220
Table 17: Percentage of Population without access to Electricity 1990-1999	225
Table 18: Access to Electricity by Regions 1990 and 1999	226
Table 19: World Bank Group Solar Projects in Developing Countries: Approved 1990-1999	228
Table 20: Officers of ISES 2001-2009	269
Table 21: Conferences and Meetings 2001-2009.....	270
Table 22: Top 10 PV Manufacturers by Year (2000-2004).....	274
Table 23: Top 10 PV Manufacturers by Year (2005-2009).....	275
Table 24: PV Module Manufacturing by Regions	275
Table 25: Annual Installed PV (%) by Country (2000-2009)	276
Table 26: Percentage of Population without access to Electricity 2000-2009	282
Table 27: Access to Electricity by Regions 2000 and 2009	282
Table 28: World Bank Group Solar Projects in Developing Countries: Approved 2000-2009	284
Table 29: Officers of ISES 2010-2019	298
Table 30: Solar World Congresses, 2011 - 2019	298
Table 31: PV Module Manufacturing by Country (2010-2018)	302
Table 32: : Top 10 PV Manufacturers by Year (2010-2014).....	303
Table 33: : Top 10 PV Manufacturers by Year (2015-2019).....	303
Table 34: Annual Installed PV (%) by Country (2010-2018)	304
Table 35: Percentage of Population without access to Electricity 2010-2016	311
Table 36: Access to Electricity by Regions 2010 and 2016	311

ABBREVIATIONS

a-Si	Amorphous Silicon
AFASE	Association for Applied Solar Energy
ANZSES	Australian and New Zealand Solar Energy Society
ARE	Alliance for Rural Electrification
ASES	American Solar Energy Society
ASU	Arizona State University
BC	Before Christ
BCA	Building Code of Australia
BIPV	Building Integrated Photovoltaics
BPSI	BP Solar International
CdS	Cadmium Sulfide
CNES	National Centre for Space Studies
CIS	Copper, Indium and Selenium
CO ₂	Carbon Dioxide
CRE	Council for Renewable Energy
CSP	Concentrating Solar Power
CSIRO	Commonwealth Scientific and Industrial Research Organisation
d.c	Direct Current
DOE	Department of Energy
ECD	Energy Conversion Devices
EEG	Erneuerbare-Energien-Gesetz
EFG	Edge-defined Film-fed Growth
ENE	Energies Nouvelles et Environnement
EPA	Environmental Protection Agency
EPIA	European PV Industry Association
ESMAP	The Energy Sector Management Assistance Program
EU	The European Union
EWEA	European Wind Energy Association
FIT	Feed-In Tariff
FSEC	The Florida Solar Energy Center
FSP	Foundation of the Peoples of the South Pacific
GEF	Global Environment Fund
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOGLA	Global Off Grid Lighting Association
GTZ	German Technical Cooperation Agency
GTZ	Global Tracking Framework
GW	Giga Watt
GW _{th}	Giga Watts Thermal
HQ	Head Quarters
IASEE	International Association for Solar Energy Education
IEA	International Energy Agency
IEA-PVPS	International Energy Agency - Photovoltaic Power Systems
IEC	Institute of Energy Conversion
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Finance Corporation
IPCC	International Panel on Climate Change
IPE	The Institute of Physical Electronics
IPMVP	International Performance Measurement and Verification Protocol
IRENA	International Renewable Energy Agency
ISCI	International Solar Cities Initiative
ISES	International Solar Energy Society
ISREE	International Symposium on Renewable Energy Education
km/h	Kilometre Per Hour

KUL	Katholieke Universiteit Leuven
kVA	Kilo Volt Ampere
kW	Kilo Watts
kWh	Kilo Watt Hour
kW _p	Kilo Watts Peak
LED	Light Emitting Diode
mc-Si	Multi-Crystalline Silicon
MIT	Massachusetts Institute of Technology
mW	Milli Watt
MW	Mega Watt
MW _p	Mega Watts Peak
MW _{th}	Mega Watts Thermal
NAPS	Neste Advanced Power systems
NASA	National Aeronautics and Space Administration
NGO	Non-Governmental Organization
NPAC	Newcastle Photovoltaics Applications Centre
NREL	National Renewable Energy Laboratory
NUS	The National University of Singapore
PERC	Passivated Emitter and Rear Cell
PLEA	Passive and Low Energy Architecture
PROMECS	Power and Communications Sectors Modernization and Rural Services Project
PSA	Plataforma Solar de Almería
PURPA	Public Utility Regulatory Policies Act
PV	Photovoltaics
PVPS	Photovoltaic Power Systems
PVMTI	PV Market Transformation Initiative
R&D	Research and Development
RCA	Radio Corporation of America
REEP	Renewable Energy and Efficiency Partnership
RESCO	Renewable Energy Service Company
RTC	Renewable Transformation Challenge
RV	Recreational Vehicle
sc-Si	Single Crystalline Silicon
SDE	School of Design and Environment
SDG7	Sustainable Development Goal 7
SEC	Solar Energy Company
SEDA	Sustainable Energy Development Authority
SEEDS	Sarvodaya Economic Enterprise Development Services
SEforALL	Sustainable Energy for All initiative
SEGS	Solar Electric Generating Stations
SELCO	Solar Electric Light Company
SELF	Solar Electric Light Fund
SEREPRO	Seminar on Rural Energy Provision in Africa
SERI	Solar Energy Research Institute
SES	Solar Energy Society
SHC	Solar Heating and Cooling
SHS	Solar Home Systems
SPREE	School of Photovoltaic and Renewable Energy Engineering
SMUD	Sacramento Municipal Utility District
SRI	Stanford Research Institute
STI	Solar Technology International
SWC	Solar World Congress
TES	Thermal Energy Storage
UAE	United Arab Emirates
UK	United Kingdom
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNSW	University of New South Wales
USA	The United States of America
USSR	Union of Soviet Socialist Republics
W	Watt
WSSP	World Solar Summit Process
ZEH	Net Zero Energy House
ZEO	Zero Energy Office
ZNE	Zero Net Energy

FOREWORD

SWC50 Booklet – A Century of Solar

Writing the Forward to this booklet, “SWC50 – A Century of Solar” is a great honor for me. When my good colleague Geoff Stapleton, who has worked many long months putting this booklet together, asked me to write this Forward, I accepted without hesitation. Geoff and I have been working together on the International Solar Energy Society’s (ISES’) Board of Directors for a number of years now. Even though I and others have also had input to this booklet, Geoff deserves significant credit for creating a vision and then developing the extensive content of this booklet.

The concept of SWC50, and this booklet that commemorates SWC50, came out of a few brainstorming sessions that I and other members of the Society held during various ISES Board meetings over the past couple of years. We were reflecting on how ISES is the oldest continuously operating solar energy society in the world, with its roots dating back to 1954 when the Association for Applied Solar Energy (AFASE) was formed in the U.S. state of Arizona. Perhaps not so coincidentally, this was the same year that Bell Telephone Laboratories patented the first commercial solar cell. AFASE changed its name to the Solar Energy Society (SES) in the early 1960s and continued its advocacy and support for solar energy research, development, and deployment, and to report on its work through scientific conferences and technical publications. Late in that decade, with the SES running into financial difficulties, representatives from Australia, and in particular the Australian-New Zealand Solar Energy Society (ANZSES) invited the SES Board to jointly organize the first International Solar Energy Congress (SWC). The successful Congress was ultimately held in Melbourne, Australia in March 1970. Following this landmark event, the SES also found a new home in Australia, developed a new charter, and changed its name to the International Solar Energy Society, with ANZSES and the American Solar Energy Society, or ASES (the successor to SES), becoming its first two Sections.

Through the discussions of this history the Board recognized that, during 2020, ISES should celebrate the 50th Anniversary of this inaugural Solar World Congress. The celebration was planned to be held in Melbourne in conjunction with the Australia’s Asia Pacific Solar Research Conference in December 2020, offering a program that not only recognizes the solar energy achievements of the past 50 years but also discusses with global experts the opportunities for solar energy in the coming 50 years. Out of these discussions, SWC50 was born, with Geoff taking the lead in the event’s organization.

Tragically the coronavirus pandemic that took over the world in early 2020, impacting global commerce and travel and the lives of millions of families worldwide, forced the SWC50 planning committee into an alternative plan for an online celebration. Furthermore, an exhibition that had been planned in conjunction with the SWC in Melbourne was transformed into a virtual “ISES Museum”. Nevertheless, this booklet, designed as a permanent and living commemoration of SWC50, has remained a key vision for Geoff and the rest of the planning committee. Throughout the year Geoff has put immense time and effort into leading its development, and I am very pleased to be writing the Forward for this accomplishment.

This booklet consists of several key components. First, the reader will find highlights of the history of ISES going back to 1955, as well as historical highlights of some of the key technologies that ISES has supported over the years: Solar PV, Solar Thermal, Concentrating Solar Power, Buildings and Architecture, and PV in the Developing World. These historical highlights, organised by decade, were developed from a number of historical books and documents, as well as personal recollections of many people who have been involved in ISES and the technology developments throughout the decades. In particular I want to highlight one key source of information here: The two-volume “Fifty-Year History of ISES”, published in 2005 and edited by Prof. Karl Boer of the University of Delaware. Karl, who passed away on 18 April 2018 at the age of 92, played many key roles with ISES and was a stalwart supporter of solar energy research and development. In the late 1980s he created the prestigious Solar Energy Medal of Merit at the University of Delaware, of whom the first recipient was U.S. President Jimmy Carter. Through the years the medal has been awarded to many distinguished pioneers in solar energy development, many of whom are ISES members.

Second, the reader will find brief biographies of over 250 research and industry pioneers, also organised by decade, who have played key roles in the remarkable success of solar energy development and use over the years. Given that this booklet is a “living document”, we look forward to adding many new pioneers in the years to come.

Third, this booklet provides highlights of the many partners and supporters who have helped make this book, as well as all of the activities associated with SWC50, possible. We deeply appreciate the support of these organizations who are also pioneers in their own right.

The booklet then closes with a summary view of the future of renewable energy, in particular as governments deal with the dual crisis of providing economic stimulus to address the COVID-19 crisis in the short term and the significant threats of climate change in the longer term. A brief outline of areas in which ISES expects to focus its work is included in this summary.

And finally, the actual program for the inaugural SWC1970 in Melbourne, and the key organizers who made that Congress possible, is provided in an Appendix at the end of the booklet.

Over the past half century solar energy technologies have evolved from curious laboratory experiments with limited commercial applications to elegant and low-cost technologies that provide, together with storage systems, reliable electricity, heating and cooling, and mobility services virtually everywhere and at almost any scale, from remote and off grid applications, to bulk energy supply. These technologies have clearly demonstrated the value they offer to the sustainable development of all communities and populations, providing low-cost, reliable, non-polluting energy services in virtually any location on earth. ISES is very proud of the role it has played in developing and advocating for these technologies and looks forward to the next half century where these technologies will provide an economically-viable and socially-acceptable solution to the climate crisis.

Dave Renné, Boulder, Colorado
Immediate Past President of ISES
3 December 2020

1. INTRODUCTION

In 1970 solar research pioneers met at the first International Solar Energy Society (ISES) Conference in Melbourne Australia. **SWC50 -The Century of Solar** commemorates that event by celebrating 50 years of progress and envisioning necessary steps for the next 50 years through:

- A virtual conference on 3rd and 4th December 2020;
- The launch of an online museum: ISES Solar Energy Museum - Past Present and Future; and
- This booklet: ISES SWC50 The Century of Solar-Stories and Vision

Why the “Century of Solar”?

Since that conference in 1970, solar energy has grown from being a mix of emerging technologies to a vibrant industry. In 1970 solar cells were mainly being manufactured for use on satellites in space. However, a few companies were evolving, and research was being undertaken in manufacturing solar cells/modules for the terrestrial market. Over the next few years a number of manufacturing companies started around the world and by 1977 the world production of Photovoltaic (PV) Modules was 750kW. In 2019 it is estimated at 627 GW. In solar thermal the solar heater panel installed capacity was 513 GWth in 2019. This represents a major transformation in the global energy sector. Now ISES looks forward to the next 50 years when solar energy will be a major cornerstone of the global energy system. Hence the “**Century of Solar**” is the period in history when **solar** returns to be the dominant energy provider after the **fossil fuel age**. It is the time when the world transforms into the **new solar age**.

As the SWC50 chair recalls from a solar conference early in his career, a presenter noted that future generations will define this timeline for the energy ages:



Prior to the industrial revolution and introduction of fossil fuels, mankind used the sun to dry crops and clothes; travelled the world in wind powered sailing ships; used waterpower to mill and perform other operations; and designed their buildings using passive solar principles. Keeping this in mind, the SWC50 chair reminds people that “Solar energy is not the future. Rather it was the way of the past. Mankind became lazy with fossil fuels but now must return to the Solar Age.”

Mankind has benefited greatly from all the advancements provided in the fossil fuel age; however, it has come at a cost -- climate change. To address this, the world must transform its energy system quickly back to solar (renewable) energy. ISES believes this is the century when this will and must happen. It is the work started by the founders of ISES back in 1950's that helps make this change possible. The SWC50 tells the stories and visions of how the Solar Age is returning.

The Start of the International Solar Energy Society (ISES)

In the early 1950's a few visionaries believed that it was time to elevate solar energy to become the foundational source of all energy consumed by humankind. One leader of this group of visionaries was Farrington Daniels, who first suggested the need for an organization to promote the development and application of solar energy and create a solar industry. In 1954 three other pioneers -- Henry Sargent, Walter Bimson and Frank Snell -- created the Association for Applied Solar Energy (ASAFE) in Arizona. This organization was formed to show the feasibility of solar energy conversion and to provide a stimulus for achieving universal acceptance for modern solar energy conversion, replacing conventional sources of energy.

The first public events of AFASE were a Symposium held in Phoenix and a Conference in Tucson in late 1955. In 1963 AFASE changed its name to the Solar Energy Society. Following its first International meeting, held in Melbourne in March 1970, the name was changed to the International Solar Energy Society (ISES), with the Australian and New Zealand Solar Energy Society (ANZSES) and American Solar Energy Society (ASES) becoming its first two Sections. A number of other Sections from around the world quickly followed suit, and ISES soon established a global reach.

The solar pioneers, who put into motion the creation of AFASE and ultimately ISES, advocated for more coordinated and accelerated research in solar technologies. This was a prophetic recognition that solar development would no longer be an activity of a few enthusiasts but would become an absolute necessity for meeting the energy needs of the future. The recognition was further motivated by Bell Telephone Laboratories, which patented the first commercial solar cell in 1954.

Over the years ISES became an important forum for solar energy scientists and engineers around the world to communicate their work, check their results, critically analyse ideas and findings, and arrive at a constantly increasing wealth of facts. Now armies of entrepreneurs and industries are providing the means for changing over from fossil and nuclear-drive energy technologies to the benign, renewable and profitable solar technologies of the future.

ISES Today

The global voice for renewable energy

For over 65 years the members of ISES have undertaken the product research that has helped the renewable energy industry to grow. ISES, through its knowledge sharing and community building programs, helps its global membership provide the technical answers to accelerate the transformation to 100% renewable energy and thereby achieve the following vision:

The International Solar Energy Society (ISES) envisions a world with 100% renewable energy for everyone used wisely and efficiently.

ISES facilitates the knowledge sharing between its members and the wider communities through:

- Active country sections and affiliates;
- The scientific publication: Solar Energy Journal;
- Webinars;
- Infographics;
- Renewable Transformation Challenge (RTC) + ISES Awards;
- Young ISES -- social and professional network for young members;
- Active participation in many international organisations and events; and
- The biannual conferences -- Solar World Congress (SWC) and EuroSun.

The Solar World Congresses

The first SWC was held in Melbourne Australia in 1970. Following the second SWC in the USA in 1971, the Congresses then became bi-annual events generally held in the odd years. The following table shows where the 27 SWCs have been held.

Table 1: Locations of SWC

Year	City, Country	Year	City, Country
1970	Melbourne, Australia	1997	Taejon, South Korea
1971	Greenbelt, USA	1999	Jerusalem, Israel
1973	Paris, France	2000	Mexico City, Mexico ¹
1975	Los Angeles, USA	2001	Adelaide, Australia
1977	New Delhi, India (held January 1978)	2003	Göteborg, Sweden
1979	Atlanta, USA	2005	Orlando, USA
1981	Brighton, UK	2007	Beijing, China
1983	Perth, Australia	2009	Johannesburg, South Africa
1985	Montreal, Canada	2011	Kassel, Germany
1987	Hamburg, Germany	2013	Cancun, Mexico
1989	Kobe, Japan	2015	Daegu, South Korea

1 A special SWC highlighted as the Solar Millennium

1991	Denver, USA	2017	Abu Dhabi, UAE
1993	Budapest, Hungary	2019	Santiago, Chile
1995	Harare, Zimbabwe		

ISES Solar Energy Museum – Past, Present and Future

ISES has developed the Museum in order to provide an online location where the history as well as the visions of ISES and the solar industry, as told through stories, photos and videos, is readily accessible to people worldwide. In the museum research institutes, companies and individuals tell their stories about how they helped develop an industry that has grown from watts to gigawatts virtually through their individual displays. The online museum allows the visitor to “enter” a lobby and either read a map guide and go straight to a particular section, or “walk” through the museum. The museum will be permanent and like all museums will have updated exhibitions. ISES sees the museum as the legacy that continues from the SWC50 celebration.

Booklet: ISES The Century of Solar - Stories and Vision

Many in-depth books have been written on solar over the years some of which have included the history of solar and its growth. This commemorative booklet has not been written to compete with any of those well researched and in-depth books. Rather, this booklet provides a brief overview of what has happened in the past and provides a vision of what is required to reach the 100% renewable energy world.

The chapters of the booklet are broken into periods of time, starting with pre 1950’s followed by chapters on each decade from the 1950’s through to the last decade (2010-2019). Each chapter highlights the significant events for ISES and the various technologies and their applications within each decade, particularly showing the growth of some of the technology sectors. However, unlike other books where these are written in paragraphs this booklet provides the information as dot points and in tables and graphs. This format allows the reader to obtain a quick overview of what has happened in this exciting industry.

The Renewable Energy Pioneers

ISES recognises that without the efforts of individual researchers, system designers, system installers, business leaders, policy makers and those within the donor community, the renewable energy industry would not have grown from watts to Gigawatts in the last 50 years. To acknowledge these efforts the booklet includes pioneers. In April 2020 ISES issued a call for submissions of the names, along with photos and brief 300-word bios, of individuals covering the following two categories:

1. Research Pioneers: Individuals who started their research in 1995 or earlier.
2. Industry Pioneers: Individuals who actively started working in or with the industry in 1995 or earlier.

In addition, the SWC50 organising committees reached out to many other pioneers described in a wide variety of publications and also contacted many industry associations and others to attempt to identify as many pioneers as possible. These pioneers are included by name, and with bios and photos where available. This is ISES’ way of acknowledging the many people who have made this industry what it is today. ISES and the SWC50 organising committees recognize that those who are listed in this booklet are really just a snapshot of the 1000s who did contribute prior to 1995.

Why 1995 as a cut-off date?


The SWC50 committee arbitrarily chose 1995 since this was 25 years after the first Congress and 25 years before SWC50. However, when the actual kW and KWh installed is studied the main growth in the renewable energy industry growth has occurred since 1995. The number of people working in the industry has grown significantly over the last 25 years. ISES appreciates that there have been other individuals who have contributed greatly to the growth of this industry since 1995, and their contributions are acknowledged in the relevant chapters in this booklet. As with the pioneers, those acknowledged are a snapshot of the many thousands who have contributed to the growth of solar.

2. 1970 SOLAR WORLD CONGRESS

SWC50 is celebrating the first Solar World Congress, held 2-6 March 1970. Roger Morse, ISES President 1970-1971, was conference chairman and Frank Hogg, ISES Secretary from 1970-1985, was conference organiser.

Figure 1 shows the promotional pamphlet that was produced for the event.

**1970 INTERNATIONAL
SOLAR ENERGY SOCIETY
CONFERENCE**



MELBOURNE, AUSTRALIA
2nd MARCH to 6th MARCH
1970

PROGRAMME: Prospective authors are invited to submit papers on—

- Survey of the status of solar energy applications in various countries.
- Solar water heaters, silicon solar cells, solar air heaters and other commercial applications.
- Radiation measurement, data processing and solar simulation.
- Solar energy economics with particular reference to developing countries.
- Solar distillation, principles of operation, operating experience.
- Air conditioning, refrigeration, and solar energy considerations in architecture.
- Dynamic analysis of solar processes.
- Solar furnaces, applications and instrumentation.
- General session of individual papers on any other relevant topic.

**A DRAFT OF PROPOSED PAPERS SHOULD BE SUBMITTED BY
31st AUGUST, 1969**

A Summary should be submitted by 15th May, 1969

DO THIS NOW:

Name:

I intend to submit a paper on

It is definite that I will attend the Conference.
 probable will not

I expect to be accompanied by

ANNOUNCING

**THE 1970 INTERNATIONAL
SOLAR ENERGY SOCIETY
CONFERENCE**

WHEN: Monday, 2nd March, 1970, to Friday, 6th March, 1970.

WHERE: The National Science Centre,
Clunies Ross House,
MELBOURNE, VICTORIA, AUSTRALIA.

FEE: \$35.00 (Aust.) for delegates.
\$20.00 for ladies accompanying delegates.

TRAVEL BOOKINGS: The Australian airline, QANTAS, has been appointed official international carrier.
For delegates from the U.S.A., the Don-Em Travel Agency (68 Post Street, San Francisco, California, 94104), will co-ordinate bookings and obtain group travel concessions.

ACCOMMODATION: The Conference Organisers are not themselves arranging accommodation, but Qantas Airlines have taken bookings at three high-class motels close to the venue.

CURRENCY: Dollars and cents — Australian.
\$1.00 Aust. = \$1.11 U.S. = 9/2d. sterling = 5.55 francs Fr.

LANGUAGE: Official language is English, and all papers should be presented and will be pre-printed in that language.

TOURS: There will be pre- and post-Conference tours to solar installations, and social functions for delegates and wives, including the Annual Melbourne Moomba Carnival.

VENUE: The city of Melbourne (pop. two million), in early autumn has average maximum of 78°F. (25.5°C) and average minimum of 65°F. (19°C), but days can reach 90°F. Generally mild and settled, little wind or rain.
The National Science Centre is the just-completed headquarters for most professional societies, with full lecture facilities and a Sciences Club.
The Australian and New Zealand Section of the Solar Energy Society is a very active division, and has close working liaison with government and industry. Australia is one of the leading countries in its application of solar energy.

ORGANISING COMMITTEE:

Mr. R. N. Morse (Chairman) Chief, C.S.I.R.O. Division of Mechanical Engineering (Vice-President, Solar Energy Society).

Mr. F. G. Hogg (Conference Organizer) Assistant to the Chief, C.S.I.R.O. Division of Mechanical Engineering (Chairman, Australian and New Zealand Section, S.E.S.).

Mr. J. G. Baker Director, Copper and Brass Information Centre, Sydney (Past Chairman, Australian and New Zealand Section, S.E.S.).

Mr. C. M. Sapsford Senior Lecturer in Mechanical Engineering, University of New South Wales.

Dr. P. E. Glaser Head, Sciences Section, Arthur D. Little, Inc., Cambridge, Mass., U.S.A. (President, S.E.S.).

Dr. A. J. Drummond Director of Research, Eppley Labs., Newport, R.I., U.S.A. (Editor-in-Chief, S.E.S.).

Dr. J. A. Duffie Director, University-Industry Research Program, University of Wisconsin, Madison, Wis., U.S.A. (Director, S.E.S.).

Dr. G. T. Ward Director, Brace Research Institute, Macdonald College of McGill University, Quebec, Canada (Director, S.E.S.).

Mr. F. G. Hogg,
The Conference Organiser,
The International Solar Energy Conference,
C.S.I.R.O.,
Post Office,
Box 26,
HIGHTETT, VICTORIA 3190,
AUSTRALIA.

Figure 1: SWC 1970 Promotional Pamphlet

The program, provided in Appendix 1, shows titles of the 62 papers presented. The conference had 190 attendees.

The SWC50 organising committee was contacted by Tom Lawand from Canada who had attended the 1970 conference. Here is a summary of his recollections from the conference:

I remember the fact that it was the first international meeting in Australia dealing with renewable energy. I am sure that Australia today is a more cosmopolitan country than what I recall from 1970.

People were invited to come ahead of the conference and some, like myself, did. Others came on the weekend before the event. For those present before the conference, that weekend was eventful. The Australian organisers were new to organising an international event and there were a few issues. In particular, some arriving over the weekend had wrong paperwork etc and some got lost. Fortunately, a number of drivers were available, and things finally got sorted but that weekend still stands out in my memory of the event.

I and others were invited by Roger Morse to have a section on solar distillation of saline or brackish water. However, the solar industry gravitated to a more industrial type of solar heating applications. This was the early days and our deliberations represented the coming of age of the field of solar energy. Today solar energy is a lot more sophisticated and renewable energy is a real contributor to our society.

I remember the cocktail party that Bill Charters and I held for the leaders from the field and those from the developing areas of the world. It felt nice to commemorate the ten years I had been previously attending renewable energy conferences all over the place, and Australia turned out to be the crown jewel.



Photo of Tom Lawland at a Village Power Conference in late 1990's

Unfortunately, none of the conference committee is still alive and no photos from the first conference were located. However, within the ISES highlights there are photos of some of the early presidents and others in Australia which possibly could have been taken during this conference. These people have left an excellent legacy: the ISES Solar World Congress has been held continually every two years since 1970.

3. OVERVIEW OF THE SUMMARIES

The following chapters comprise the sections as described below.

3.1 ISES

The International Solar Energy Society (ISES) was the first membership-based organisation to focus on the advancement of solar energy. Although its roots were in the scientific community from the 1950's to the early 80's, anyone with an interest in solar energy joined ISES or one of its many national sections around the world. This included researchers, scientists, those in industry and even the general public. ISES was where one found out what was happening in the world of solar energy, and in particular, research and new developments. If you look at those involved in the 50's and 60's, many were involved in solar thermal and in particular the growing solar hot water market. Solar architecture and the building sector were very well represented, along with those involved with resource assessment and wind power. Hence the interest in the early conferences in the USA, as well as the first ISES Solar world congress in 1970 which this booklet is celebrating.

In the 60's, and in particular with the oil crisis of the 70's, there was a growth in the interest of a new solar product known as photovoltaics (PV). This led to the Institute of Electrical and Electronics Engineers (IEEE) creating a PV group and holding conferences. During the 80's and 90's, many more organisations either formed or started to take an interest in solar energy. However, some of these had their seeds planted by ISES, including Solar Cities and many such as the International Energy Agency (IEA) who work closely with ISES. With the solar industry growing, so too did the number of solar industry associations around the world. By the 1990's, those interested in solar energy had many groups where they could obtain their information and/or become members.

The forefathers of ISES, and everyone who has been involved over the years, should be very proud of what has been achieved today. Solar is (or has become) a mainstream industry. Meanwhile, ISES still plays a very active part providing the opportunity for researchers and scientists to demonstrate new advancements in 'Solar Energy', the official journal of ISES, and the International Solar World Congresses. The organisation itself also plays an active role in being members and partners in a number of organisations.

In 2005 ISES published a two-volume book titled '*The Fifty-Year History of the International Solar Energy Society and its National Sections*'. These two volumes provide a very detailed history of ISES from the early 1950s to 2005. The book contains the following two chapters:

- Volume 1 Chapter 1 -The Internal Solar Energy Society: The First 25 Years, 1955 to 1980 (64 pages) by John A. Duffie and Harry Z. Tabor.
- Volume 1 Chapter 2- The Internal Solar Energy Society: The Second 25 Years, 1981 to 2005 (254 pages) by David R Mills.

These highlights of ISES provide a summary of events documented in the above two chapters, along with key events of the last 15 years (2005 to 2020), as recorded in the Society's own publications '*SunWorld*' and the ISES Europe's '*Sun at Work in Europe*'.

3.2 Photovoltaics (PV)

The PV industry has been one of the fastest growing industries over the last 10 years. At the turn of the century, the cumulative PV installed capacity was approximately 700MW. In comparison, the cumulative installed capacity in 2018 was approximately 500GW.

The highlights include the discovery of the photovoltaic effect in the 1880's, and other discoveries until development of the modern silicon cell at Bell laboratories in 1954. From there it goes through the start of a new industry, with PV used on satellites before being brought down to earth for various early off grid applications. The highlights also include significant events in the "*childhood and adolescence years of terrestrial photovoltaics*" from the 1960s to 2000.

From the early 1990's, the IEA PVPS (Photovoltaic Power Systems) has provided annual data on PV installations through its yearly Trend Reports. The highlights use this data to display tables showing the growth in PV installations and where this growth has occurred. These tables demonstrate that during the early days, the primary markets were Japan and USA, with Europe slowly growing. Then with the introduction of the Renewable Energy Sources Act in Germany, by 2009 48% of all modules installed that year were installed in Germany. The tables also show that in 2000, 80% of modules were manufactured in Japan (57%) and USA (23%), with Europe at 15% and others 5%. By 2007 this had changed where USA was now 6%, Japan 15%, Europe 29% and others 50% (mainly China). Due to the growth in manufacturing in China, by 2018 it had grown to be manufacturing 73% of modules, with 43% of these modules installed in China due to various Chinese policies.

3.3 Solar Thermal

The first solar hot box collector was developed in 1767, while in the 1880's solar collectors using reflectors were developed for solar stoves. However, at the 1878 world fair in Paris Augustin Mouchot used a reflector to create steam to drive a pump. By the 1890's, commercial solar water heaters were being promoted in California. Although panels were used in in the early 1900's for heating air and water, it was from 1960 onwards the industry grew with manufacturing companies commercialising the products. The main market was solar water heating, however the building/architecture section of this booklet also includes examples of where solar heating panels were integrated with buildings. One market that grew as the 20th century progressed was using solar thermal for industrial heating applications, and this has continued to grow over the last 20 years.

The majority of individuals involved with the formation of the Alliance for Affordable Solar Energy (AFASE) and the early days of SES and then ISES typically worked in the solar thermal field. However, ISES has always had a very close working relationship with the IEA Solar Heating and Cooling (IEA SHC) programme which began in 1977. Many current and past active board members of ISES have also been very active on the various tasks within the IEA.

The solar thermal section includes data that has been collected by the IEA SHC. The highlights include information on early uses of solar thermal and early events, but primarily focuses on listing the key developments and projects that have been undertaken since the 1950's .

3.4 Concentrating Solar Power (CSP)

The phenomena of heat being generated from sunlight reflecting off mirrors was first observed in the 3rd century, and in the 16th century Leonardo da Vinci developed drawings of applications using parabolic dishes. The first record of a "solar powered" engine was in 1874, however it was not until the 1970's when the technology began to be employed in a larger scale.

The highlights mention the early events but mainly focus on listing the key projects that have been undertaken since the 1970's, in particular showing the rapid growth of systems in the last decade.

3.5 Solar Architecture and Buildings

The application of passive solar energy for buildings and cities goes back to the ancient times, and in particular China, Greece and the Roman Empire. Individuals like Socrates identified that by having living spaces facing the sun (that is South in Greece), houses can be warmer during the winter months. The highlights briefly look at these early times, before moving forward to about the 1800's when a number of architects were also applying the same principles. The highlights provide some early examples of passive solar principles being applied in buildings however, it would be fair to say that there are many undocumented uses of passive solar applied by individuals around the world who have identified the advantages and principles.

With the development of solar hot water panels in the early 1900's, buildings could now be heated in the winter months by using these panels on the roofs and circulating the hot water through the house in radiators and later underfloor heating. Solar buildings started to adopt the principles of passive solar design and incorporating solar hot water panels for heating purposes. The highlights provide some early examples of this from the mid 1900's.

With the development of commercially available PV in the 1970's, using solar energy in buildings further developed by incorporating PV in the building and supplying electrical power to the building. This could occur with either the solar modules being mounted on the building or being converted into actual building material such as roof tiles/shingles and wall material.

With the rapid growth of grid connected PV systems from the 1990's onwards, the number of examples of the integration of PV with buildings that also incorporate passive solar techniques and possibly solar water heating is too great to even attempt to document in these highlights. However, ISES has always had a very close working relationship with the IEA Solar Heating and Cooling (IEA SHC) programme that started in 1977. To provide the reader with further information, the highlights refer to a number of the IEA publications, in particular those relating to case studies.

By the 1990's the term 'Zero Energy Buildings' started to be applied, and the highlights provide a snapshot of some of the Zero Energy Buildings which have been built. The IEA SHC also has numerous case studies of Zero Energy Buildings. The highlights outline some of the countries which have introduced Zero Energy Building regulations or similar. Zero Energy Buildings are the future and they are how the world will move towards 100% renewable energy.

3.6 Solar Energy for the Developing World

In recent years, there has been growing interest in the PV industry and mini-grid markets for providing power to the unelectrified population in areas of Africa, Asia and other developing countries. However, it is fair to say that over the last 20 years with the booming grid connect industry, the off-grid market in the developing world has been overlooked by the majority of the industry. This is reflected in the fact that less than 1% (possibly as low as 0.1 or 0.2%) of PV modules are used in off grid systems, meanwhile in 2018 789 million people did not have access to electricity. In 1993, 63% of the modules were installed in off grid systems, and in the 70's and 90's the figure varies between the 80 to 100% range at times.

Although a few village systems were trialed in the 80's, the main systems being supplied were known as Solar Home Systems (SHS). These were individual household systems comprising a solar module often in the 20 to 50W range, one controller, one battery and a number of fluorescent lights (later compact fluorescent lights and currently LED). The systems often had the ability to power a radio and small d.c. TV. Solar lanterns also become very popular as a way of providing lights to the unelectrified.

Despite the simplicity of the systems, there were still quality problems with the products and installation. This led to individuals such as Peter Varadi (founder of Solarex) starting the PV Global Approval Program (PV GAP) to develop product standards, the late Mark Fitzgerald forming Institute for Sustainable Power (ISP) to develop a program to accredit training programs, and Bernard McNelis et al to encourage the IEA PVPS to form Task 9, 'PV in Developing Countries' which developed a series of Recommended Practice Guides in the early 2000's.

The PV GAP standards became International Electrotechnical Commission (IEC) standards, while the work carried out by Task 9 is now being done by organisations such as the International Renewable Energy Agency (IRENA) and under the UN through the Sustainable Energy for All (SE4ALL) program and numerous others. In addition, the Lighting Africa program which was established in 2009 later expanded to become Lighting Global, which developed a standard (now IEC standard) for small plug and play solar home system kits. Today there are plug and play solar home kits ranging up to 350W that are tested and approved through Lighting Global. With the development of new energy efficient appliances and LED lighting, a 50W system today can provide the equivalent energy services to a 300-500W system in the 1990's. These small systems have become a commercial market, with some companies in Africa selling up to 20,000 systems a month using micro credit whereby customers make payments via their mobile (cell) phone.

Many people working in the grid connect market are completely unaware that there is an industry where people are providing systems to households in the 5 to 100W range. Those providing MW systems would see these small systems as insignificant, however in reality, they are not. At one stage Grameen Shatki, an organisation in Bangladesh, was supplying 30,000 to 50,000 of these systems a month and employing 14,000 people. That equates to 14,000 jobs per 1 to 2MW of systems per month—a significant social benefit in rural regions of a country.

Off-grid can be a hard but rewarding market to work in. Many of the people who started in this market in developing countries last century, are industry pioneers that are passionate in what they did (and still do.) For this reason, the highlights of the 1980's and 1990's includes the names of some of the individuals and companies who were the early leaders in providing solar power to the unelectrified. The work undertaken by these people lead to many small businesses being established, however unfortunately it is difficult to obtain information or list all of those in this booklets.

The highlights demonstrate that although upfront costs of solar was relatively high at the time (and can still be for some), it was the provision of micro-finance and similar schemes for people to pay off their solar that led to many systems being sold through private industry. When compared to the grid electricity, providing power with solar home systems at the time on a \$/kWh energy price was more expensive, however what was often forgotten was that these people were using kerosene or disposable batteries that reflected a much higher cost than that of solar.

The highlights provide a sample of some of the aid programs that were introduced and their various objectives such as promote and raise awareness of the use of solar in rural areas, buy down (reduce) the upfront cost of the solar, and/or provide the capital for the microfinance.

The last 20 years has seen companies manufacturing the plug and play solar home systems, programs such as Lighting Global that introduced a Quality Assurance Framework for these products, and Global Industry Associations such as Alliance for Rural Electrification (ARE) and the Global Off-Grid Lighting Association (GOGLA) being established to help develop off-grid markets. The summary includes these initiatives and lists some of the early manufacturers of the plug and play products, however these are just a sample of the many that have now entered the industry.

Ideally, the highlights would have included the actual figures on the number of individuals who are powered by small off grid solar home systems, however this data is difficult (or impossible) to obtain. What is available and shown are the number of unelectrified people, how many households (and individuals) have benefited from some of the solar aid programs, as well as the figures being provided by Lighting Global and organisations like GOGLA.

4. PRE 1950

4.1 PV Pre 1950

1839

- French scientist Edmond Becquerel discovered the photovoltaic effect while experimenting with an electrolytic cell made up of two metal electrodes placed in an electrically conductive solution where the electricity generated increased when exposed to light.

1873:

- Willoughby Smith discovered the photoconductivity of selenium.

1876:

- William Grylls Adams and Richard Evans Day (UK) discovered that selenium produces electricity (photovoltaic effect) when exposed to light. Although selenium solar cells failed to convert enough sunlight to power electrical equipment, they proved that a solid material could change light into electricity without heat or moving parts.

1883

- Charles Fritts (USA) created the first working selenium cell. He coated selenium with a thin layer of gold and the first functional solar cell had a conversion of 1%

1887

- Heinrich Hertz (Germany) observed the photoelectric effect. The Photoelectric effect is the phenomenon in which electrically charged particles are released from or within a material when it absorbs electromagnetic radiation. The effect is often defined as the ejection of electrons from a metal plate when light falls on it.

1904

- Albert Einstein (Germany) described in theoretical detail the photoelectric effect.

1916

- Robert Milliken (USA) proved the photoelectric effect theory in experiments.

1914

- Goldman and Brodsky (USA) correlate the photoelectric effect with the existence of a barrier to current flow at a semiconductor metal which helps to provide insight into building practical photovoltaic devices.

1918:

- Jan Czochralski (Poland) discovered a method, known as the Czochralski process, for monocrystalline silicon production.

1921

- The Nobel Prize in Physics 1921 was awarded to Albert Einstein «for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect.»

1932

- Audobert and Stora discovered the photovoltaic effect in Cadmium Selenide (CdSe).

1940/41

- In 1940 Russel Ohlworking at Bell Laboratories discovered the P-N junction. In 1941 he noticed the effect on light on the junction basically creating a solar cell.

4.2 Solar Thermal Pre 1950

1767

- Horace-Bénédict de Saussure built his “hot box” plate collector.

1860

- Starting in 1860, the French mathematics professor Augustin Mouchot constructed a series of solar water heaters made of reflectors in various shapes and water-flowing cylindrical absorbers made of blackened copper. Mouchot used these devices partly as solar stoves, partly as distillation apparatus for brandy and partly to produce steam to drive motors and pumps.

1891

- Clarence Kemp developed the Climax Solar Water Heater that was marketed on the West Coast of the USA.

1904

- A Portuguese priest, Manuel António Gomes (aka Father Himalaya) wins the first prize at the St. Louis World fair with its Pyrheliophor, capable of reaching 3 800 degrees Celsius. He started his experiments inspired by the work of Augustin Mouchot. His goal was to reach temperatures able to melt metals and rocks, as part of his experiments on fertilisation of soils and nitrogen compounds. His first experiments were carried out in the French Pyrenees and he continued his work in different countries, before moving to the United States of America to demonstrate his solar furnace

1909

- In the summer of 1909, in a little outdoor shop in the Los Angeles suburb of Monrovia, an engineer named William J. Bailey began selling a solar water heater that eventually revolutionized the industry. It supplied solar-heated water not only while the sun was shining but for hours after dark and the following morning as well— hence its name, the Day and Night.

1936

- In Australia G Bates produced a Solar water heater for use in Queensland Australia inspired by a design of Dr H W Kerr and with input from Roger Morse. The results were “gratifying”.

1942

- Professor Hoyt Hottel and his graduate student Byron Woertz of the Massachusetts Institute of Technology (MIT) laid the foundation for the analysis of active solar energy systems with their classic paper on solar collectors

1943

- George Löf designed an early flat-plate solar heating unit and installed it on the roof of his house in Boulder, Colorado. It was called the “first solar-heated home” in the United States.

4.3 CSP Pre 1950

- Dositheius, a mathematician in the 3rd century, observed that solar rays bouncing off a parabolic mirror are focused on a point and can produce high temperatures.

Around 1515

- Leonardo da Vinci developed drawings for industrial applications of solar energy using parabolic mirrors.

1878

- The largest solar machine, which Mouchot constructed for the 1878 World Fair in Paris, had a conical reflector five meters in diameter - enough to drive a pump that could transport around 2,000 liters of water per hour, and enough to even produce ice. By coupling his apparatus to a refrigerating machine, which the French engineer Ferdinand Carré had already designed in the 1850s, Mouchot succeeded in creating the first surviving example of solar cooling.

1913

- Financially supported by a group of British investors, the American Frank Shuman built a power plant from 1913 onwards in the then British protectorate of Egypt. It consisted of five elongated parabolic trough collectors that reflected solar heat onto a zinc pipe suspended in its focal point and heated water in it.

Shuman's power plant achieved an output of 55 horsepower and, given the coal prices in Egypt at the time, was also competitive with fossil fuel power plants. This plant used an insulated tank to store hot water to allow the plant to run 24 hours a day. Schuman also formed the Sun Power Company A year later, the German government commissioned Shuman to build a much larger power plant in the then colony of German Southwest Africa, now Namibia. However, the outbreak of the First World War prevented the plans from being realized.

1949

- Felix Trombe built a large parabolic dish in France to produce very high temperatures for research purposes.

4.4 Solar Architecture Buildings Pre 1950

Ancient times-BC.

- 2000 b.c. the Chinese developed the gnomon (sticks or rocks perpendicular to the ground) and used this to track the movement of the sun. In the Zhou Dynasty (before 12th century b.c.) the government instructed builders to use gnomon to determine where what we now call solar noon was at the equinoxes and solstices and by 7th century b.c. positioning buildings to face true south.
- Socrates in ancient Greece promoted that houses should be pleasant to live in and be cool in summer and warm in winter by having buildings that provided shade when the sun was high and provided warmth on porches when sun was low. Archaeologists found a rectangular building near Athens, where Socrates lived, that faced south with the entrance and courtyard in that direction and the main rooms on the north.
- Olynthus was northeast of Athens . Around 345 b.c. a new district was created in area called North Hill. The streets ran east-west so that the houses could be built facing south. They streets were spaced wide enough so that they would all get the winter sun.
- Vitruvius was a Roman architect in first century b.c. and is believed to have visited Greece as a military engineer . He wrote *The Ten Books of Architecture* and in this he advised architects and builders in more temperate parts of the Roman Empire that : “ buildings should be thoroughly shut in rather than exposed towards the north, and the main portion should face the warmer(south) side”
- Pliny the Younger a wealthy official had two Villas that were built to make full use of the sun and it appears to save money by being able to have a smaller furnace and fewer heating ducts. One of his Villas made full use of the sun with respect to heating and light and also had an underground room to escape the hotter summer days. However, he had one room called a *heliocaminus* (solar furnace) where it appears the southwest openings had glass or thin transparent stones. These materials would trap the heat and temperatures would rise.

1st to 4th century AD.

- The famous Roman bathhouses in the first to fourth centuries a.d. had large south facing windows to let in the sun's warmth.
- In a domus, a large house in ancient Roman architecture the atrium was the open central court with enclosed rooms on all sides. In the middle of the atrium was the impluvium a shallow pool sunken into the floor to catch rainwater from the roof.
- As early as the first century after the birth of Christ, there is a description of how the Romans tried to grow cucumbers all-round the year (Hix, 1974). The Romans grew cucumbers in large pots with wheels so that they could be easily pushed out into the sun. The pots were covered with a transparent material as protection against the cold outside air and so that sunshine may be utilised more effectively. The transparent material was talc which was cut into thin layers. The greenhouse effect was thus noted even then, namely that transmission of short-wave solar radiation through glass and closely related materials is high, while the long wave thermal radiation which is emitted, in this case from the pot, is not transmitted so easily but rather kept inside.

600 AD

- Sunrooms on houses and public buildings were so common that the Roman Justinian Code initiated “sun rights” to ensure individual access to the sun.

1200s AD

- Ancestors of Pueblo people called Anasazi in North America live in south-facing cliff dwellings that capture the winter sun.

1800s

- John Claudius Loudon was a gardener and botanist in England at the end of the eighteenth and the first half of the nineteenth century. He advocated the use of glass and iron for greenhouses. This produced slender structures and admitted more light into the greenhouse. Spans could also be larger than for wooden structures. Loudon developed theories according to which the angle of the glazed surface should be perpendicular to the direction of solar radiation, as in this way transmission of solar radiation was greatest. He did not recommend flat roofs since condensation would in this case drop straight down and damage the plants. Roofs should instead be angled (as in a pitched roof) so that one side was perpendicular to the morning sun and the other to the afternoon sun. Condensation could be drained down into the iron construction which supported the roof. In order to prevent rust, the iron rods could be heated and then covered with paint, coal tar, lead or a tin alloy. Loudon who died in 1843 had a great influence on the development of greenhouses. He and many others studied the effect of different technical options, for instance the slope of the glass, orientation, window opening, solar control and different types of heating systems. He also had great visions which he set out in his book *Encyclopaedia of Gardening 1822* (quoted from Hix, 1974): *"Indeed, there is hardly any limit to the extent to which this sort of light roof might not be carried; several acres, even a whole country residence where the extent was moderate, might be covered in this way."*
- One of the most prominent engineers in this field of greenhouses in England in the 19th century was Richard Turner (Hix, 1974). He designed many glass buildings, but what he became best known for was the Palm House in Kew Gardens on the outskirts of London. The building was designed in 1844-66 in collaboration with the architect Decimus Burton and was wholly constructed of glass and iron. The Palm House is still in existence; it was completely restored in 1984-89.
- The Palm House in Kew Gardens was one of the first glass buildings constructed with tax free glass in England. The tax on glass which had been levied in England was repealed in 1845 (Cornell, 1952). Previously it was only wealthy people who could use a lot of glass in their buildings.
- Dr Bernard Christoph Faust writes a book on how to construct houses, villages etc to maximise solar heat gain in the winter and minimise solar gain in the summer months. Faust had a dream of a solar city (original drawn in 1807 and planned in 1824) and lived in a house that had been built in 1649 which had a façade filled with windows all facing south and south-west. Faust later writes a book titled: *All Buildings of Men Should Face towards the Middy Sun*
- Faust had communicated his ideas with letters to architect Gustave Vorherr. Vorherr became the royal Bavarian building officer for the court of Joseph Maximilian, King of Bavaria. Vorherr started the *Monthly Journal for Building and Land Improvement* where he promoted solar architecture.
- In the 1830s Frederick William IV emperor of Prussia embraces solar architecture which leads to Charles-Henri Junod building Faust's Solar City in a new housing district of La Chaux-de-Fonds in the 1840s.
- In England in the mid 1800s social critic John Ruskin promoted that the working class should have improved living conditions. Some industrialists developed working class communities which had plenty of sunlight and greater space.
- Arcades also became popular. An arcade is characterised by a mixture of small shops with different types of goods (Pevsner, 1976). By making the street accessible only to pedestrians and also covering it over as protection against rain and snow, a pleasant passage or arcade was created. The possibility of using glass and iron for roofs was made great use of in the 19th century for arcades. Climatic protection was created and at the same time not much light was lost. An important example is GUM in Moscow. This bazaar consists of 16 blocks with longitudinal streets and three shorter cross streets. It was designed by Pomeranzev and built in 1888-1893 (Pevsner, 1976).
- In 1893, the Bradbury Building in Los Angeles was constructed by George Wyman. It contained a four-storey atrium covered with a glass roof (Bednar, 1986). In the atrium there were staircases with access balconies on all sides, and two open lifts of iron construction. The atrium was decorated with palms, and the design of the building was based on science fiction speculations on what buildings would look like in the year 2000.
- In the 1800's with great advances in iron and glass manufacturing techniques. Courtyards could then have horizontal glazing overhead, eliminating some of the weather elements from the space and giving birth to the modern atrium with its interior lighting being provided by daylight.

1928

- The 26 architects who attended the First international Congress of Modern Architecture held in Switzerland issued a declaration that the driving force of architecture should be “maximising accessibility for all to enjoy fresh air, light and sun”
- Swiss German Architect Hannes Meyer (who had attended the Swiss conference) designed and built the Federation of German Trade Unions school near Berlin with the philosophy of maximising maximum exposure to the winter sun in all 60 rooms.

Late 1920s

- German Architect Hugo Haring (who had attended the Swiss conference) designed single story houses that ran east-west whose main rooms had large windows facing south and had retractable awnings for keeping out the summer sun.

1920s and 1930s

- Solar architecture spread across Europe with many new buildings adopting the principles of using the sun in winter to warm the rooms and also ensure buildings did not shade others during winter.

1939

- Solar I, completed in 1939, was the first demonstration house in America to be heated by the sun’s energy. A single-story house-like structure on the MIT campus, Solar I used solar radiation as a heat source for the winter, but projects were also conducted on summer air conditioning and power generation. The project was managed by Professor Hoyt C Hottel , who in the 1960’s was member of the Solar Energy Society’s advisory scientific committee and winner of the very first Farrington Daniels Award in 1975.

1943

- Dr George Löff , who studied under Professor Hottel at MIT , designed an early flat-plate solar heating unit and installed it on the roof of his house in Boulder, Colorado. It was called the “first solar-heated home” in the United States. Dr Löff was also involved with ISES from the very beginning and was President in 1973-1975.

1948

- MIT *Solar House II* was completed.
- Frank Lloyd Wright designs and builds the “Solar Hemicycle” in Madison Wisconsin, USA due to its semicircular layout and being built from stone, concrete, and wood, materials which allowed the house to retain solar energy

1949

- MIT *Solar House II* was converted into *Solar III*, which returned the heat collectors to the roof. Aesthetically more pleasing, Solar III was the first solar house to be used as a home, and was inhabited by a student family with one child. The house was demolished after it caught on fire in December 1955.
- MIT’s the Dover Sun House, built in Dover Massachusetts, USA was different from the others. The house heating unit was designed by Dr. Maria Telkes, an assistant in MIT’s Department of Metallurgy, and instead of water, the heating storage device was Glauber salts (sodium sulfate decahydrate).

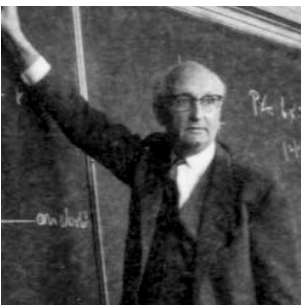
4.5 Research Pioneers Pre 1950



Farrington Daniels SES President 1964-1967 (1889-1972)

Country: USA
Year joined industry/research: 1911
Institute: University of Wisconsin
Still Active in Research/Industry: No

Farrington Daniels was a physical chemist and is considered one of the pioneers of the modern-day use of solar energy. He joined the University of Wisconsin as an assistant professor in 1920 and remained until his retirement in 1959 as chairman of the chemistry department. Daniels became a leading international expert on the principles involved with the practical utilization of solar energy. He pursued understanding of the heat and the convection as well as the electrical energy that can be derived from the sun. In 1952 Farrington Daniels met Henry Sargent and suggested to him that there was a need for an organization to promote the development and application of solar energy. Two years later (1954), Sargent, organized the Association for Applied Solar Energy. In 1953, Farrington Daniels organized a symposium at Wisconsin on solar energy that again covered a wide range of topics, with a broad range of speakers. Thirty speakers from five countries participated, with proceedings published in the book 'Solar Energy Research'. He was involved in the planning and execution of the first major activities of AFASE—the 1955 Phoenix World Symposium on Applied Solar Energy (where he was a keynote speaker) and the Tucson Conference on the Scientific Basis. Farrington Daniels built many good friendships across the small but growing international solar energy research world. The AFASE became known as the Solar Energy Society in the early 1960's, and Farrington Daniels became its first president; a position he maintained until 1967. Farrington Daniels won a number of awards including the Willard Gibbs Award (1955) and the Priestley Medal (1957). After his death in 1972, ISES established the Farrington Daniels award in honour of the man who inspired the formation of the organization and who did so much to keep the Society alive during the crisis years.



Julio Hirschmann (1902-1981)

Country: Chile
Year Started Research: 1937
Title of Research: Solar Energy
University: Universidad Tecnica Federico Santa Maria
Still Active in Research: No

Julio Hirschmann was born on October 25, 1902, in Bolivia, with Chilean nationality. He studied mechanical engineering at the Technical University of Braunschweig, Germany. Between 1932 and 1936 he worked in Russia on issues related to hydraulic machines, the chemical industry at the University of Leningrad. In 1937 he returned to Chile to work as a professor at the Technical University Federico Santa María (UTFSM), Valparaíso. In 1944 he was appointed Dean of the Faculty of Mechanics and later became Vice-Rector. He was the first director of the Solar Energy Laboratory from 1960. From 1974 he was director of the Solar Energy Research Center of the university. Hirschmann was aware of the unique conditions of solar radiation in northern Chile and was in permanent contact with researchers working on solar measurements in Chile and the world. In 1960 Hirschmann received Farrington Daniels in Chile, traveling together to Antofagasta. In 1961 he participated as an official delegate of Chile in the United Nations Conference on New Sources of Energy, in Rome; in 1962 he travelled to Melbourne to participate in the World Energy Conference and then returned to Australia in 1970 for the ISES conference that year. In 1970 he participated in the ISES conference in Maryland, USA and then, in 1973, he was a Chilean delegate at the UNESCO world congress in Paris. In Chile, Hirschmann and his associates promoted the creation of a solarimetric data center for the entire country. As a result, in 1965 the Chilean Meteorological Office and UTFSM signed an agreement to create the National Archive of Solar Evaluations at the Solar Energy Laboratory. On December 5, 1970, this National Solarimetric Archive was inaugurated in the presence of delegates from the United Nations World Meteorological Organization. Julio Hirschmann died in 1981 in Valparaíso.



Hoyt C Hottel (1903-1998)

Country: United States

Year Started Research: 1939

Title of Research: Solar 1, world's first solar house

University: MIT

Still Active in Research: No

Hoyt Clarke Hottel was a professor in the department of Chemical Engineering at the Massachusetts Institute of Technology (MIT). He was an expert on energy, radiant heat transfer, fire, fuels and combustion. In 1984, he wrote the often quoted words "A case can be made for fire being, next to the life processes, the most complex of phenomena to understand". Hottel was in charge of solar energy research program at MIT from the late 1930s to the mid-1960s. This involved research on non-biological uses of solar energy by humanity. The work led to develop the first accurate analytical models for solar heat collectors. The modelling and testing work led to what is currently known as the Hottel-Whillier model of the flat plate collector. Hottel co-authored three books, contributed sections to 15 others and wrote more than 150 technical papers while acquiring eight patents. The Hoyt Clarke Hottel Award is made each year by the American Solar Energy Society Awards Committee. The primary requirement is that the recipient has made a significant contribution to the technology in any area of the energy field. Further information on Hoyt C. Hottel's life and achievements can be found on the website https://en.wikipedia.org/wiki/Hoyt_C._Hottel



Harry Zvi Tabor ISES President 1981-1983 (1917 – 2015)

Country: Israel

Year joined industry/research: 1949

Company/ Institute first worked for: National Physical Laboratory of Israel

Harry was born in London, UK in 1917. He received a BSc in Applied Physics from the University of London in 1939. In 1949, David Ben-Gurion, Israel's first Prime Minister, invited Harry to move to Israel to create the National Physical Laboratory (NPL). While there he invented the 'selective solar surface' and was the 'father' of the solar collector industry in Israel. In 1961, together Lucien Yehuda Bronicki, he developed the low-temperature Organic Rankine Cycle turbine (the Ormat turbine). This could operate efficiently at the temperature achievable with a flat-plate solar collector, and turn a generator for electricity or a water pump. In 1966 a demonstration unit was set up in Mali, but there was no infrastructure for its maintenance. Harry also did a lot of research on solar ponds. He asserted that the Dead Sea would be an ideal 'solar collector'. Harry was one of the founders of ISES. He was a long serving member of the Board and was President of the Society from 1981-83. In 1981 UK-ISES hosted the ISES World Solar Forum in Brighton. This was the occasion when Harry was awarded the Farrington Daniels Award. On Harry's 80th birthday, ISES published a selection of his scientific papers, edited by Mort Prince. This was never done before nor has been since. In 2014 Harry, aged 96, received the President's Prize for Life Accomplishment, one of Israel's most prestigious awards, from President Shimon Peres. Eulogising Harry, Peres wrote that Harry was "a symbol of Israeli innovation – a man who, with the invention of the solar water heater, has had an impact on the lives of millions of people over many generations, and inspiring scientists and entrepreneurs in the area of solar energy and in scientific research in general."



Dr Maria Telkes (1900-1995)

Country: United States
Year Started Research: 1948
Title of Research: Dover Sun House
University: MIT
Still Active in Research: No

Dr. Mária Telkes) was a Hungarian-American biophysicist, scientist and inventor who worked on solar energy technologies. She is considered one of the founders of solar thermal storage systems, earning her the nickname “the Sun Queen”. Dr Telkes was a prolific inventor of practical thermal devices, including a miniature desalination unit (solar still) for use on lifeboats, which used solar power and condensation to collect potable water. The still saved the lives of airmen and sailors who would have been without water when abandoned at sea. She moved to Texas in the 1970s and consulted with a variety of start-up solar companies, including Northrup Solar, which subsequently became ARCO Solar, and eventually BP Solar. Telkes worked as a biophysicist in the United States; and, from 1939 to 1953, she was involved in solar energy research at Massachusetts Institute of Technology. In 1948, Dr Telkes started working on the Dover Sun House; she teamed up with architect Eleanor Raymond, with the project financed by philanthropist and sculptor Amelia Peabody. The system was designed so that a special salt would melt in the sun, trap the heat and then release it once it cooled and hardened. The system worked with the sunlight passing through glass windows, which would heat the air inside the glass. This heated air then passed through a metal sheet into another air space. From there, fans moved the air to a storage compartment filled with the salt (sodium sulfate). These compartments were in between the walls, heating the house as the salt cooled. More information on Dr Maria Telke’s life and achievements can be found on the website https://en.wikipedia.org/wiki/Mária_Telkes



Derek Wrigley

Country: UK/ Australia
Year Started Research: 1948
Title of Research: Solar-improved design of Australian housing
University: University of New South Wales then ANU (1957)
Still Active in Research: No

Derek F. Wrigley, Dip. Architecture, (Mancs), ARIBA, LFAIA, LFDIA; OAM was born 1924 and educated at Manchester Colleges of Art and Design and College of Science and Technology. He moved from the UK to Australia in 1946 and in 1958 initiated the (now) Design Institute of Australia, and the Design Council of Australia when at the Australian National University (ANU). His research was Solar-improved design of Australian housing and he initiated Australia’s first tertiary study of Building Science in 1949 at the School of Architecture, University of New South Wales, emphasising the practical utilisation of solar energy. Derek joined the ANU Design Unit in 1957 and became University Architect in 1962. Additionally, from 1948 Derek designed many houses incorporating specific solar energy utilisation principles. In 1990, he concentrated on retrofitting principles. Most houses in the colder areas of Australia could only use solar energy to heat the north half the house. From 1999 to 2002 Derek was Convenor of the ANB Buildings & Technology Committee, within the Nature and Society Forum. Between 1991 and 2018 he initiated ~20 retrofitted systems to his Canberra house, most of which were documented in his 2004 book “Making your home sustainable”. From 2001 Derek pioneered the use of reflectors which make use of the ‘wasted’ sunlight which flows over to the southern side of the roof - with nine repeat commissions around Canberra. Two research reflectors were built to suit the developer-built house he bought in 1984. The first was a reflector of ~12m² which rotated round a vertical column to reflect approximately 2.5 MWh/year of winter sunlight and heat into the south-facing dining room. The second version was horizontally pivoted with 8m² polished stainless steel on one side and photovoltaic panels on the reverse. In total the house is capable of producing ~8 kWh/day of usable heat and electricity.

4.6 Industry Pioneers Pre 1950

Rudolph Bloch

Country: Israel

Year joined industry: in the 1940's

Company first worked for: Dead Sea Works

Technology area: Solar Thermal

Still active in the industry: No

Dr Rudolph Bloch was the Director of Research of the Dead Sea Potash Works. During his work he noticed a temperature inversion in the evaporation ponds that he associated with a salinity gradient which stopped convection and led to higher temperature at the bottom. In 1948 he registered a British Patent for a solar pond acting as a solar collector. Nobody was interested in it only in 1954 he broached the idea to Harry Tabor who then started a serious research which led to the construction of a number of ponds culminating with a power station of 5 MW built in 1982 by Ormat, who operated it for 7 years, but was decommissioned when the oil prices collapsed.



Richard Crowther (1910-2006)

Country: United States

Year joined industry: 1945

Company first worked for: Richard Crowther, FAIA Architect

Technology area: Solar Architecture/Buildings

Still active in the industry: No

Richard L. Crowther, FAIA, was an architect and author who achieved international renown for his progressive holistic compositions, particularly his pioneering designs employing passive solar energy. His pioneering work in residential solar technology led to lectures at the Smithsonian Institution, solar conferences and universities across the U.S. Crowther's architecture publications are still used to teach students. His "Sun-Earth" text has a reputation for setting a benchmark in holistic architecture design, with arguments outlining economic and environmental benefits. He practiced what he preached, both by living and working in holistically designed spaces, and by a diet replete with organic and natural foods. Starting in 1945 with his own home, Crowther began to implement passive solar energy systems into the residences and office buildings he designed. This resulted in him being much sought after to design architecture implementing these systems throughout Colorado and the southwest. He wrote books and lectured about this topic both within the United States and internationally, and his innovation and ideas are still studied and admired by architecture students to this day. Some of his solar buildings in Cherry Creek North still exist, including his former headquarters at 310 Steele Street and his residence at 500 Cook Street. He also helped design and implement the Atmospheric Science CSU Solar House Environmental Village project at Colorado State University in Fort Collins. A partial list of the numerous books, pamphlets and articles Richard Crowther wrote is as follows:

Ecological Architecture; Butterworth-Heinemann, 1992 ISBN 0-7506-9171-9

Sun, Earth: Alternative Energy Design for Architecture; Simon and Schuster paperback, 1983 ISBN 0-442-21498-7

Affordable Passive Solar Homes: Low-Cost, Compact Designs; American Solar Energy Society, paperback ISBN 0-916653-00-5

5. 1950-1959

5.1 ISES 1950-1959

1951

- The American Academy of Arts and Sciences organised a conference on the *Sun in the Service of Man*. Participants were primarily from the Boston area, many being from Harvard and MIT.

1952

- An Ohio Academy of Sciences symposium included topics on solar radiation, heating, photosynthesis, photochemistry, photovoltaics, and optical systems.
- Farrington Daniels met Henry Sargent and suggested that there was a need for an organization to promote the development and application of solar energy—i.e. a solar industry association.

1953

- Farrington Daniels, with financial support from the National Science Foundation, organised a symposium in Wisconsin on solar energy, covering a wide range of topics and with 30 speakers from five countries. The proceedings were published in *Solar Energy Research*.

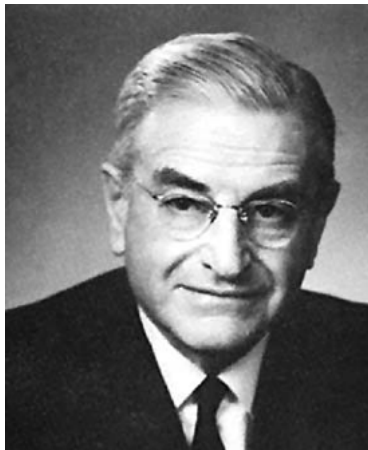


Figure 2: Farrington Daniels, a key figure in the establishment of AFASE, and the first SES President elected by the membership 1964 – 67.

1954

- The *Symposium on Wind and Solar Energy*, held in New Delhi, India, was organised and supported by UNESCO, and attended by Farrington Daniels and Prof. Felix Trombe, the French solar scientist. Participants toured locales in India where the potential of solar energy to improve the lives of the population seemed particularly high.
- A group of men from industry, agriculture, finance, and education -- all interested in furthering the practical application of solar energy -- met in Phoenix, Arizona March 17, 1954.
- At this meeting Henry Sargent, with Walter Bimson and Frank Snell, organised the **Association for Applied Solar Energy**, AFASE. Articles of incorporation, signed by the three founders, were filed with the State of Arizona on December 24, 1954.
- Henry Sargent was elected the first AFASE President.
- The Association's objectives, as stated in the by-laws, were "to foster and encourage the research, development, application and education in fields related to solar and other energies."

1955

- The first public activities of AFASE took place in October and November 1955 - the year usually associated with the beginnings of the International Solar Energy Society (ISES).
 - *Conference on the Use of Solar Energy—the Scientific Basis*. October 31-November 1 at the University of Arizona in Tucson, Arizona. About 500 participants. Transactions were published in five volumes by the University of Arizona Press in 1958.
 - *World Symposium on Applied Solar Energy*, held in Phoenix the following week. 900 registrants, many of whom had been in Tucson. 130 non-USA delegates from 130 countries. Proceedings were published by the Stanford Research Institute in 1956.
- Phoenix Symposium also included a major exhibition of solar energy equipment entitled *The Sun at Work*, with 85 exhibits from 50 exhibitors. 29,000 visitors attended



Figure 3: Harry Tabor with a flat-plate selective-surface steam generator at the “Sun at Work” exhibition at Phoenix in 1955

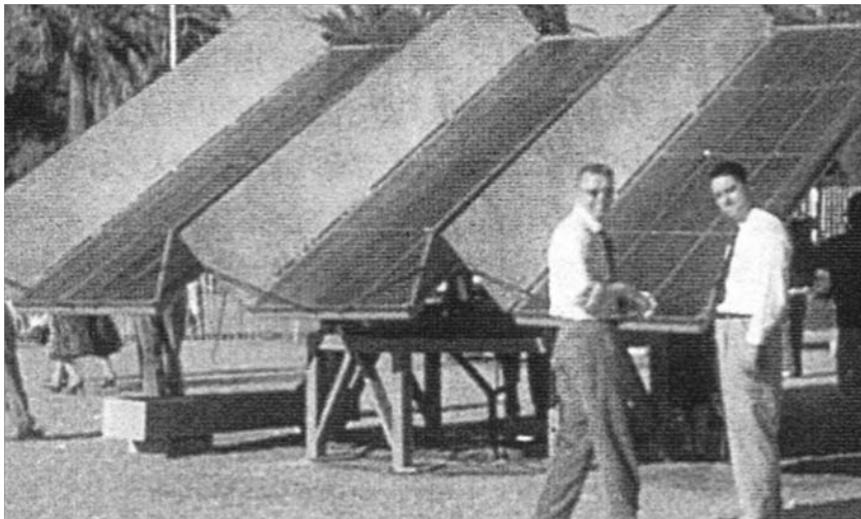


Figure 4: SOMAR pump (Italy) at “Sun at Work” exhibition at Phoenix in 1955



Figure 5: Solar cookers on display at the Phoenix “Sun at Work” exhibition, 1955

- The original Board of Directors of the Association included sixteen members, all leaders of business, industry, agriculture and education and mostly from Arizona.
- The membership structure changed from time to time, but always included “collective” (corporate, institutional) and individual. A student membership category was added eventually.
- AFASE Executive committee joined with Stanford Research Institute (SRI), to employ the AFASE Secretary / SRI Assistant Director John I. Yellott.
- AFASE offices were established in a Phoenix office building.

1956

- The first issue of the quarterly newsletter *Sun at Work* appeared in March 1956.
- *Sun at Work* Volumes I and part of II were edited by Guy Benveniste and Jean Jensen.
- AFASE librarian, Jean Jensen, with assistance from Maria Telkes and others, assembled a collection of some 5,000 solar energy items (including books, papers, periodicals, and patents).

1957

- A quarterly technical journal -- *The Journal of Solar Energy Science and Engineering*—later shortened to *Solar Energy* – was established.
- Jean Jensen also became editor, assisted by an Editorial Board, including Frank Edlin and others.
- AFASE launched the International Architectural Competition, in cooperation with the Phoenix Association of Home Builders. 113 entries from 31 countries. The winning design, by Peter R. Lee, was built and in 1958 AFASE published a book titled, *Living with the Sun*, which included plans and drawings of sixty of the entries in the competition.

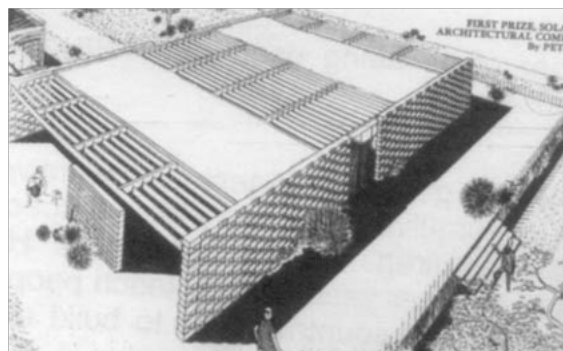


Figure 6: Drawing of Peter Lee’s winning design for the AFASE solar house competition

- An Advisory Council had grown from the committees that oversaw the development of the first three conferences/symposiums in Arizona.

1959

- The Advisory Council met in New York in 1959 which resulted in two actions that were to change AFASE over the coming four years.
 - Responsibilities of the Council in AFASE were defined.
 - AFASE organization would transform into a Society with a Board of Directors and Officers elected by its members.

Table 2: Officers of AFASE (1950-1959)

Year	President	Vice President	Secretary or Secretary / Treasurer	Executive Officer or Asst Treasurer
1955	H. Sargent	W. R. Bimson	F. L. Snell	
1956	J. Oostermeier	W. T. Lucking	J. I. Yellott	
1957	J. Oostermeier	W. T. Lucking		J. I. Yellott
1958	J. Oostermeier	W. T. Lucking		J. I. Yellott (to 6/58) E. L. McLean (6/58)
1959	J. Oostermeier	W. T. Lucking H. Sargent	F. L. Snell (Sec)	E. L. McLean

Table 3: Conferences and Meetings (1955-1959)

Year	Location	Overview
1955	Tucson USA	Conference on the Use of Solar Energy Approx. 500 registrants, 93 papers
1955	Phoenix USA	World Symposium on Applied Solar Energy, 900 registrants Sun at Work Exhibition: 29,000 visitors
1957	Phoenix USA	Solar Furnace Symposium Approx. 200 registrants, 15 papers.
1959	New York USA	First Meeting of AFASE Advisory Council Sponsors: AFASE, SRI and New York University Approx. 130 in attendance

5.2 PV 1950-1959

The decade where the modern solar photovoltaic (PV) cell is developed and by the end of the decade they are being used to power satellites.

1951

- The first germanium solar cells are made.

1953

- Gerald Pearson begins research into lithium-silicon photovoltaic cells at **Bell Labs**.
- Daryl Chapin is working at Bell Labs looking solutions for providing intermittent power to remote sites and is provided the 2.3% efficient silicon photovoltaic cell by Pearson.
- Dan Trivich of Wayne State University made some theoretical calculations on solar cell efficiency with different materials, and on solar spectrum wavelengths.

1954

- On April 25th Daryl Chapin, Calvin Fuller, and Gerald Pearson developed the silicon photovoltaic (PV) cell at **Bell Labs**. The solar cell had a 4% efficiency which is increased to 6% within a few months.
- **Radio Corporation of America (RCA)** Laboratories published a report on CdS photovoltaic effect.

1955

- **Western Electric** commenced selling commercial licenses for silicon photovoltaic (PV) technologies.
- **National Fabricated Products** in California purchases a license and commences to produce solar modules for the commercial market.

1956

- William Cherry, from the U.S. Signal Corps Laboratories, approached **Radio Corporation of America (RCA)** Labs' Paul Rappaport and Joseph Loferski about developing photovoltaic cells for proposed orbiting Earth satellites.
- General James O'Connell Commander of US Army Signal Corps arranged for Corps lead researcher Dr Hans Ziegler to visit Bell laboratories. Ziegler promoted the use of the cells on, what was a secret then, the development of a communication satellite.
- **Hoffman Electronics** Semiconductor Division creates a 2% efficient commercial solar cell with 14 mW peak power for \$25/cell or \$1,785/watt.
- **Spectrolab** is founded initially working on optical devices but later supplying solar cells for space through its Heliotek division.

1957

- **AT&T** assignors (Gerald L. Pearson, Daryl M. Chapin and Calvin S. Fuller) received patent US2780765, "Solar Energy Converting Apparatus." It is referred to as the "solar battery".
- **Hoffman Electronics** achieved 8% efficient photovoltaic cells.
- Mohamed M. Atalla developed the process of silicon surface passivation by thermal oxidation at Bell Laboratories. The surface passivation process has since been critical to solar cell efficiency.
- The first telephone repeater powered by solar cells was built in Americus, Georgia.

1958

- T. Mandelkorn, U.S. Signal Corps Laboratories, fabricated a n-on-p silicon photovoltaic cells (critically important for space cells; more resistant to radiation).
- **Hoffman Electronics** achieved 9% efficient photovoltaic cells.
- On 17th March the Vanguard I space satellite was launched and used a small 0.1W, 100 cm² solar module to power its radios. The system ran continuously for 8 years.
- Later in the year, Explorer III, Vanguard II, and Sputnik-3 launched with PV-powered systems on board.

1959

- **Hoffman Electronics** achieved 10% efficient, commercially available photovoltaic cells and introduces the use of a grid contact, reducing the cell's resistance.
- On August 7, the **Explorer VI** satellite was launched with a photovoltaic array of 9600 cells (1 cm x 2 cm each).
- On October 13, the **Explorer VII** satellite was launched.
- **Sharp's** research team developed a working solar cell.

5.3 Solar Thermal 1950-1959

1950s

- Development of selective surface coatings by **Beasley Industries** in conjunction with **CSIRO** produced better performing collectors for cooler climates.

1953

- Solar energy was identified as a technology of strategic significance to Australia and by 1954 a prototype solar water heater had been built and tested and a report on its design and construction published. An account of this work was presented by Roger Morse which was one of the first to set out the principles on which the design of solar water heaters could be based. It drew on what had previously been published, particularly Hoyt C Hottel's work on flat plate collectors at Massachusetts Institute of Technology (MIT) .
- Thermosiphon solar water heaters developed and sold by **SW Hart & Co** in Perth Western Australia under the brand name **Solahart**. The brand is now owned by **Rheem Australia** and has been exported to over 70 Countries. In the mid-1970's **Solahart** invested substantial capital in the plant associated with producing a mild steel, vitreous enamel lined tank for its solar water heater. The new product offered durability and material cost advantages over conventional copper, bronze, and stainless steel tank systems available at the time. It also incorporated an antifreeze heat transfer fluid to avoid frosting problems.

1954

- Farrington Daniels and John Duffie set up the **Solar Energy Laboratory** at the University of Wisconsin Madison. Bill Beckman became the Second Director of the laboratory in 1988. Over the years over 100 students in Mechanical and Chemical engineering received MS and PhD degrees from UW Solar Energy Laboratory.

1957

- George Löff built a house in the Cherry Hills neighborhood of Denver which used a Löff designed flat-plate collection system which heated air and circulated the heat to be stored in rock beds in large cardboard tubes inside the house. This led to rock bed storage design criteria that is still used today. Löff lived in the house for more than 50 years until his death.
- Development of Black Nickel by Harry Tabor in Israel and later black chrome

1958

- Hoyt Hottel and his student Austin Whillier began the practice of “solar engineering”. Studies of the performance of the five solar buildings at MIT led to the development of the Hottel-Whillier equation”. Hottel, H.C., and Whillier, A. (1958) Evaluation of flat plate collector performance, Transactions of the Conference On the Use of Solar Energy, 2. According to Beckman 1998 The “equation has stood the test of time”. About the only modification of this equation that has been deemed necessary is to include the temperature dependence on UL.

$$Q_u = A_c F_R (I_T (\tau \alpha) - U_L (T_{in} - T_{amb}))^+$$

where:

Q_u is the useful rate of energy gain of the collector

A_c is the collector area

F_R is the collector heat removal factor (collector effectiveness)

I_T is the solar radiation incident on the tilted collector

$(\tau \alpha)$ is the effective transmittance-absorptance product

U_L is the collector loss coefficient

T_{in} is the inlet fluid temperature

T_{amb} is the ambient temperature

+ implies a controller is present to prohibit negative values of Q_u

Late 1950s

- In the late 1950's and 60s Early research on solar water heating was undertaken in Australia by Roger Morse, Wal Read, Bob Dunkle, Terry Hollands and Don Close of **CSIRO** and Bill Charters Univ of Melbourne.

5.4 Solar Architecture Buildings 1950-1959

1956

- Solar houses are built in Tokyo ,Japan and in Bristol and Rickmansworth in England.
- Architect Frank Bridgers designed the world's first commercial office building (Bridgers-Paxton Building) in Albuquerque, New Mexico using solar water heating and passive design.

1957

- Dr George Löff built a house in the Cherry Hills neighbourhood of Denver which used a novel method to collect and store solar heat. It was designed by architect James M. Hunter, and Löff designed a flat-plate collection system which heated air and circulated the heat to be stored in rock beds in large cardboard tubes inside the house. Löff lived in the house for more than 50 years until his death.
- AFASE launched The International Architectural Competition, in cooperation with the Phoenix Association of Home Builders. (Refer to Section 5.1 ISES 1950-1959)

1958

- Solar houses were built in Casablanca Morocco and Nagoya Japan.

1959

- MIT Solar IV, located in Lexington MA, was completed in 1959 after the Department of Architecture held a contest on solar house design. After collecting data for three heating seasons, MIT sold the house to a private owner.

5.5 Research Pioneers 1950-1959



Erich Farber (1921-1917)

Country: USA

Year Started Research: 1950's

Title of Research: Experimental research on practical applications of solar energy

University: University of Wisconsin/University of Florida

Still Active in Research: No

Erich Farber was one of the early pioneers working on solar energy since 1950. He one of the attendees of the first meeting of solar energy scientists and engineers in Phoenix, Arizona in 1954. Around that time, he moved from the University of Wisconsin to the University of Florida and set up the Solar Energy and Energy Conversion Laboratory, which became a well known solar energy research center. His work focused on experimental research on practical applications of solar energy. He developed working prototypes of applications and displayed them in the solar energy lab spread over 23 acres of land, which became known as the "Solar Energy Park". The exhibits at the solar energy park included solar water heaters, solar cookers, solar desalination stills, solar refrigeration systems, a solar furnace, a solar steam engine, a number of Stirling Engines and an electric car. Around 1980, Erich Farber started an educational program called, "Training in Alternative Energy Technologies (TAET)" funded by the US Agency for International Development (USAID). TAET program educated and trained thousands of scientists and engineers from many countries in the applications of solar energy technologies. Most of those scientists went back to their home countries and started very successful renewable energy research and development programs in their countries. Among his research and developments, various types of Stirling Engines and Nano-Scale Antennas for solar power conversion stand out. Both of these developments still hold the potential to become successful in the future. Erich Farber also developed an energy self-sufficient Solar House in the solar energy park for demonstration and for his graduate students to live. The American Society of Mechanical Engineering (ASME) declared the Solar Energy Park and the Solar House as a National Historical Landmark in 1997. Erich Farber was born in Austria in 1921 and migrated to USA before WW II to escape Hitler. He passed away in 2017.



John Page (Deceased)

Country: United Kingdom

Year Started Research: 1955

Title of Research: Solar radiation and climate data

University: University of Sheffield

Still Active in Research: No

John Page's career was devoted to developing climate knowledge bridges, believing these bridges had to span between the basic work of meteorological observers and applied work of designers located in global design offices. John, who became Emeritus Professor of Building Science at the University of Sheffield, attended the 1955 International Symposium on Applied Solar Energy in Phoenix, organised by ISES fore-runner, the Association for Applied Solar Energy; John became their first UK member. July 1973 - UNESCO hosted the 'Sun in the service of Mankind'. Forty Brits attended, including John and Dr. Mary Archer; the idea grew of forming a UK section of ISES, and was launched 24th January 1974 with John as first Chairman. John received the ISES Farrington Daniels Award at the Kobe Congress in 1989 and was active within UK-ISES until his death in 2019. John prioritised providing scientific advice to UN Agencies such as UNEP, UNCHSS, WHO, UNESCO and the World Meteorological Organization (WMO). In 1974, John (member of WMO Building Climatology Group) was in Geneva. He believed that WMO needed to give climate aspects of solar energy applications more attention, but the Secretary General was too busy. In true John style he was invited to lunch the next day with the S.G. John continued his passion for solar radiation data, co-authoring with countless top international researchers. In January 2000, the first volume of the new web-based atlas, European Solar Radiation Atlas (ESRA), Fundamentals and Maps, was published, followed by vol. 2 Database and Exploitation software. In John's words; 'I never envisioned when I saw Sputnik 1 satellite circulating the world one starry night in October 1957 that so much radiation information would be beamed down to us from the sky above using instruments of ever-increasing complexity. Our climatic task is to help deliver human progress.'



Dr Mort Prince

Country: USA

Year Started Research/Industry: 1951

Institute: Bell Telephone Laboratories

Still Active in Research/Industry : No

Morton Prince obtained his Ph.D. in Physics in 1951 from the Massachusetts Institute of Technology and then joined the Bell Telephone Laboratories (BTL). In 1954, he participated in the analysis and experimental development and improvement of the newly “invented” Bell Solar Battery. He developed a diffusion technique for producing junctions in silicon without destroying the minority carrier lifetime in the material. This allowed him to develop an extremely efficient silicon (conductivity modulated) power rectifier. Mort is an ISES pioneer, presenting a key paper at the historic 1955 “Conference on Solar Energy—the Scientific Basis” in Tucson Arizona. In 1956, he joined the Hoffman Electronics Corporation, Semiconductor Division, initially as Director of Research and Development, where he helped to commercialize the solar cells/modules he was involved with at the BTL. It was in 1957 that his organization convinced the Vanguard I Satellite engineers to use his Hoffman solar cells for space power—leading to the world’s 1st solar-power satellite and ushering in the first PV markets in space. In 1960, Dr. Prince became Division Manager and Corporate Vice-President and was responsible for overall administrative, technical, marketing, manufacturing and financial operations of the Semiconductor Division, encompassing two separate plants, employing more than 1,000 employees. After leaving Hoffmann, he became involved in other activities including his own organization. However, in 1975, when the Energy Research and Development Administration (ERDA) was started, he was invited to join the organization to lead the photovoltaic section and was responsible for planning, funding and monitoring the Federal Photovoltaic Program. Dr. Prince retired from the program in 1993. He was awarded the Becquerel Prize in 1999 and Marconi Premium of the British Institute of Radio Engineers in 1958 for a paper on solar cells. He served on various committees for many organizations, including the Institute of Radio Engineers, American Institute of Aeronautics and Astronautics, WESCON, IEEE and ASES. Mort Prince is a pioneer with leading roles in 3 major PV events: the Bell Discovery of the modern solar cell, the powering of the 1st solar-PV satellite, and the establishing of the U.S. terrestrial PV program.



Eugene Ralph

Country: USA **Year Started Research:** 1955

Title of Research: Single Crystal Solar cells

University/Research Centre: Hoffman Electronics Corp

Mr. Eugene L. Ralph joined in 1955 what soon after became the Semiconductor Division of Hoffman Electronics Corp. At Hoffman’s Ralph engaged in R & D on single crystal silicon solar cells for terrestrial applications, and on their transition to space applications. His early activities in process development resulted in a patent on the formation of ohmic contacts with aluminium on n-type silicon. In 1961, he was a member of the joined Heliotek which was part of Spectrolab where he stayed as vice President until 1983. He acted as President in 1979 and 80. Spectrolab, quickly attained the largest share of the space solar cell market through achievement of consistent fabrication of high performance, reliable, and radiation resistant cells at high yield. By continuously pursuing this quality goal in his responsibilities for research and engineering at Spectrolab; he helped assure Spectrolab’s leading role as a space solar cell supplier. At Spectrolab he promoted large scale solar utilization for terrestrial applications. From 1983 to 1993 he was chief scientist/engineer at the Space and Communications group at the Hughes Aircraft Corporation. From 1993 to 2000 he was chief scientist/engineer and director of Advanced Development at TECSTAR, Applied Solar Division where he was responsible for the development of advanced solar cells. While at TECSTAR he developed and patented an advanced concentrator space solar array. In 2000 he started his own consultancy business. Over the years he was involved with many committees and conferences and he served as General Chairman of the 1975 International Solar Energy Conference. In 1985 he was awarded the IEEE William Cherry award.

Norman B. Saunders

Country: United States

Year Started Research: unknown

Title of Research: Several solar houses, including 100% solar and cooled Shrewsbury House and Cliff House

University: Self; lived in Weston, Massachusetts, USA

Still Active in Research: No

Norman B. Saunders' 100% solar heated and cooled homes, all in northern climates, are the subject of two books by Dr. William A. Shurcliff. The first is called "Saunders Shrewsbury House", May 1982, 100 pages, published by W. A. Shurcliff. In a cover letter to Bruce N. Anderson on May 28, 1982, Dr. Shurcliff wrote: "The variety and novelty of the design strategies used are remarkable. Equally remarkable is the simplicity of the execution. The performance seems almost too good to be true: 100% solar heating (no furnace or wood stove), ample window areas on all 4 sides of the house, integral greenhouse, constant supply of fresh air, DHW solar preheating, fully automatic oration (no daily cares such as operating thermal shares - there are none), cooling in summer, and overall simplicity and durability. I can't think of any other solar house or super insulated house that rivals this one - for high performance, low cost." It employs 20 new strategies of energy collection, storage, control, and distribution. This house and two there Saunders houses are the subject of Shurcliff's later book "Super Solar Houses", 1983, Brick House Publishing Company. Saunders' first solar house, his own, was completed in 1960.



Steven V Szokolay

Country: Australia

Year Started Research: 1953

Title of Research: climatic design for office buildings

University: University of Budapest/University of New South Wales

Still Active in Research: No

Steven V Szokolay started working and studying as a draftsman in Budapest in 1953, when his studies were interrupted by the Russian incursion. Finished 1961 at the University of NSW. Worked at the Commonwealth Works Department; in his final year accepted a position with Sydney architects Edwards Madigan and Torzillo. 1963 left for Westfield, where designed shopping malls, including Blacktown and Dee Why. 1963, left Westfield for Europe, worked for Richard Gallino on the town center redevelopment Weston Super Mare. Attended 1973 ISES Conference Paris, becoming a Society member, and meeting Australians from CSIRO working in solar, and 12 other Hungarians working in solar energy. 1974-1976 was tenured by Liverpool University in Nairobi, where he became interested in architectural science and design. Enrolled in a Masters on climatic design for equatorial highland climates concurrent whilst teaching in Nairobi. Senior lecturer at Technical Centre London and Portsmouth: designed a Solar Scope and founded the Environmental Sciences teaching group. Worked with Otto Koenisberger at the AA School and subsequently employed as Senior Lecturer at the University of QLD, St Lucia. Moved to the Brisbane campus in August 1984. Norm Sheridan and Bill Carr built Australia's first official active solar house in Melbourne. Steve was working on solar air conditioning. Was approached to assist in a 'solar city' development at Mt Cotton; the Dept of Mines and Energy gave a monitoring performance grant. Authored the influential Introduction to Architectural Science. The basis of sustainable design, seminal in inspiring many architectural students. Successfully enhanced his architectural science unit at UQ, authoring over 150 research papers, mostly on solar energy and energy conservation in buildings, climatic design and sustainable architecture, publishing over a dozen books. Received the ANZSES Special Award (2001), Order of Australia (AM) for his solar work and the Centenary Award (2002) for educational achievements.



Harry Thomason

Country: United States
Year Started Research: 1959
Title of Research: Solaris #1
University: in the field
Still Active in Research: No

“Dr Thomason built—and moved his family into—his own first sun-heated house in 1959. The fuel bill for the initial winter season totalled a very satisfying (to the home’s designer especially) \$4.65. Since that time, he has built four other solar homes himself, and hundreds of other dwellings using his sun-power system have been constructed through his licensing program. Every one of them has performed remarkably well. “THOMASON: Well, we completed the house—which, incidentally, we call Solaris No. 1—in 1959. But I had been working on collectors and flow systems for some time before that, and actually applied for my first patent in ‘58. I moved my family into that three-bedroom house just before the winter of 1959 hit, and we lived there until 1962. We used only 31 gallons of oil for backup heat during the entire winter. When we finally left to move into Solaris No. 3, the total fuel bill for three winters of residence stood at \$18.90. The house was never chilly, nor did we suffer any interruption of heating service. And by the way, that house is still in operation today, receiving the majority of its heat from the sun, and having undergone only minor routine maintenance and repair.”Further details on Dr Thomason’s life and achievements can be found on the following links:

<https://www.motherearthnews.com/green-homes/solar-home-design-zmaz79ndzraw>

<https://www.builditsolar.com/Projects/SpaceHeating/Thomason/ThomasonPatents.htm>



Defang Wang

Country: China
Year Started Research: 1954
Title of Research: Researcher, Chief engineer
University: Gansu Institute of Natural Energy
Still Active in Research: No

Defang Wang was born in January, 1935, and is the founder of design method of thermal response coefficient method of China. He has developed a variety of thermal process analysis software for passive solar house. In the 1980s, passive solar houses mainly relied on building thermal measures to create certain indoor temperature conditions to meet winter heating requirements. Among the solar houses that have been built in China, a considerable number of solar houses have not been constructed in accordance with the correct method for building thermal calculations, or have not performed thermal calculations at all, resulting in low room temperature after completion and failing to reach the predetermined level. Defang Wang proposed a relatively simple and practical calculation formulas and calculation parameters of natural convection heat transfer between the sunlight room and adjacent rooms through the door opening, including direct benefit type, (Trumbe type) collector wall type and additional solar room type thermal calculation mathematical model and simulation program PSHS, referred to as “Passive Solar House Thermal Calculation Software”. This software uses the reaction coefficient method to replace the traditional difference method in the invariable heat transfer calculation of the collector wall, greatly simplifies the commonly used radiation heat transfer algorithm at that time and is suitable for computer calculation. In 1991, Defang Wang realized the connection of meteorological database, engineering databases and graphic libraries in the same software and solved the problem of processing meteorological data used for the hourly thermal performance calculation of buildings, which can directly meet the practical needs of engineering, and greatly promotes the transformation of scientific research results into productivity. Defang Wang also participated in the design and construction of various solar buildings in Yuzhong, Gansu Province funded by the United Nations, and compiled technical and economic optimization design software for solar passive houses.



John Yellott (1908-1986)

Country: United States

Year Started Research: 1958

Title of Research: Passive solar at John Yellott Engineering Laboratories, and the Yellott Solar Energy Laboratory

University: Arizona State University

Still Active in Research: No

John I. Yellott (October 25, 1908 – December 30, 1986) was a scientist internationally recognized as a pioneer in passive solar energy, and an inventor with many patents to his credit. In his honor the American Society of Mechanical Engineers (“ASME”) Solar Division confers a biannual “John I. Yellott Award” which “recognizes ASME members who have demonstrated sustained leadership within the Solar Energy Division, have a reputation for performing high-quality solar energy research and have made significant contributions to solar engineering through education, state or federal government service or in the private sector.” In June 1958 Yellott founded John Yellott Engineering Laboratories, and the Yellott Solar Energy Laboratory, in Phoenix, Arizona. He became an industrial consultant, with a primary focus on reflective glazing. He served as Headmaster and then Director of Development for Phoenix Country Day School and taught environmental control systems at the College of Architecture at Arizona State University. As the first Chairman of the ASME Solar Energy Applications Group (later Solar Energy Division) he was in a position of leadership “that was critical to the official ‘rediscovery’ of solar energy following the 1973 oil crisis”. Soon after the oil crisis, Arizona State’s College of Architecture instituted a solar program and chose Yellott as its head; he continued to teach there until his retirement at age 70. Further details on the life and achievements of John Yellott can be found at https://en.wikipedia.org/wiki/John_I._Yellott

5.6 Industry Pioneers 1950-1959



Lucien Bronicki

Country: Israel

Year Started Research/Industry: 1956/1964

Company first worked for: National Physical Laboratory, Jerusalem (1958)

Technology area: Solar Thermal and Geothermal

Still active in the industry: No

In 1964 the solar program at the National Physical Laboratory was terminated and Bronicki received a license for his patent and established Ormat Turbines Ltd. to continue the R&D and commercialize his invention. 1966- first commercial unit was a solar powered ORC power unit of 600W which powered an electric water pump in Mali, Africa. 1970'- lack of interest in small solar units for remote villages forced Ormat to look for other applications: power for unattended telecommunication repeaters where low maintenance requirements of these units now modified to use kerosene or LPG, made them superior to diesel -generator sets. About 3,000 units 200W to 4kW units were sold. 1979- after the 1973 energy crisis, renewed interest in solar energy led to the development of a 150kW ORC unit powered by a solar pond followed by a 5MW plant, which operated for 7 years. 1980' -energy prices dropped forcing Ormat to look again for other applications: this time were MW scale ORC systems for electricity production from geothermal heat sources and industrial waste heat. 2020- Ormat has built more than 500 modules in the power range of 1 to 40 MW, totaling more than 2,000 MW, largest pure ORC plant is the 100 MW Ngatamariki in New Zealand. In the last two decades, Ormat’s patents which are now in the public domain, were adopted by GE, Pratt and Whitney, Mitsubishi, and Fuji Heavy Industries and others. Ormat units still represent 90% of the world’s total ORC. Ormat Technologies Inc.(the successor of Ormat Turbines), is a public company traded on New York and Tel Aviv Stock Exchanges. (www.ormat.com) Bronicki holds alone 35 US patents and another 70 US Patents in cooperation with others. He has authored some 80 professional articles. Mr. Bronicki was member of the Studies Committee “Energy for Tomorrows World Commission” of the World Energy Council.

Benjamin Doron

Country: Israel

Year joined industry: 1955

Company first worked for: National Physical Laboratory

Technology area: Solar Thermal

Still active in the industry: No

In early 1950's Benjamin Doron was an assistant to Harry Tabor working in selective surfaces. He designed test equipment, conducted tests, and finally led the technology transfer to MIROMIT a solar collector company established by Mr. Sobotka. Doron built and tested a Vacuum isolated solar collector in 1958 which was industrialized 20 years later by LUZ company and now use 1 thousand MW of solar through power plants as well as Chinese solar water heaters. As assistant to Harry Tabor Doron built and tested the first lab model Solar ponds in 1958. Later in Solmat Ltd and Ormat was involved in R&D in particular turbidity control. Doron co-authored the U.S. Patents: 4,595,505 (1987) Methods of suppressing growth of algae in solar ponds.



Fred Treble (1915-2010)

Country: UK

Year joined industry: 1959

Company first worked for: Royal Aircraft Establishment

Technology area: PV

Still active in the industry: No

Fred Treble after distinguished work in aerospace engineering, joined a group of Britain's Royal Aircraft Establishment (RAE) in 1959 to investigate new means of generating electricity for the growing satellite industry. Photovoltaics proved to be the most promising, and thus began his long involvement with PV technology development and application. In 1960, he was appointed head of the Solar Cell Group in the Space Department at RAE, where he remained until his retirement in 1977. He was responsible for all aspects of PV systems for satellites and for managing R&D contracts on crystalline silicon and CdS cells and modules. On retirement, Treble established himself as a consultant and worked closely with the European Commission programmes on the selection and monitoring of PV R&D and demonstration projects. He collaborated with the Joint Research Centre (JRC), ISPRA, to develop test and measurement procedures. His work on the European PV Pilot projects highlighted the need for design qualification tests. Results of this work have since become international standards. Throughout his career he was active with various bodies including the UK-ISES and British Photovoltaic Association (PV-UK), serving on committees and giving lectures. He was recognised as a Pioneer in Renewable Energy at the 1994 World Renewable Energy Congress and in 2000 he was awarded the prestigious Becquerel Prize.

5.7 SWC Associate Supporter: American Solar Energy Society



American Solar Energy Society (ASES) was founded in 1954, the same year that Bell Labs patented the first silicon solar cell. This highly efficient photovoltaic material launched the solar industry into a period of endless opportunity and innovation. ASES is a 501(c)(3) non-profit that advocates for sustainable living and 100% renewable energy. We share information, events and resources to cultivate community and power progress in the U.S. and beyond. As the U.S. section of the International Solar Energy Society (ISES), we work with individuals and groups around the world to accelerate the transition to a renewable energy and sustainable living society. ASES is based in Boulder, Colorado.

ASES was established by visionaries who imagined a brighter future than the preceding post-war decades had produced. These pioneering minds understood the deep historical precedent of thousands of years of solar utilization through passive solar design and solar thermal technology. They envisioned a new era of energy innovation when these and other proven technologies would speed the world toward a more peaceful, sustainable energy economy.

ASES and ISES began as the Association for Applied Solar Energy (AFASE), founded in Arizona by Farrington Daniels (a University of Wisconsin researcher), together with Arizona businessmen Henry Sargent, Walter Bimson, and Frank Snell. The first AFASE solar conference was held shortly thereafter, in Tucson in 1955, followed by the World Symposium on Applied Solar Energy the following week in Phoenix. The scientists from Bell Labs demonstrated their solar cells at the exhibition associated with the Phoenix Conference. In January 1964 the AFASE changed its name to the Solar Energy Society (SES). By then the SES already had several international branches (later called Sections); the first being Australia-New Zealand, formed in 1962, followed by Chile and then Italy. The SES had financial difficulties throughout the 60's. In 1970 the Australian-New Zealand section invited the SES Board to host their meeting in Melbourne. A five day Congress, with financing from the Australian Government, was organized in conjunction with that meeting. At that Board meeting it was decided to move the SES offices from Arizona to Melbourne, and also agreed on a proposal for the creation of the American Solar Energy Society. The official name changes to ISES and ASES occurred in 1971 when the necessary legal documents were filed. In 1976 Karl Boer created the first ASES office in Florida, and in 2020 ASES re-domesticated in Colorado.

The vision that launched an industry

Many among solar, renewable energy and sustainability's finest have left their marks on ASES. Whether as leaders, supporters, staff, board members, educators, researchers, or advisors, their tireless efforts, expertise and vision over more than 60 years have had a positive, dramatic effect. Could they have imagined the many business models and economies they would spawn? The subsequent entrepreneurship, research and design ultimately shifted 21st century thinking and lifestyle toward smarter, more sustainable lifestyle choices.



AMERICAN
SOLAR
ENERGY SOCIETY

A legacy of leadership

The impact of these early solar champions can be seen in:

- More than six decades of advocacy, research and scientific papers
- 49 National Solar Conferences and counting
- 33 years of *Solar Today* magazine issues
- 17 volumes of *Advances in Solar Energy*
- ASES Policy reports
- 25 years of the National Solar Tour

Today, ASES is steadfastly focused on the goal of achieving 100% renewable energy and sustainable living for the benefit of all life on Earth. The viability of a sustainable global economy powered by renewable sources is proving itself around the globe and redefining human potential. ASES recognizes the opportunities in the challenges we face, and invites you to help make a difference at a time when it matters most. Our vision: Lead the transformation to 100% renewable energy and sustainable living for all life on earth.

The Power of Community

ASES is unique in our integrated perspectives of science, industry, policy and consumers. Together, these valuable viewpoints represent the sum of possibility that has delivered solar and renewable energy to the respected space it now occupies in the energy landscape. We remain committed to this community for the promise it holds for the future.

We believe knowledge and community are a powerful combination for change. Through trusted, well-researched content and comprehensive, thoughtful perspectives, we continue to nurture a transition to a more sustainable world. Through signature publications such as *Solar Today* magazine and annual events like the National Solar Tour and National Solar Conference, we engage individuals, businesses and partnering groups to advance the possibilities of sustainability and renewable energy in the U.S. ASES fosters an informed, inclusive society by presenting technical data and academic research in highly relatable, engaging formats to the greater community.

We connect the community of renewable energy and sustainable living companies to ASES readers, over 3,500 ASES members and attendees through:

- *Solar Today* magazine
- Solar@Work and Eight Minute Update newsletters
- Monthly Webinar Series
- National Solar Conference
- National Solar Tour
- Zero Emissions Network (ZEN)
- Emerging Professionals opportunities
- Tiny Watts project
- Partnership with the [Clean Energy Credit Union](#)
- Expertise, white papers, professional recognition, and resources
- Sponsorships, partnerships, and networking

We connect the solar and renewable energy communities through:

- 37 Regional chapters in 41 states and the District of Columbia, including five student chapters at colleges and universities across the country.
- Eight Technical Divisions of Student, Business, Professional and Life members.

5.8 SWC50 Supporter: Smart Energy Council



**SMART ENERGY
COUNCIL**
SOLAR. STORAGE. SMART ENERGY

The origins of the Smart Energy Council (SEC) founded in 1954 can be found in 50 years Solar Energy in Australia and New Zealand - A history of the Australian and New Zealand Solar Energy Society. Assembled by Garry Baverstock in 2005 the comprehensive report tracks early developments in solar powered technologies and highlights the passion, determination and breakout successes of industry pioneers.

The Smart Energy Council's Hall of Fame acknowledges the stellar achievements of a number of the scientists, researchers and engineers who are widely acknowledged as laying the solid foundation for what has become a monumentally successful multi-billion dollar renewables industry.

We applaud the likes of John Ballinger, David Mills, Graham Morrison, Monica Oliphant, Wal Read, Bill Charters, Roger Morse, Clarry Small, Steve Szokolay, David Allen-Williams, Ron Brown, Tom Crawford, Steven Kaneff, Wes Stein, Ian Onley, Bill Charters, Keith Lovegrove, Jim Were, John Riley, Muriel Watt, Andrew Blakers, Stephen Kaneff, Zhengrong Shi, Stuart Wenham and Martin Green. And, among the architects who pioneered energy efficient buildings: Gareth Cole, David Baggs, John Held, Geoff Barker, Trevor Lee, Richard Sale and David Oppenheim.

Professor Green remains active in industry and research and has been awarded the world's highest scientific prize for his breakthroughs in solar cell advances that have lifted efficiency, increased economies of scale and delivered all round PV affordably for millions across the globe which has curtailed millions of tonnes of carbon emissions.

Today large (utility-) scale solar plants provide about 3 per cent or 5.82TWh of Australia's annual 198.73TWh and small scale solar is a story of phenomenal success, generating 11.82TWh. Back in 2008 there were just 7,000 solar PV systems on Australian households and battery storage technology was barely a blink on the radar. Today more than 2.5 million (one in five) households have a rooftop PV system and the commercial and industrial sector is booming. The "people's plant" has reached a phenomenal 10GW capacity and it is estimated that will have trebled to 30GW by 2032.

The story could have been very different had Australia's coalition government – one that remains pro-fossil fuels, hostile to clean energy and has gained a worldwide reputation as climate laggard - succeeded in its determination to dump the Renewable Energy Target (RET) that promotes investment in large and small scale solar, wind and other low emissions technologies. The government also in 2014 wanted to dismantle the two agencies, the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC), that are instrumental to the uptake of renewables by instilling confidence in investment in new low emissions technologies.

The situation was as drastic as it was threatening, and that's where the Smart Energy Council, previously known as Australian Solar Energy Society (the Ltd NFP company name retains that heritage) and the Australian Solar Council, stepped in. The organisation has never shirked from its responsibility to support the researchers and the industry they created through focused strong advocacy. The Smart Energy Council ran powerful and effective campaigns, rallies and media appearances to highlight the need to retain the two agencies and the RET or face the demise of large- and small-scale solar plants and widespread job losses.

That has ever been thus, as successive federal (and some state) administrations seek to curtail the progress of renewables.

John Grimes, who in 2008 was appointed chief executive of the association that has become the national voice of solar and renewables for the media and policy makers, said the toughest challenge has always been political ideology over fact. Together with Smart Energy Council President Steve Blume, the Board, and Government and Stakeholder Relations Manager Wayne Smith, John Grimes has forged strong and enduring partnerships with key influential people including high-profile current and former political leaders, Prime Ministers and State Premiers. The partnerships have been instrumental in saving and growing the sector.



SMART ENERGY
COUNCIL
SOLAR, STORAGE, SMART ENERGY

But activities do not end there. The Smart Energy Council is a grass roots organisation dedicated to supporting its 1500 members, who in turn employ hundreds of thousands, through a broad range of services and activities: an annual conference and exhibition that attracts more than 6000 delegates, regular seminars and webinars, roadshows and technical training for professional development and robust industry standards that boost PV uptake and consumer confidence.

The Council also assembles market intelligence reports, industry and technology news updates for its data base of more than 30,000 industry stakeholders and produces a quarterly magazine which has been published continuously since 1980, a fine legacy from long-time former Editor and Board member the late Bill Parker.

Moving with the times the Council in 2013 launched an Energy Storage division and in 2019 its Hydrogen Australia division, foreshadowing enormous potential in the generation and export of the commodity.

On behalf of the ACT (capital territory) government the Council currently manages the ACT Renewables Hub. Thanks to Smart Energy Council Patron and former ACT Deputy Chief Minister Simon Corbell and his then adviser Steve Blume, the ACT is a trail blazer in low emissions and this year became the first jurisdiction in the world to source 100 per cent renewable energy. The ACT has now pledged to phase out fossil gas by 2045 and no new gas connections.

With its proactive agenda and suite of resources the Council's membership, which comprises individuals, small and medium businesses, Australian and international corporations, developers, installers, investors, energy traders, salespeople, market analysts, engineers, scientists and recruiters, has grown fifteenfold in twelve years. Council revenue has multiplied ten times.

Many have commented that the Smart Energy Council, which is based in the nation's capital Canberra and has a permanent staff of just ten, punches well above its weight.

"We have always made ourselves extremely relevant," John Grimes commented.

What does the future hold?

Australia's renewables industry stands on the cusp of a series of substantial developments.

Australia's state governments that have listened to the Smart Energy Council and set zero emissions targets by 2050, are developing utility scale plants and gigawatt scale Renewable Energy Zones, holding reverse auctions and in general powering ahead with renewables.

At the same time prominent and active business and industry groups in Australia along with farmers, miners, superannuation providers, corporations, unions and others are steering low carbon emissions technologies through divestment in fossil stock and investment in renewables. It is heartening to witness.

"Progress is an inevitable as it is unstoppable," John Grimes said.

"As David Attenborough states in his book A life on our planet 'Our careless use of fossil fuels has set us the greatest and most urgent challenge we have ever faced... we may yet pull off a miracle and move to a clean energy world by the middle of the century'."

Perhaps we can conclude this report by adding another profound statement, this one delivered by Cindy Nelson, former Administrator of the American Solar Energy Society, who in 2002 declared 'Solar energy people are the best! This ethical, highest common goal approach to life seems to bring intelligent well-meaning people to solar energy societies around the world.'

Hear hear!

6. 1960-1969

6.1 ISES 1960-1969

1960

- AFASE moved to ASU-donated offices; Hal Walmsley became President; Milton Lowenstein, the AFASE librarian; Prof. A. B. Stafford, *Solar Energy* editor; and S. W. Wilcox, *Sun at Work* Editor.
- The Advisory Council developed bylaws in April 1960 in Madison, Wisconsin
- A. J. Drummond, Publications Committee, member helped revitalize the *Solar Energy* journal.

1962

- The Australia—New Zealand AFASE branch (later called section) was formed with Roger Morse as chairman.
- Charles A. Scarlott became the Association/Society's editor for six volumes of *Solar Energy*.
- Board approved Council by-laws, recognizing the importance of the scientific community.
- This ultimately resulted in a new direction for AFASE—a series of annual meetings organised by Council members and devoted to solar science and technology.

1963

- The next branch (later called section) organised was Chile, with Julio Hirschmann as Chairperson.
- The Society is accredited by the United Nations Economic & Social Council (ECOSOC).
- AFASE's name was changed to the SOLAR ENERGY SOCIETY (SES) and it was reorganised

1964

- The Italy section was formed in under the guidance of Vittorio Storelli.

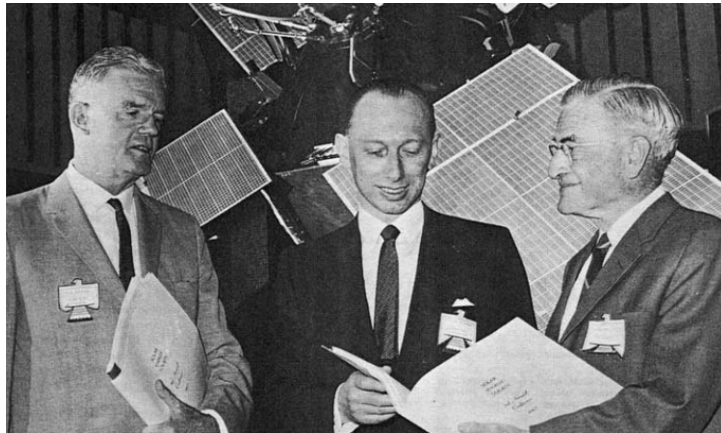


Figure 7: Roger Morse (Australia), Peter Glaser and Farrington Daniels (USA), the first three Presidents of SES elected by society membership

1967

- The Indian Section was formed.



Figure 8: Frank Edlin, Farrington Daniels and Peter Glaser at Tempe meeting, 1967 Indian Section was formed.

Table 4: Officers of AFASE 1960-1963

Year	President	Vice President	Secretary or Secretary / Treasurer	Executive Officer or Asst Treasurer
1960	H. Walmsley	J. Oostermeier W. T. Lucking H. Sargent	F. L. Snell	
1961	H. Walmsley	J. Oostermeier W. T. Lucking H. Sargent	F. L. Snell	
1962	H. Walmsley	J. Oostermeier W. T. Lucking H. Sargent	F. L. Snell	J. I. Yellott
1963	H. Walmsley	J. Oostermeier W. T. Lucking H. Sargent	F. L. Snell	J. I. Yellott (to 6/58) E. L. McLean (6/58)

Table 5: Officers of SES 1964-1969/70

Years	President	Vice President	Secretary or Secretary / Treasurer	Executive Officer or Asst Treasurer
1964-65	F. Daniels	R. Krause (to 3/64) W. B. Gibson		H. Walmsley
1965-66	F. Daniels	W. B. Gibson		H. Walmsley (to 5/65) F. E. Edlin (9/65)
1966-67	F. Daniels	W. B. Gibson		F. E. Edlin
1967-68	P. E. Glaser	R. N. Morse		F. E. Edlin
1968-69	P. E. Glaser	R. N. Morse	C. N. Hodges	
1969-70	R. N. Morse	J. A. Duffie	C. N. Hodges (to 2/70)	

Table 6: Conferences and Meetings 1965-1968

Year	Location	Overview
1965	Phoenix USA	Annual Meeting of SES Approx. 50 papers, 110 in attendance
1966	Boston USA	Second Annual meeting SES conference Approx. 43 papers
1967	Tempe USA	<i>Industrial Aspects of Solar Energy</i> General Chair: Peter E. Glaser Approx. 100 in Attendance.
1968	Palo Alto USA	4 th Annual Meeting of SES General; Chair” W.B. Gibson

6.2 SES Presidents 1964-1969

Farrington Daniels



Figure 9: Farrington Daniels, President 1964-1967

Farrington Daniels (USA) was the first president of the Solar Energy Society elected by the membership. His name is given to the most prestigious award given by ISES at every Solar World Congresses (SWC), the Farrington Daniels Award for outstanding intellectual leadership in the field of solar energy. Daniels was born in 1889 and died in 1972. He was a physical chemist and is considered one of the pioneers of the modern-day use of solar energy. He joined the University of Wisconsin as an assistant professor in 1920 and remained as chairman of the chemistry department until his retirement in 1959. Daniels became a leading international expert on the principals involved with the practical utilization of solar energy. He pursued an understanding of the heat and the convection as well as the electrical energy that can be derived from the sun. In 1952, Farrington Daniels met Henry Sargent and suggested to him that there was a need for an organization to promote the development and application of solar energy. Two years later, Sargent, with Walter Bimson and Frank Snell, organised the Association for Applied Solar Energy, AFASE. During these early years, Farrington Daniels built many relationships across the small but growing international solar energy research world.

Peter Glaser

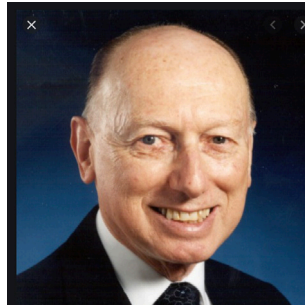


Figure 10: Peter Glaser, President 1967-1969

Peter Glaser was born and raised in Bohemia and educated in Czechoslovakia, England, and America. In 1955 he joined Arthur D. Little, a consulting organization in the United States, where he was a lunar scientist and worked with imaging furnaces and space power systems throughout his career. He participated in the AFASE Solar Furnace Symposium in 1957 and was active in Society matters for many years thereafter. In addition to being President, he also was Editor of Solar Energy.

6.3 PV 1960-1969

Japan started to use solar power on marine navigation buoys and lighthouses. **Hoffman Electronics** attempted to commercial photovoltaic powered navigational aids. PV continued to be the power of choice for space, meanwhile individuals began to explore their use terrestrially with companies being founded to undertake the R & D.

1960

- **Hoffman Electronics** achieved 14% efficient photovoltaic cells.
- **Silicon Sensors Inc** of Dodgeville, Wisconsin, is founded. It starts producing selenium and silicon photovoltaic cells.
- The idea of bifacial photovoltaic modules is independently developed by Japanese scientist H. Mori and Russian scientists A.K. Zaitseva and O.P. Fedoseeva. These bifacial photovoltaic modules have two active surfaces and thus have the potential to generate more electric energy with roughly the same size collector.
- The first sun-powered automobile was demonstrated in Chicago, Illinois on August 31st
- In June the US Army Signal Corp demonstrated the first coast to coast two-way radio signal powered by solar. It was from the corps station at Ft Monmouth New Jersey to El Monet, California headquarters of **Hoffman Electronics**.
- Stanford and Iris Ovshinsky established **Energy Conversion Devices (ECD)** in Michigan.

1961

- American physicist William Shockley and German physicist Hans-Joachim Queisser became the first to define the maximum theoretical efficiency of a solar cell using a single p-n junction to collect electricity from the cell. The Shockley-Queisser limit is fundamental to direct solar energy conversion.
- The **Institute of Electrical and Electronics Engineers (IEEE)** held its first specialty conference on photovoltaic energy in Philadelphia
- "Solar Energy in the Developing World" conference was held by the United Nations.
- The Defence Studies Institute organised a photovoltaic conference in Washington.
- **Sharp Corporation** launched solar powered transistor radio.

1962

- **Bell Telephone Laboratories** launched the first telecommunications satellite, the Telstar (initial power 14 watts).

1963

- **Sharp Corporation** succeeded in producing volume production of practical silicon photovoltaic modules.
- **Sharp Corporation** installed a solar powered buoy in Yokohama Bay.

1964

- NASA launched the first **Nimbus** spacecraft - a satellite powered by a 470-watt photovoltaic array.

1965

- Peter Glaser conceived the idea of the satellite solar power station.

1966

- NASA launches the first Orbiting Astronomical Observatory, powered by a 1-kilowatt photovoltaic array, to provide astronomical data in the ultraviolet and X-ray wavelengths filtered out by the earth's atmosphere.
- **Sharp Corporation** installed a 225 watt, photovoltaic array on a lighthouse on Ogami Island, in Japan the world's largest array at that time.

1967

- Russian **Soyuz 1** became the first manned spacecraft to be powered by solar cells.
- Akira Fujishima discovered the Honda-Fujishima effect which is used for hydrolysis in the photoelectrochemical cell.
- The Azur Satellite used **AEG** solar cells.
- Wolfgang Platz became manager of the PV Programme at the French National Space Agency (**CNES**).

1968

- Robert Riehl introduced the solar-powered wristwatch.
- The **OVI-13** satellite with two CdS panels was launched.
- **Dundee University** work in PV related areas started under Professor Walter Spear (Harris Chair of Physics) and co-worker Peter LeComber.
- Dr Elliot Berman commences to pursue his research on developing solar cells.

1969

- Roger Little established **Spire Corporation**, which became and still is an important producer of solar cells production equipment.
- Dr Elliot Berman joined the Exxon laboratory in Linden New Jersey to pursue his research on developing solar cells.

Dates Unknown

- **Photon Power** in El Paso Texas worked on cadmium sulphide cells.
- **Katholieke Universiteit Leuven (KUL)** (Belgium) researched PV under Roger van Overstraeten.

6.4 Solar Thermal 1960-1969

1963

- Czarnecki at CSIRO Melbourne tested the performance of an inflated polyvinyl chloride pool cover as a means of heat outdoor swimming pools.

1965

- Solar water heater test centre set up at the University of NSW, Australia by Charles Sapsford. The Centre was later used by Graham Morrison to develop testing procedures that became the basis of many Australian and International Standards and the TRNAUS extension to TRNSYS that covers Thermosyphon water heaters.

1966.

- World's largest solar still built at Coober Pedy Australia, to convert saline bore water to fresh water for the town's residents. The still was based on a prototype which the CSIRO Division of Mechanical Engineering had been operating successfully at Muresk Agricultural College in Western Australia since 1964, under the guidance of Wal Read.

Late 1960s

- Solar thermal research group at University of Melbourne set up By Bill Charters and Bob McDonald.

6.5 Solar Architecture Buildings 1960-1969

1967

- Felix Trombe and Jacques Michel design and build a passive solar house in Odeillo, France.

6.6 Research Pioneers 1960-1969



Robert Boehm

Country: United States

Year Started Research: 1968

Title of Research: Solar Energy Applications

University: University of Nevada, Las Vegas

Still Active in Research: Yes

Robert Boehm taught in Mechanical Engineering, from September 1968-1990 at the University of Utah and 1990-2022 at the University of Nevada Las Vegas (UNLV). He served as Chair for a period at each University and ended with rank of Distinguished Professor at UNLV. He specialized in teaching solar energy and pursued research in that and related topics. He played a significant role in the development of the solar and renewable energy minor at UNLV and was the primary developer of the Center for Energy Research. The latter had physical facilities at the University as well as at the Southern Nevada Water Authority Treatment Lab. Some titles and honors held by Boehm: California PE 1966; Fellow ASME 1983-; UofU Distinguished Teaching Award 1988; UNLV Harry Reid Research Award 2002; UNLV Distinguished Teaching Award 2002; Associate Editor Energy the International Journal 2002-; UNLV Distinguished Professor 2004-; John Yellott Award, highest ASME solar energy award 2010; Co-Advisor UNLV 2nd Place winner of the 2013 International Solar Decathlon House Competition; Editor ASME Journal of Solar Energy Engineering 2015-2019. One of the contracts received by Boehm as PI is briefly outlined. The Center for Energy Research responded to a USDOE Call-for-Proposals to plan, design and install a significant amount of solar and other energy saving technology for a large installation, either industrial or residential. CER put forth a proposal working with a major home builder and a local utility to install cost-effective energy conserving approaches on peak energy uses in a new home development of 185 starter houses. This resulted in an approximate \$16,000,000 plus significant cost share, 5-year-contract. Using a combination of built-in equipment as well as energy-saving strategies, reductions of 65% peak energy usage were shown with those costing somewhat more than houses built to code.



Dieter Bonnet (1937-2016)

Country: Germany

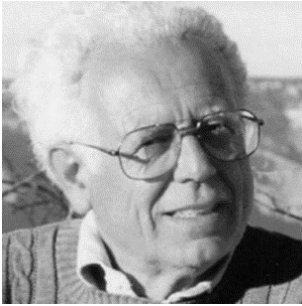
Year Started Research: 1961

Title of Research: Photoelectric properties of organic materials and CdTe/CdS thin-film solar cells

University: University of Frankfurt and Battelle Institute

Still Active in Research: No

Dieter Bonnet obtained his his PhD at Frankfurt University in 1963 on photoelectric properties of organic materials. Dr. Dieter Bonnet started his professional career in 1965 at the Battelle Institute in Frankfurt/Germany, where he soon became head of the solid state physics department. He dedicated many years to R&D in the field of solar photovoltaic thin film cells where he contributed especially to CdSe, CdS and CdTe since 1968. In 1970, he developed the world's first CdTe/CdS thin-film solar cells in the presently known configuration and in 1972 this cell had an AMO efficiency of 6%. When in 1993 the Battelle Institute was closed down Dieter Bonnet together with other employees initiated a buyout from the institute and so became a co-founder and shareholder of ANTEC GmbH, out of which grew the solar firm ANTEC-Solar in Arnstadt, Thuringia. As head of the Solar Energy Department of ANTEC Dieter Bonnet continued the development of the CdTe technology and brought it to mass production maturity. This enabled ANTEC Solar in 2001 to start the operation of the worldwide first commercial CdTe thin film solar production. In June 2001 the city council of Arnstadt honored his merits on the building up the first solar factory in Arnstadt by naming a street "Dr.-Bonnet-Weg". In his time with ANTEC Dieter Bonnet joined together the European scientific CdTe community. He initiated SOLARPACT, a global network that connects research groups and industrial units to promote the technology of photovoltaic modules based on CdTe and related components in view of a cost-competitive mass production. In 2006 the Commission of the EU expressed its recognition to Dieter Bonnet for his achievements in the field photovoltaic energy by awarding to him the renowned Becquerel Prize. After his retirement he supported as an advisor the creation of CTF Solar as the successor company of the ANTEC group.



Jeffrey Cook

Country: United States

Year Started Research: 1962

Title of Research: Vernacular and passive solar architecture

University: Arizona State University

Still Active in Research: No

Jeffrey Cook is known for pioneering work on bio-climatic design, distinctive because of breadth of interests and concern to make connections between them - anthropology, vernacular architecture and tribal cultures balanced by a lively interest in contemporary architecture, architectural theory and criticism. Born Nova Scotia, studied Manitoba University School of Architecture Winnipeg, graduated 1957. Completed architectural training at Pratt Institute, Brooklyn where tutor Sybil Moholy-Nagy introduced him to 'native and anonymous' vernacular architecture, profoundly influencing his later interests. In 1962, commenced academic career at Arizona State University, 1988 elected as Regent's Professor at College of Architecture. First UK appointment - Manchester Polytechnic School of Architecture. His knowledge of Paolo Soleri's work brought him to AA School and AA Quarterly. Living near Frank Lloyd Wright's Taliesin West and Paolo Soleri's Cosanti Foundation, acquainted with the demands of architecture that responded to nature and the wider environment. Own house, begun in 1968, one of first examples of solar passive energy in Arizona; its subsequent publicity catapulted Jeff into prominence as solar energy guru in Arizona; became an energy adviser to the US Government. First President - Passive Low Energy Association (PLEA). Diverse interests enhanced by elected memberships and awards including International Committee of Architectural Critics to Hon Fellowships ,RIBA and Bulgarian Association of Architects. Founder-editor of Passive Solar Journal. Visiting Professor at University of Westminster, worked with Tanis Hinchcliffe on major energy system studies, particularly ventilation and heating, in major nineteenth-century buildings such as the Natural History Museum and Strangeways Prison. Served for many years as a guest tutor and examiner in energy design at AA School. Many publications including photographic study of the homes and habitats of Anasazi people (tribe that preceded the Hopi in Arizona), followed by studies of the 'Makona Group' that grew around Hungarian Imre Makovecz.



Prof. (Dr.) H. P. Garg

Country: India

Year Started Research: 1965

Title of Research: Solar Energy Research, Development and Education

University: Indian Institute of Technology (IITD), New Delhi, India

Still Active in Research: Yes

A pioneer in Renewable Energy Research and Education in India, Prof. (Dr.) H.P. Garg has achieved National and International recognition for his outstanding original contributions to the development and design of solar energy technology applications. Largely due to the zeal and perseverance of Prof. (Dr.) H.P. Garg, a range of quality assurance processes have been adopted in India and abroad which has earned him the credit of Renewable Energy Man. In addition, Prof. Garg has spearheaded the establishment of academic programmes focusing on research and training in renewable energy at Indian Institute of Technology (IIT) Delhi as well as at many other engineering institutions in the country. He has also led the effort to develop suitable training material for several of these academic programmes, including his 18 books, more than 520 research papers, 80 technical reports and supervising 30 Ph.D. students. Prof. Garg has been actively engaged in Teaching; Research, Development and Demonstration (RD&D), and Consultancy in the field of Renewable Energy; Technical & higher education, Management and Energy Education and Administration for the last 55 years, mainly at Indian Institute of Technology (IITD), New Delhi, India as Professor (Solar Energy) and Head. In between, on deputation, he was Director General and Principal Secretary, Department of Science & Technology, M.P. Govt., India during 2002-2004. Presently Prof. Garg is the Director General at Trinity Group of Educational Institutions, New Delhi and Adjunct Professor, Netaji Subhash University of Technology, New Delhi. Prof. Garg has a large number of Awards/Honours (more than 15 International & National awards) and recognitions to his credit. He is a recipient of prestigious UNESCO Chair and IREDA Chair and President/Vice President/Member of several leading national/international professional societies. Prof. Garg is a widely travelled scientist and has delivered invited lectures in more than 120 countries of the world.



Baruch Givoni

Country: Israel

Year Started Research: 1960's

Title of Research: Man, Climate and Architecture

University: Dept. Building Climatology, Building Research Station, Technion - Israel Institute of Technology AND Solar Buildings Unit, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev

Still Active in Research: No

Prof. Emeritus Baruch Givoni passed away one month before his 100th birthday. He was a pioneer and guide in the fields of building and urban climatology, thermal comfort, solar buildings and more, thus worldwide acknowledged and respected. He was a very modest and non-assuming person, thus he was also loved by those that met him. In 1958 he founded the Dept. of Building Climatology at the Building Research Station (currently the National Building Research Institute) at the Technion. Soon after he founded and headed the Solar Buildings Unit at the J. Blaustein Institute for Desert Research, Ben-Gurion University of the Negev (1977). He researched and published extensively, was active on numerous international organizations, and was honored with many prestigious awards. Many of his books and papers have been seminal, still widely read and consulted. Prof. Baruch Givoni was lucid and active to his last days. We had the great fortune to collaborate with him, supervise together research students and publish research papers on topics touching on the most recent practices and most relevant issues. We shall remember him as a teacher and a friend.



Yogi Goswami **ISES President 2004-05**

Country: United States

Year Started Research: 1969

Title of Research: Photo-electrochemical oxidation

University: North Carolina A&T State University, Clean Energy Research Center at the University of South Florida, Florida, U.S.A.

Still Active in Research: Yes

Dr. Yogi Goswami a true pioneer in the research and development of alternative energy solutions, especially solar energy. He is also active in research on energy storage, air-conditioning and indoor air quality. His research works are always strongly based on scientific principles and further lead to the development of new technologies that can be practically applied to effectively solve engineering problems. His groundbreaking and revolutionary engineering research efforts set him apart, not only as an explorer who help forge many new pathways to advance the field of engineering, but also as an entrepreneur who develops his research into technologies to benefit the society. Prominent successes include the Goswami thermodynamic cycle for multi-generation, solar photocatalytic water purification, photo-electrochemical oxidation (PECO) technology for air purification, among others. The PECO technology has been commercialized and the PECO products are available worldwide to safeguard our health. It is noteworthy that the PECO technology is timely as it can effectively kill viruses to fight against COVID-19. The above achievements have been well recognized by his professional peers with awards, such as the AAES Joan Hodges Queneau Palladium Medal for Engineering Excellence for Environmental Conservation and Karl Boer Award and Medal for Solar Energy, as well as the media at large, for example, Time Magazine's cover story about his air disinfection invention, naming it among the top 25 inventions of 2017. Dr. Goswami's valuable teaching and mentoring also make significant contributions to research indirectly. He is truly a role model to his students coming from different parts of the world. Dr. Goswami not only imparts technical knowledge in science and engineering, but also deeply inspires students by his philosophy of life and selfless contributions to the society.



David Hall

Country: UK

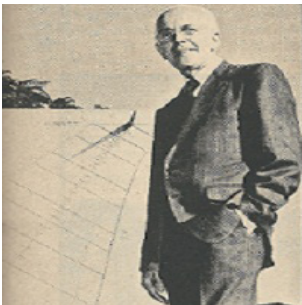
Year Started Research: 1963

Title of Research: Bioenergy

University: University of California, Berkley

Still Active in Research: No

David Hall advocate for energy from plants and scientist with consuming passion for biomass. Encyclopaedic memory and diverse contacts in science, technology and policy, he contributed to issues of bioenergy, global change, energy and environmental policy and plant physiology. Recognised connections between science, technology and policy, as acknowledged by his service to the Inter-Governmental Panel on Climate Change, other international scientific committees, UN agencies and the European Union. Embraced international collaborative projects before current environmental concerns and particularly influential in developing Brazil's ethanol from biomass industry. Born in East London, South Africa, educated at Kearsney College and Natal University. Research career started at University of California, Berkeley, where he took his PhD studying the physiology of photosynthesis; a year at Johns Hopkins in Baltimore followed before he joined Kings College London (KCL) in 1964 as lecturer, promoted to Professor of Biology in 1974. Influential member of the UK Solar Energy Society, which he co-founded, 1972. From 1987 – 1992, he hosted the Society at Kings College London. Held a number of posts, including Chairperson and Honorary Treasurer; at the time of his death, was Meetings Secretary. In 1978 at first UK SunDay event, he organised sunrise congregation outside the House of Commons to promote the use of solar energy. In 1978 He was a founding member of UK charity, The Solar Trust for Education and Research. In 1981 he was Chairperson of ISES Solar World Congress, Brighton. He was an ISES Board Member during 1980s. In 1998 - obtained permission to use the prestigious Great Hall Kings College London, critical for persuading then Energy Minister John Battle presenting the Society's Annual Christmas Lecture– first time for an energy minister. This annual lecture was subsequently renamed the David Hall Memorial Lecture. In 1998- presented with Society's Special Service Award, recognising his outstanding service and commitment to the Society and biomass.



Harold Hay

Country: United States

Year Started Research: 1967

Title of Research: Sky Thermal House

University: San Luis Obispo University

Still Active in Research: No

John Yellott's collaboration with solar entrepreneur Harold Hay on developing an evaporative solar system called a roofpond, which Yellott considered "the simplest system which can accomplish both heating and cooling with the same equipment," proved to be not so simple. The experiments at Yellott's laboratory encountered obstacles such as the unexpected "healthy growth of 'wrigglers' within plastic-enclosed water" from the city mains; then "a pair of nesting birds was attracted to the comfort of a projecting portion of the roofpond." (The researchers eliminated the unwelcome 'wrigglers' as well as a prolific growth of algae with chemical treatment; they considered the "cheerfulness of the birds a pleasant relief from the drudgery of data-collection," but recommended "preventive measures for those not wanting such company.") Yellott's and Hay's experiments did prove the roofpond concept technically feasible, later confirmed with expanded testing on dormitory roofs at Trinity University in Texas. Nonetheless, in the words of solar scientist Kenneth Haggard of the San Luis Obispo Solar Group, implementation of the idea of maintaining a large puddle of water on one's roof to cool the interior "awaits the next period of blossoming of passive solar architecture." (Hay defended roofponds, acknowledging that while a roofpond design error proved "highly expensive to a young architect and his client," nonetheless there is an "unnecessary fear of having bodies of water overhead." Hay also noted that a review of all roofpond installations in the United States concluded the roofpond "outperforms any other single passive system in both heating and cooling modes" and opined "It may be DOE's best kept-secret buried under hundreds of reports."). Further details on Harold Hay's life and achievements can be found on the following link:

<https://www.latimes.com/archives/la-xpm-2007-nov-10-fi-haroldhay10-story.html>



Ruben Piacentini

Country: Argentina

Year Started Research: 1967

Title of Research: Solar Energy, Atmospheric components that attenuate solar radiation and Climate change

University: Institute of Physics Rosario, CONICET-National University of Rosario, Rosario, Argentina

Still Active in Research: Yes

Professor of the first post-graduated Course on “Fundamentals of Solar Energy” in Faculty of Exact Sciences and Engineering, National University of Rosario (FESE/NUR), Argentina (1978). Invited professor of graduate and post-graduate courses and Researcher at different national and international Universities and Research centers (1984-present). Researcher at CONICET, Argentina, from the Independent to Superior categories on Solar Energy, Atmospheric components that attenuate solar radiation (ozone and aerosol) and Climate change (1978-present). Founder and Director of the Solar Energy Group at FESE/NUR, 1977-1980. From 1981 to the present, Director of the Atmospheric Physics, Solar Radiation and Astroparticles Group, Institute of Physics Rosario, CONICET-National University of Rosario. Director of the Master Degree Energy for Sustainable Development, Faculty of Exact Sciences, Engineering and Surveying, National University of Rosario (2007-2018). Director of 9 doctorates in Solar Energy and related subjects (1997-2013) and of 15 researchers (1977-present). International, regional and national publications (188) and books or chapter of books (20). Conferences, seminars, courses and special classes given at Universities and Research Centre of France, USA, Belgium, Spain, Italy, Brasil, Chili, Uruguay. Awarded prize of “Technological Innovation” presented at the International Exposition in Buenos Aires for the Solar grain dryer with bare collectors (1982). “William T Pecora” prize given by NASA and the Department of Interior/USA, as part of the TOMS (Total Ozone Mapping Spectrometer) Science Team at Goddard Space Flight Center/NASA (2006). Co-founder of the Argentina Solar Energy Society. Co-author and reviewer of the WMO/UNEP world reports on Ozone, Solar UV radiation and Climate change (1998-present). Named Member of the Argentina National Academy of Exact, Physical and Natural Sciences (2003). Editor and Reviewer of Journals (Drying Technology, Atmosphere, Journal of Environmental Research, Energy, Optics Express, ERMA)



Stephen L. Sargent

Country: United States

Year Started Research: 1963

Title of Research: Solar Power Generation for Developing Countries

University: Arizona State University

Still Active in Research: No

Stephen L. Sargent first became interested in solar energy in 1963 while an engineering student at Arizona State University. He applied for and received a Fulbright grant to study the subject at the Israel Institute of Technology in 1964. He completed MS and PhD work at the University of Wisconsin, where he was affiliated with the Solar Energy Laboratory. He taught mechanical engineering courses at the University of Maryland, where he initiated a solar energy course. He joined the US Energy Research and Development Administration where he served as a program manager in the newly created solar energy research program. He worked in the Department of Energy's solar program until his retirement in 2004. Dr. Sargent joined the Association for Applied Solar Energy, the predecessor to the International Solar Energy Society, in 1963 and remained a member throughout his career. He is the recipient of the Rebecca Vorhies Award for exceptional service given by the American Solar Energy Society. He has given a number of presentations at ASES and ISES conferences on various solar-related topics.



Ali Sayigh

Country: United Kingdom

Year Started Research: 1969

Title of Research: Solar Energy Systems, Buildings, and Advocate

University: London University/University of Reading

Still Active in Research: Yes

Dr. Ali Sayigh graduated from London University & Imperial College, BSC.AWP, DIC, Ph.D., C Eng. in 1966. He is a Fellow of the Institute of Energy and Fellow of the Institution of Engineering & Technology, Chartered Engineer, Chairman of the Iraq Energy Institute. Prof Sayigh taught in Iraq, Saudi Arabia, Kuwait, Reading University and the University of Hertfordshire (1966–2004. He was Head of Energy Department at Kuwait Institute for Scientific Research (KISR) and Expert in renewable energy at AOPEC, Kuwait (1981-1986). He started R&D in solar energy in 1969. He established “The Journal of Engineering Sciences” (1972) in Saudi Arabia and in 1984 he established the International Journal for Solar and Wind Technology, as an Editor-in-Chief and Journal of Renewable Energy in 1990. In March 2014, he left WREN Journal as editor-in-chief but remain as founding editor. He is editor of several international journals published in Morocco, Iran, Bangladesh, Nigeria, and India. He established WREN and the World Renewable Energy Congress in 1990 and is a member of various societies related to climate change and renewable energy. He established the by-annual Forum in 2011 “Mediterranean Green Buildings and Renewable Energy Forum”, and served as Editor-in-Chief of Comprehensive Renewable Energy, contributing 8 volumes to Elsevier in 2012 (winner of the 2013 PROSE Award). He was consultant to many national and international organizations, among them, the British Council, ISESCO, UNESCO, UNDP, ESCWA, & UNIDO. Dr. Sayigh founded the ISES Middle East Section of the Society. He has collaborated with ISES in several world conference events. He runs conferences in 40 different countries, published more than 600 papers and associated in 40 books. He supervised more than 80 M Sc. and 35 Ph. D students. He established (2016) Renewable Energy Magazine, RE and the year, since 2000. He established as Editor-in-chief, well-refereed Journal of Renewable Energy and Environmental Sustainability.



Roger Van Overstraeten(1937-1999)

Country: Belgium

Year Started Research: 1963

Title of Research: Physical and micro electronics

University: Stanford University

Still Active in Research: No

Roger J Van Overstraeten (1937 – 1999) received civil engineering degree in electronics and mechanics from the University of Leuven in 1960 and his PhD in physical electronics from Stanford University in 1963. In 1965 he was appointed Associate Professor, University of Leuven, Professor in 1968. From 1972 to 1984 he was director Microelectronics Department of Leuven Research & Development Guest professor – University Florida (1974), Stanford University (1979) and Pilani (India, 1980) 1981 – 1984 - Chair, Department of Electrical Engineering. Set up Electronics, Systems, Automation and Technology (ESAT) laboratory, which he directed until 1984. From 1984 to 1998 he was President and guiding inspiration of the Interuniversity Microelectronics Centre (IMEC), international research and development organisation active in fields of nanoelectronics and digital technologies. Under his direction, IMEC set up 15+ spin-off companies, and created new venture capital fund IT Partners, orientated to information technology. In 1989, awarded the first Becquerel Prize by the European Commission - prize to honour scientific, technical or managerial merits in the field of photovoltaic solar energy, established at the occasion of the 150th anniversary of a ground-breaking experiment by Alexandre-Edmond Becquerel, also known as Edmond Becquerel, in which he discovered the photovoltaic effect. The prize is awarded to a single individual who is recognized for continuous achievements in the field of photovoltaic energy conversion. Served on numerous advisory and editorial boards, and fellow of the Institute of Electrical and Electronics Engineers, from which he received the Frederik Phillips Award in 1999. Elevated to the nobility by the Belgium King as Baron Van Overstraeten.



Jerome Martin Weingart

Country: USA

Year Started Research: 1962

Title of Research: PV-powered tetrahedral research satellites (TRS)

University/Research Centre: Space Technology Laboratories, California

Still Active in Research:

Jerome Weingart is a physicist whose work since 1962 has been at the nexus of renewable energy, sustainable development, and poverty alleviation. He is a graduate of MIT and Brandeis University in physics. Jerome is a former NASA engineer, research faculty member at Caltech, and former Regents' Professor in Energy and Resources at UC Berkeley. He has led assignments for UN agencies, the World Bank, ADB, USAID, and the private sector. He has published extensively on physics, renewable energy, and international development. In 1971 he persuaded the author of President Nixon's Congressional message on energy resources to include two sentences on solar energy: In response the NSF/NASA Solar Energy Panel was established January 1972. It produced the foundation for a national solar energy R&D program. He led the renewable energy program at the International Institute for Applied Systems Analysis in the mid-1970s. His collaboration with IASA produced the prize-winning monograph *The Helios Strategy*, which quantified the potential for global deployment of solar and wind energy systems. Jerome would say that he is not a lone pioneer, but someone who thrives on collaboration, cooperation, and trans-disciplinary initiatives, and works best in institutions and programs that support such initiatives. From this have come: The Village Power Program at NREL, culminating in two global Village Power Conferences at the World Bank in 1998 and 2000; The Eastern Islands Pilot Project to electrify villages using solar/wind hybrid power systems, with Westinghouse / IPC and Indonesian Government; Renewable energy and energy-efficient building design, for the US Government, Sandia, private A&E firms. Co-authored pioneering studies and book *New Energy Technologies for Buildings / Institutional Problems and Solutions* (with Richard Schoen and Alan Hirshberg) at JPL and Caltech and Commercial diffusion of residential solar water heating in Southern California: JPL, Caltech, SoCal Gas Co.



Prof. Masafumi Yamaguchi

Country: Japan

Year Started Research/Industry: 1968

Institute: NTT Electrical Communications Laboratories

Still Active in Research/Industry:

Prof. Masafumi Yamaguchi received his Ph.D. degrees from Hokkaido University in 1978. In 1968, he joined the NTT Electrical Communications Laboratories, where he was engaged in research on semiconductors but in particular, III-V compound solar cells working as a Supervisor and a Section Head. Dr. Yamaguchi was the first to demonstrate the superior radiation-resistance of InP materials and solar cells. His group also developed high-efficiency and radiation-resistant InP cells with efficiencies of 17% at AM0 and showed the great potential of InP cells for space applications in 1983. The first satellite using InP cells was launched in early 1990. His group also proposed a double-hetero structure tunnel junction for realizing a high performance and stable multi-junction cell interconnection in 1987. They developed high-efficiency (20% at AM1.5G) GaAs solar cells fabricated on Si substrates in 1989 and demonstrated space flight experiment using GaAs-on-Si cells in 1994. In 1994, he moved to being Professor at the Toyota Technological Institute, Director of the Super High Efficiency Photovoltaics Research Center. Prof Yamaguchi has been an International Committee member for the European Photovoltaic Solar Energy Conference since 1994. He is an Editor of the journals "Progress in Photovoltaics" and "Renewable and Sustainable Energy Reviews". He made considerable contributions to R&D of photovoltaic technology as a member of the New Sunshine Program Promotion Committee of the Ministry of International Trade and Industry and as a Chairman of Super High-Efficiency Solar Cell Committee of the New Energy and Technology Development Organization. He has published more than 200 original papers and presented at more than 250 International Conferences. He was are cognised with William Cherry Award in 2008 and the Becquerel Prize in 2004.

6.7 Industry Pioneers 1960-1969



Garry Baverstock

Country: Australia

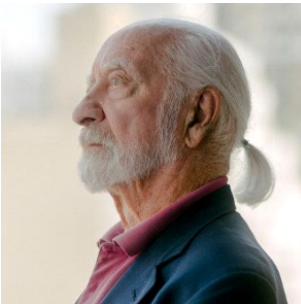
Year joined industry: 1969

Company first worked for: Ecotect Architects

Technology area: Solar Architecture/Buildings

Still active in the industry: Yes

For over 45 years Garry Baverstock has been designing, building, educating and researching in the field of Ecological Sustainable Design. Apart from studying and becoming an architect in 1972, he studied Construction Engineering part-time while running his practice and then completed a MSc in Applied Physics in building studies in the early 1990s. He is still one of the world experts in the use of thermal inertia storage linkage with PV. Garry's involvement with ISES goes back to the 1970's. He was a member of the ANZSES/AuSES- WA State Committee 1978 – 2011, starting as Hon Secretary from 1978 to 1989 and was on the Steering Committee for the ISES World Congress in Perth in 1983. He developed the Solar Energy Information Centre which was the headquarters of ANZSES 1989 – 1993 (now Heritage Listed). In mid 1980s he was a founding member of Formed the Buildings Group with the late David Oppenheim, Trevor Lee, David Baggs, Deo Prasad, Prof John Ballinger, Dr Steve Szokolay and others (including Prof David Mills). From 2001 – 2004 he co-ordinated the Australian submission with Prof David Mills for the 50th year ISES history for Australia and authored both chapters in the 2 part volumes. From 2009 onwards he was the President of WA committee. In 2020 he founded the Clean Energy Innovation Hub in Bayswater and the Thermal Inertia Storage Group collaborating with Murdoch University and UniSA. In his working life he has won numerous awards: Twelve WA Home of the Year Awards, along with numerous MBA, James Hardie innovation awards in the 1990's, HIA GreenSmart Awards. He has two Awards of Merit and numerous Commendation Awards from the Royal Australian Institute of Architects (RAIA). In 2006 Garry was awarded an Order of Australia (AM) for his contribution to architecture and energy efficiency education. On the 27th November, 2007 he was awarded a Life Fellowship with the Australian Institute of Architects (AIA) for his long-term commitment to the profession.



Elliot Berman

Country: United States

Year joined industry: 1968

Company first worked for: Itek Corporation (Solar Power Corporation)

Technology area: PV

Still active in the industry: Yes

In 1968 Elliot Berman founded Solar Power Corporation. In 1970 the company was funded by Exxon to carry out a photovoltaic research program with the goal of a \$.50/peak-watt solar cell based on organic semiconductors. At the same time, they studied the possibility of a commercial business based on sales of silicon solar cells for terrestrial applications. Their commercial market study suggested that a modest market existed with solar modules selling for \$20/peak-watt. In their hands, this required a manufacturing cost of \$10/peak-watt. Based on the Chapin Patent, they developed systems able to meet their cost goals. Important markets included Navigation Aids, Microwave Relay Stations, Educational TV. The research program was able to achieve an efficiency of 1%. The availability of organic semiconductors with "good" conductivity was limiting. From 1979-1990 Elliot was Chief Scientist at ARCO Solar.



Emmanuel Fabre

Country: France

Year joined industry: 1969

Company first worked for: Philips Subsidiary RTC (Radiotechnique-Comeplec)

Technology area: PV

Still active in the industry: No

Dr Emmanuel Fabre joined the research department of the Philips subsidiary Radiotechnique-Compelec (RTC) in 1969. He spent a year at the Philips laboratories in the USA (New Your State). From 1973-74 most of his time was spent on PV research liaising with then solar cell production plant in Caen, France. In 1981 the Philips RTC solar business was merged into Photowatt and Dr Fabre became the Scientific Director of Photowatt. He was one of the founding directors of EPIA and served as president twice. When Photowatt was acquired by Chronar he stayed and was appointed chairman. In 1998 when Photowatt was bought back then he became Executive Director of Chronar France . When Chronar corporation collapsed NAPS acquires Chronar France and Dr Fabre became managing director the role he maintained until he retired in 2007.



Roger Little

Country: United States **Year joined industry:** 1969

Company first worked for: Spire Corporation

Technology area: PV

Still active in the industry:

Roger Little founded Spire Corporation in 1969 and served as the Company's Chairman, Chief Executive Officer and President until Dec 2013. Spire corporation initially manufactured solar cells for space and then terrestrially however it moved into the business of the manufacturer and supplier of the equipment required for manufacturing of solar cells and modules and the associated testing equipment . The company offered turnkey project solutions to support the solar module manufacturers in establishing their manufacturing facilities. Roger was the face of Spire and was personally active in promoting the company at shows etc. He was also active on many committees related to PV and serving as president of the US Solar Energy Industry Association in the early 1990's. After retiring continued to serve as Chairman of the Board of Directors of the Company.



Derrick McDiarmid

Country: Zimbabwe

Year joined industry: 1968

Company first worked for: Solamatics

Technology area: Solar Thermal and Solar PV

Still active in the industry: Yes

Derrick McDiarmid began manufacturing solar water heaters under licence to Beasley Industries (Australia) in 1968. This led to the formation of Solamatics which continues in this field today. As PV became commercially viable, Derrick pursued opportunities for involvement in this field and installed a 3kW system for a rural hospital, and several PV pumping systems in 1983/4. In 2008 the PV activities had grown sufficiently that a separate company was formed (Ultimate Power Solutions) to provide better focus for the two activities. Derrick has been involved in developing standards in South Africa and Zimbabwe, and has attended ISES conferences in 1979,81,83,87,91,93,95 (as conference organiser), 2001, 2003. Under Derrick's guidance Solamatics, with Danish Aid funding developed a PV vaccine refrigerator to WHO approval, and has installed several large institutional solar water heating systems in cooperation with a Danish company - Arcon Solvarme. Currently Derrick provides design guidance and consultancy for larger scale solar water heating systems for Solamatics and design for domestic, commercial and off-grid systems for Ultimate Power Solutions. He is a Member of the Zimbabwe Institute of Engineers (retired), was a founder member of the Solar Energy Society of Zimbabwe (formed in 1974, but now defunct), and the initiator in the formation of the Solar Energy Industries Association of Zimbabwe in 1984.



Stanford Ovshinsky

Country: United States

Year joined industry: 1960

Company first worked for: Energy Conversion Devices

Technology area: PV

Still active in the industry: No

Born 1922 in Ohio, Stan Ovshinsky only completed high school education and initially pursued a career as machinist in car tyre mould factory. He explored ways to harness the sun; 1979 began streamlining mass production of inexpensive amorphous silicon solar panels [US Patent No. 4,519,339]. In 1960 he started Energy Conversion Devices and soon after, his inventions drew widespread attention. At the time of his death, Stan held more than 400 patents. In 1982 he told researchers in his lab that experimental battery presented to him in a beaker would one day power an energy-efficient car; his Nickel–Metal Hydride (NiMH) [US Patent No. 4,623,597] has powered electric and hybrid vehicles since the early 2000s. The wholly-owned subsidiary, United Solar Ovonic (Uni-Solar), was the first, and at one time the world's largest, producer of flexible solar panels. Panels were made of 11 triple junction amorphous silicon solar cells connected in series with 11–13% in conversion efficiency, and encapsulated in ETFE, high light-transmissive polymer. These 'solar shingles' were manufactured in rectangular strips with wiring at one end, glued to any suitable supporting surface and used on roofs, motorhomes, semi-trailer cabs and similar applications. In 1998 Ovonic NiMH batteries were used in Chevrolet S-10 EV and 1999 General Motors EV1, many other hybrid vehicles in production today. ECD sold its subsidiary, Ovonic Battery Company, in 2012 to BASF Corporation. In 1999 Stan was honoured with ISES Karl Boer Solar Energy Medal of Merit, and as Hero for the planet by Time Magazine while in 2005 he was inducted into the US-based Solar Energy Hall of Fame. He was a Fellow - American Physical Society and American Association for the Advancement of Science, and received Diesel Cold Metal Medal (Germany), Coors American Integrity Award, Toyota Award for Advancement and three honorary doctorates.



Wolfgang Palz

Country: Germany

Year joined industry: 1970

Company first worked for: French National Space Agency

Technology area: PV

Still active in the industry: Yes

Wolfgang Palz's first academic thesis in 1963/65 was on PV. He was a professor for Semiconductor physics in Nancy France from 1965 to 1970. In 1970 he joined the French National Space Agency CNES as a solar expert in charge of power system development. During this period Palz was active with solar projects in French speaking African countries including the installation of solar water pumping systems. In 1973 he was the co-organiser of the Paris UNESCO Congress "The Sun in the Service of Mankind". In 1977 he joined the EU commission in Brussels, and he managed the Renewable Energy development programmes until 1997. During that 20 years he oversaw almost \$1 billion in projects to industry and academia. The R & D programme covered a wide variety of renewable energy projects including Solar Architecture, Solar energy, Wind Energy, Biomass and ocean energy. During this time, he also took the lead in promoting the establishment of the European PV Industry Association (EPIA), the European PV conferences and was a supporter of the fledgling PV industry in Europe. He was instrumental in establishing the prestigious Becquerel Prize awarded to those who made major contributions to the science, technology or application of photovoltaic solar electricity. In 1997 he became a member of the EU Commission Council for renewable energy deployment in Africa. From 2000-2002, Palz was a member of an energy committee of the German Parliament that established the energy strategy for Germany to the year 2050. After leaving the commission he worked as a consultant on projects in Latin America. He has been an active participant on many organisations including being chairman of the World Renewable Energy Council. Palz has been recognised in many awards including Order of Merit of Germany and the Becquerel Prize (2003). He has been the author of many books with his first in 1978.



Peter Varadi

Country: United States

Year joined industry: 1968

Company first worked for: Communication Satellite Corporation (COMSAT)

Technology area: PV

Still active in the industry: Yes

Peter F. Varadi after a scientific career in 1968 was appointed head of the Communication Satellite Corporation's (COMSAT) chemistry laboratory in the USA. In this function he also participated on research in photovoltaic (PV) solar cells, which were used to power the satellites. In 1973 he co-founded SOLAREX Corporation, Rockville, MD (USA) to develop the utilization of solar cells (PV) for terrestrial applications. SOLAREX was one of the two companies which pioneered this field. By 1983 it became the largest PV Company in the world having manufacturing plants in USA, Europe, Asia and Australia, when it was sold to AMOCO. Since then he continued consulting 10 years for Solarex, after that for the European Commission, The World Bank, NREL, etc.. In recognition of his lifelong service to the global PV sector and his continuing commitment striving for excellence in the PV industry, he received in 2004 the European Photovoltaic Industry Association' (EPIA) (now SolarPower Europe) John Bonda prize. His book "Sun above the Horizon" (published in 2014) describes the history of the terrestrial utilization of solar cells (PV) from its beginning until it became a part of the world's electricity generating systems. His following books ("Sun towards High Noon" published in 2017 and "The Sun is Rising in Africa and the Middle East" published in 2018) narrates how PV became one of the world's major electricity generation systems.



Herbert Wade

Country: United States

Year joined industry: 1963

Company first worked for: Eppley Laboratory, Newport RI

Technology area: Solar measurement, solar thermal for home heating, PV both off and on grid

Still active in the industry: Yes

In 1963 Herb Wade began at the Eppley Laboratory helping design and calibrate pyranometers and pyrhemometers for various research applications. In 1972 he moved to Arizona and teamed with Jeffrey Cook at ASU in the design of Passive Solar Homes and small-scale solar heating for housing. In 1976 he was selected to work as the Deputy Director of the Arizona Solar Energy Research Commission. In 1978 he was selected to establish and manage the Renewable Energy Division of the Missouri Department of Natural Resources. In 1982 he was selected as Deputy Director of the Fiji Department of Energy then in 1983 Director of Fiji Department of Energy. In 1984 he became Deputy Director of the UN Pacific Energy Development Programme focusing on renewable energy and energy efficiency. In 1989 he became Program Manager for the South Pacific Institute of Renewable Energy (Tahiti). In 1993 he was the Developer of short courses in renewable energy at the Asian Institute of Technology, Thailand and in 1996 became the program manager for the Naresuan University Solar Energy Research and Training Center (SERT). Since 2003 he has been a freelance consultant in renewable energy in 32 countries focusing mostly on Pacific Islands and SE Asia. In 2020 he is still continuing in that position based in Bangkok.



Jim Were (Deceased)

Country: Cyprus/Australia

Year joined industry: 1965

Company first worked for: Solar Aspect Ltd in Cyprus

Technology area: Solar Thermal/commercial scale solar water heating

Still active in the industry: No

Jim Were was a Building Services Engineer with wide experience in charge of design, supervision and installation of major projects in New Zealand, United Kingdom, North and West Africa and the Middle East. Jim was co-founder of Solar Aspect Ltd. formed in Cyprus to design, develop and produce high performance solar collectors and active hot water systems, refrigerant superheat reclaim systems, residential space heating and passive solar procedures. In Australia from March 1986, Jim was involved in surveying and correcting the operation of troublesome air-conditioning systems in Commonwealth non-residential and ACT Education buildings, for optimum effectiveness and fuel efficiency, and contract administration of mechanical services installation in a Melbourne central business district high-rise. Until the Program's termination, Jim Were was approved under the Enterprise Energy Audit Program to certify that energy audits undertaken by Energy Partners had been properly conducted. He was an experienced and accredited assessor for the Australian Capital Territory - House Energy Rating Scheme (ACTHERS). James Saunders Were, born in New Zealand 28 September 1929, died in Canberra, Australia, 20 March 2007, Life Member of the American Society for Heating, Refrigeration and Airconditioning Engineers.



John Yerkes (1934-2014)

Country: United States

Year joined industry: 1967

Company first worked for: Spectrolab

Technology area: PV

Still active in the industry: No

John William (Bill) Yerkes after an early career at Chrysler and Boeing joined Spectrolab in 1967, one of the first U.S. producer of solar cells and panels for space applications. Yerkes served as president-CEO and oversaw development of the solar array that Apollo 11 left behind on the moon. When Spectrolab was purchased the new owners let Yerkes go and he founded Solar Technology International (STI) in 1975. They worked on reducing the cost of manufacturing and developed a simplified method for screen printing the silver metal contacts used to interconnect the cells and extract electric current from them. STI was eventually bought by oil giant Atlantic Richfield and became, ARCO Solar. During Yerkes' tenure running the ARCO PV unit, it became the world's largest solar company, with modules shipped to and deployed in every major region of the globe. Yerkes left ARCO in 1985, and founded Yerkes Electric Solar that worked on cadmium telluride solar cells. He then returned to Boeing and he led the establishment of Boeing's High Technology Center in Bellevue, WA, which developed gallium-arsenide solar cells. He went on to work as power systems manager for Teledesic, a startup that produced 1,000 low-Earth-orbit satellites for internet telecommunications. In 2005, he cofounded Solaicx in California and Oregon, where he developed a proprietary high-efficiency, low-cost silicon-crystal-growth technique for solar cells." MEMC the parent company of SunEdison, bought Solaicx in 2010.



Amnon Yogev

Country: Israel

Year joined industry: in the 1964

Company first worked for: National Physical Laboratory (in 1967 he moved to Weizmann Institute)

Technology area: Solar Thermal

Still active in the industry: No

In 1967 - 2003 Amnon Yogev served as a senior researcher and professor member of the Weizmann Institute. Yogev engaged in research in Solar pumped laser with three-stage solar concentration: The Weizmann Institute's solar tower, a three-dimensional non-simulating center and a two-dimensional non-simulating center. He later initiated the construction of the solar tower at the institute, and headed a group that studied solar-powered lasers. The research led by Yogev had research partners on a sabbatical from Rotem Industries. Over the years, there has been an exchange of researchers from the Yogev Group with the Roland Winston Group at the University of Chicago. Research achievements included peak power Laser-solar sunbeams in the visible field. In the 1990's, Yogev was a member of the Association Committee of the Office of the Chief Scientist of the Ministry of Industry and Trade. In 1995, Yogev initiated and established the Consolar Consortium for Concentrated Solar Energy as part of a bilateral agreement between Israel and the United States and the incorporation program of the Office of the Chief Scientist of the Ministry of Industry and Trade. Yogev headed the association from its establishment in 1995 until the end of its activity in 2000, and was a research partner for projects that were conducted in it. Consul Consort had members from academia, Israeli industry and American industry. The consul had a number of joint projects, with the Weizmann Institute being a partner in all the projects and erecting the solar tower for this purpose. The projects included, among others: a field of heliostats, an original transparent pyrex receiver to heat compressed air to high temperature (about 1000 degrees Celsius) a turbogenerator using the hot air to drive a generator Consolar included the Weizmann Institute, Boeing, Rotem and Ormat. US Patent 3,842,593 (1973) Closed Rankine Cycle Power Unit.

7. 1970-1979

7.1 ISES 1970-1979

1970

- The Society's first International conference was held in Melbourne, Australia.



Figure 11: Roger Morse (Australia), Jack Duffie (USA), Taro Hisada (Japan) and Julio Hirschmann (Chile) examine a solar water heater at Melbourne, 1970

- The Society changed its name to the **International Solar Energy Society (ISES)**.
- American Section was formed.
- ISES headquarters moved from the USA to Australia.

1971

- First issue of ISES News featured the new headquarters.



Figure 12: Frank G. Hogg (Australia), Secretary-Treasurer of ISES from 1970 to 1985, and editor of ISES News

- Peter Glaser became Editor of Solar Energy, produced by Pergamon Press.

1972

- ISES participated in the United Nations Conference on the Human Environment in Nairobi, Kenya.
- Professor Brian Brinkworth (UK) published the seminal book, *Solar Energy for Man*.

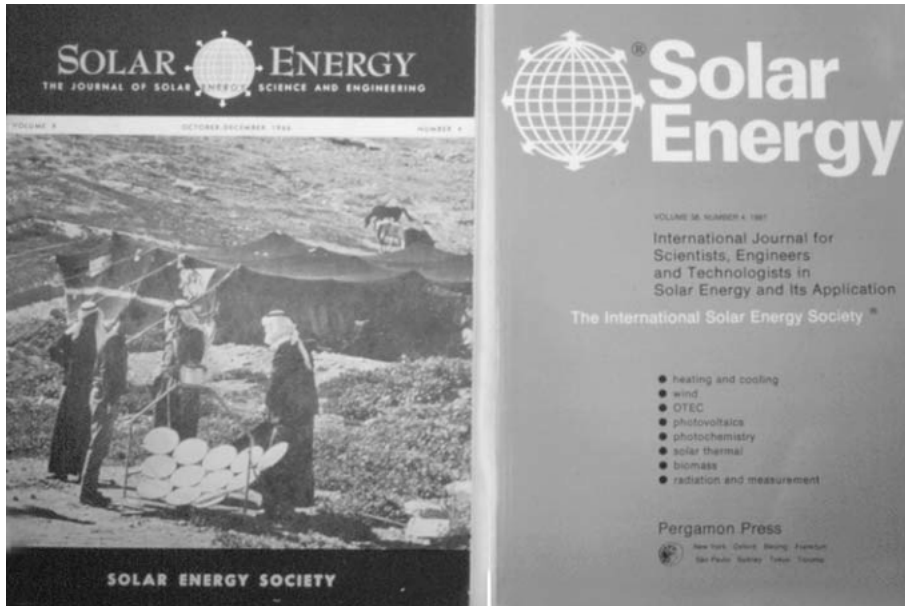


Figure 13: New design of Solar Energy, instituted by Andy Drumond, on right. Old cover design is on left

1973

- The oil crises of 1973 and related issues contributed to growth in ISES membership.
- A major function of ISES was to facilitate communications among the membership, with the aim of making solar energy Research and Development (R&D) as effective as possible.
- Total membership went from 703 in 1970, to 815 in 1973, to 4,126 in 1975, to 8,854 in 1979.



Figure 14: Membership Growth 1970-1980

- The Japanese Section was formed.
- Karl Böer and Maria Telkes completed the Solar One house in Delaware.
- ISES participated in the UNESCO Summit, *Sun in the Service of Mankind*, held in Paris in July.
- Dr Mary Archer and Professor John Page founded the UK Section.

1974

- The South Africa and French Sections were formed.

1975

- The frequency of *ISES News* was increased to quarterly, and expanded to eight pages
- The proceedings of conferences were published after each biennial meeting.
- The Dutch Section was formed
- The first ISES award, the *Farrington Daniels Award*, was awarded to Professor Hoyt Hottel.

1976

- The *Solar Energy Journal* had six issues (380 pages) rather than four.
- *SunWorld*, the replacement for the *Sun at Work* (which ceased in 1967) was started with Everett Howe and Yvonne Howell as editors.
- The following Sections were formed: Israel, Ireland and Scandinavia.

1977

- The Arab, German and Belgian and South African Sections were formed.
- The second *Farrington Daniels Award* went to Dr. Valintin Baum (USSR).

1978

- *Solar Energy Journal* began to be published monthly.

1979

- ISES celebrates its Silver Jubilee at the Solar World Congress in Atlanta, USA.
- Professor Felix Trombe was the third recipient of the *Farrington Daniels Award*.
- The Canadian and Finish Sections were formed.
- China Solar Energy Society was founded.



Figure 15: Wall ReadCSIRO, Bill Charters Uni of Melbourne, Jack DuffieUniv of Wisconsin and Roger Morse CSIRO

The four people in Figure 15 were each ISES Presidents at some stage during their careers.

1977

- The Arab, German and Belgian and South African Sections were formed.
- The second Farrington Daniels Award went to Dr. Valintin Baum (USSR).

1978

- Solar Energy Journal began to be published monthly.

1979

- ISES celebrates its Silver Jubilee at the Solar World Congress in Atlanta, USA.
- Professor Felix Trombe was the third recipient of the Farrington Daniels Award.
- The Canadian and Finish Sections were formed.
- China Solar Energy Society was founded.



Figure 16: The first board of China Solar Energy Society (1979, Xi'an, China)

Table 7: Officers of SES 1970-1971

Years	President	Vice President	Secretary or Secretary / Treasurer	Executive Officer or Asst Treasurer
1970-71	R. N. Morse	J. A. Duffie	F.G. Hogg	

Table 8: Officers of ISES 1971-1979/80

Years	President	Vice President	Secretary or Secretary / Treasurer	Executive Officer or Asst Treasurer
1971-72	J. A. Duffie	G. T. Ward	F. G. Hogg	
1972-73	J. A. Duffie	G. T. Ward G. O. Löf	F. G. Hogg	
1973-74	G. O. G. Löf	W. H. Klein M. Perrot	F. G. Hogg	
1974-75	G. O. G. Löf	W. H. Klein F.H. Morse	F. G. Hogg	
1975-76	W. H. Klein	R. L. Datta J. A. Eibling	F. G. Hogg	
1977-78	R. L. Datta	W. W. S. Charters F. H. Morse	F. G. Hogg	W. H. Klein (asst. treas.)
1978-79	R. L. Datta	W. W. S. Charters F. H. Morse	F. G. Hogg	W. H. Klein
1979-80	W.W.S. Charters	E. D. Howe H. Tabor	F. G. Hogg	W. H. Klein

Table 9: Conferences and Meetings 1970-1979

Year	Location	Overview
1970	Melbourne Australia	1970 ISES Conference Australia General Chair: R. N. Morse; Conf. Organizer: F. G. Hogg Approx. 190 attended; 62 papers
1971	Greenbelt USA	Goddard Space Flight Centre General Chair: W. R. Cherry 180 attended, 40 papers
1973	Paris France	Theme: <i>The Sun in the Service of Mankind</i> Organised jointly with AFEDES and COMPLES General Chair: P. Auger Approx. 600 registrants, 300 papers, 60 countries represented
1975	Los Angeles USA	Theme: <i>Solar Use Now; a Resource for People</i> General Chair: E. L. Ralph; Program Chair: J. A. Duffie Nearly 2,000 registrants, 280 papers Farrington Daniels Award: Professor Hoyt C. Hottel (USA)
1977 but held January 1978	New Delhi India	Theme: <i>Mankind's Future Source of Energy</i> Secretary: J. Gururaj, Program Chair: Frank de Winter 1,100 registrants, 342 papers Farrington Daniels Award: Professor Valentine A. Baum (Russia)
1979	Atlanta USA	Theme: <i>Silver Jubilee Congress</i> General Chair: W. Shropshire, Program Chair: W. A. Beckman 2,000 registrants, 430 papers Farrington Daniels Award: Professor Félix Trombe (France)

7.2 ISES Presidents 1970-1979

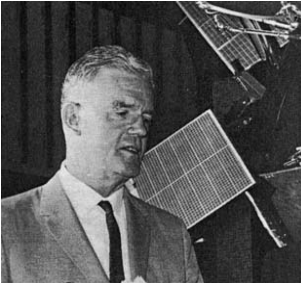


Figure 17: Roger Morse, President 1969-1971

Roger Morse

Roger Morse (Australia) was born in 1914 and passed away in 2003. He was educated at the University of Sydney, Australia and gained experience in the industry before his service with the Australian army in Papua-New Guinea during World War II. He was responsible for establishing the Engineering Section — later to become the Division of Mechanical Engineering — of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and led its work on air conditioning, refrigeration, and solar energy applications. He was largely responsible for the work that led to the development of the solar water heater industry in Australia. A very practical, hands-on engineer, he could see in a minute what constituted a good or bad solar heater design. He attended the AFASES conference in 1955. In 1964, when AFASE became the Solar Energy Society he became a Board Member. He was Chair of the ISES Solar World Congress in Melbourne in 1970 and was the first Chair of the first section of the society, the Australian- New Zealand section, formed in 1962.



Figure 18: Jack Duffie, President 1971-1973

Jack A Duffie

Jack Duffie (USA, a chemical engineer by training, established the Solar Energy Laboratory in the College of Engineering at the University of Wisconsin and was its Director until he retired in 1988. With Bill Beckman and Sandy Klein, he wrote a series of books on the engineering of solar processes. He was on the SES and ISES Boards for many years and served as Editor-in chief-of the ISES Solar Energy journal for eight years from 1985 until 1993.

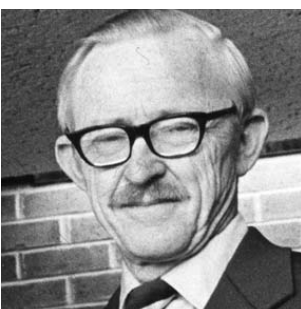


Figure 19: George Oscar Löf, President 1973-1975

George Löf

George Oscar Löf (USA) was a chemical engineer and inventor. He graduated from the University of Denver in 1935 and did his PhD in chemical engineering at the Massachusetts Institute of Technology in 1940. Löf became interested in solar energy at MIT, where he worked under Hoyt C. Hottel. Löf taught chemical engineering at the University of Colorado and the University of Denver before serving on the faculty of Colorado State University in the civil engineering department from 1967 - 1987. He founded the university's Solar Energy Applications Laboratory in 1972. Löf received the Charles Greeley Abbot Award, given by the American Solar Energy Society in recognition of contributions in the solar energy field. 1943, Löf designed an early flat-plate solar heating unit and installed it on the roof of his house in Boulder, Colorado. It was called the «first solar-heated home» in the United States.



**Figure 20: William Klein,
President 1975-1977**

William (Bill) Klein

Bill Klein (USA) was a plant pathologist and Director of the Smithsonian Radiation Biology Laboratory in Bethesda, Maryland. Educated in the USA, Klein started his career with the Smithsonian in 1951. He was associated for many years with the classical work on solar radiation measurements of C. G. Abbot and developed an international network of stations measuring solar and ultraviolet radiation.



**Figure 21: R.L. Datta,
President 1977-1979**

R. L Datta

R. L. Datta (India) was educated in India and England, with degrees in Chemistry and Applied Chemistry. He studied separation processes at the Max Planck Institute in Germany and worked at the Central Salt and Marine Chemicals Research Institute in India. His contributions to solar energy R&D were in the field of salt production by solar evaporation, solar distillation, solar ponds, and space cooling. He was active in a wide variety of energy agencies, including as chairman of the All-India Solar Energy Working Group, Convener of the Energy Research Committee of CSIR (the government of India), Member of the ad hoc Committee of the USA Academy of Sciences for Solar Energy for Developing Countries, and others.



**Figure 22: William
Charters, President
1979-1981**

William (Bill) Charters

Bill Charters (Australia) received his early education in China and Australia, followed by university degrees from England and the USA, where he earned a Master's in Mechanical Engineering from Princeton. He had industrial and military experience in engineering R&D and worked in Trinidad and in Canada at the Brace Research Institute of McGill University. He held a personal chair in the Department of Mechanical and Manufacturing Engineering at the University of Melbourne from 1992 to 2000 and was Dean of the Faculty of Engineering from 1988 to 1997. His work on solar thermal systems and solar vapour compression heat pumps resulted in a number of patents and earned him several awards including the CSIRO Research Medal. For over 25 years Charters was a consultant to governments and international agencies, including the United Nations, on ecologically acceptable and environmentally viable energy solutions. He was a Fellow of the Institution of Engineers Australia. He and his research group in Melbourne have contributed in collector design, heating and cooling systems, and heat transfer problems relating to solar energy processes.

7.3 PV 1970-1979

Though total production is small, many companies started manufacturing PV cells and modules predominantly driven by the oil crises of 1973. Solar cells began to power navigation warning lights and horns on many offshore gas and oil rigs, lighthouses, railroad crossings and telecommunication systems. The household solar applications are viewed as sensible applications in remote locations where connection to the utility owned power grid is not economical.

1970

- Soviet team led by Zhores Alferov developed the first highly effective GaAs heterostructure solar cells.
- **Institute of Physical Electronics (IPE)** was established at Stuttgart University by Werner Bloss and his team of 15 scientists.

1972

- The **Institute of Energy Conversion** was established at the University of Delaware to perform research and development on thin-film photovoltaic (PV) and solar thermal systems, becoming the world's first laboratory dedicated to PV research and development. First director is Professor Karl Böer and he steps down as director in 1975 to work full time at SES Incorporated which he founded in 1973. After a 12 month search Dr Allen Barnett is appointed the next full time director of IEC .

1973

- From 1969 Dr. Elliot Berman had designed solar cells using lower grade silicon than those being used in space and brought the price down from \$100 a watt to \$20 a watt by 1973. Solar Power Corporation was established by Dr Elliot Berman with finance by Exxon. The company started commercial business in 1973, when a sales office in Braintree, Massachusetts was opened.
- Dr Joseph Lindmayer and Peter Varadi founded the **Solarex Corporation** in Rockwell, USA.
- Karl Boer founded **Solar Energy Systems (SES Incorporated)** in Newark, USA.
- The University of Delaware built "Solar One," one of the world's first photovoltaic (PV) powered residences. The system is a PV/thermal hybrid. The roof-integrated arrays fed surplus power through a special meter to the utility during the day and purchased power from the utility at night. In addition to electricity, the arrays acted as flat-plate thermal collectors, with fans blowing the warm air from over the array to phase-change heat-storage bins. It was also the first instance of building integrated photovoltaics (BIPV).
- Skylab was powered by solar cells.
- **Philips RTC** pilots terrestrial PV Cells and Modules.
- **Tideland Signal Corporation** (Houston) was approached by **Solar Power Corporation** and developed a solar power buoy. **Tideland** had 30% of the battery light market, **Automatic Power** which had a solar patent had 70% of the battery light market that were being used on buoys and oil rigs at that period of time. The solar powered buoy became very popular by end of the 70's.

1974

- The establishment of the **Solar Energy Research Institute (SERI)** was approved by the US Government though it would not open officially until 1977. This is the forerunner for the **National Renewable Energy Laboratory (NREL)**.
- Japan launched "Project Sunshine", a broad R&D program in solar energy. The goal was to produce new sources of clean energy by the year 2000. This encourages many of the large Japanese electronics manufacturers to start PV research and development over the next few years.
- **Solar Power Corporation** convinced **Southern Railway** to trial a solar module powering a crossing signal in Rex, Georgia. The railways were convinced when during winter grid power failed due to ice build-up on the wires while the solar was still working.
- John Oades, a microwave system engineer with **GTE Lenkurt** (subsidiary of GSTE), built a low powered microwave repeater and demonstrated the first one using solar power with the support of his boss Bill Hampton. The first unit was bought by the **Navajo Communications Corporation** to connect to a community in Mexican Hat Utah. Over the next 6 years 1000 units are sold.
- Professor Martin Green joined **University of New South Wales (UNSW)** (Australia) and started research on solar cells and the research group years later became what is now known as **UNSW School of Photovoltaic and Renewable Energy Engineering (UNSW-SPREE)**.

1975

- **The Florida Solar Energy Center (FSEC)** was established as the state's energy research institute. FSEC later becomes a world leader in solar energy research.
- **Solec International** was established by Ishaq Shahryar.
- The American government encouraged **JPL Laboratories** to conduct research in the field of photovoltaic systems for application on Earth.
- Bill Yerkes started **Solar Technology International (STI)**.
- **Lucas Industries (UK)** entered solar market.
- **Kyocera Corporation** began research into solar power technology, led by Kazuo Inamori.
- **Panasonic** started research and development of amorphous solar cells.
- **Sanyo**, under the guidance of Yukinori Kuwano, became involved with PV focussing first on amorphous silicon under the brand **Amorton**.
- **Total** (French oil company) buys majority share of **Photon Power** (based in El Paso Texas) and established a pilot production plant for Cadmium sulphide solar cells in partnership with **Libbey-Owens-Ford** (US glass company).

1976

- David Carlson and Christopher Wronski, **RCA Laboratories**, fabricated the first amorphous silicon photovoltaic cells which had an efficiency of 2.4%.
- Solec International was established by Ishaq Shahryar.
- The idea of fluorescent photovoltaic cell is independently developed by German scientists Adolf Goetzberger, W. Greubel, W.H. Weber and J. Lamb.
- **Telecom Australia** were mandated to provide phone service to everyone in Australia. Senior Power engineer Arnold Holderness came across solar at **Sharps** headquarters in Japan in 1975 but the price was too high. With \$20 per watt from the USA, Michael Mack from Telecom found it was cost effective to start the roll out of solar power phones across the country.
- Zoltan Kiss founded **Chronar Corporation** in New Jersey, USA.
- Guy Smekens, Spigniew Szawlowsky and Rene Grosjean established the PV company **Energies Nouvelles at Environnement (ENE)** in Brussels.

1977

- The U.S. Department of Energy opened the **Solar Energy Research Institute (SERI)** as a Federal facility dedicated to harnessing power from the sun.
- Total photovoltaic manufacturing production exceeded 500 kilowatts.
- **NASA LeRC** commenced implementing photovoltaic systems in six meteorological stations in different locations within USA. NASA LeRC introduced additional trial demonstration projects.
- In the American Indian reservation, Papago Indian Reservation located in southern Arizona, **NASA LeRC** constructed a 3.5 kW PV system - the first system ever to satisfy the demands of the entire village. It was used for water pumping and power supply of 15 households.
- Captain Lloyd Lomer from **USA Coast Guard** had previously installed a demonstration solar unit on a buoy in Alaska to prove solar would work on navigational buoys. In 1977 he obtained funding to commence solarizing the Coast Guards Installations.
- **AEG Solartechnik** (Germany) started their terrestrial business after providing cells to satellites.
- Atlantic Richfield acquired **Solar Technology International (STI)** and STI becomes **ARCO Solar**.

1978

- The first solar-powered calculator is released.
- Environmental Protection Agency (EPA) outlawed dumping batteries in Ocean and therefore both **Automatic Power** and **Tideland Signal Corporation**, began supplying solar lights to the oil rigs in the gulf and around the world. Note, other Solar Navigational Light Manufacturers of the time included **Integrated Power** and **Orga**.
- Leroy-Somer (French electrical conglomerate) invested in Solarex and commenced the jointly owned subsidiary **France Photon** managed by Alain Ricaud.
- **Telecom Australia** constructed their first large scale solar powered telecommunications system with thirteen (13) solar powered repeaters 40kms apart from Tennant Creek to Alice Springs in the Northern Territory. From this success Telecom went on to build seventy similar projects with the longest being 2420 kilometres using forty-three (43) repeaters spaced 57kms apart.

1979

- **ARCO Solar** of Camarillo, California, built the biggest solar cell and photovoltaic module production plant (1MW) at that time.
- In Mt. Laguna, California, a trial 60 kW hybrid diesel-photovoltaic system was built as a power supply for a radar station.
- **Strategies Unlimited** is founded by John Day and it became the primary reference source on development and status of terrestrial solar industry over the following decades.
- **Lucas Energy Systems** is formed.

Dates Unknown

- **IES-UPM** (Instituto de Energia solar at Universidad Politecnica de Madrid) (Spain) under Professor Antonio Luque stated work on PV in late 1970's.
- **Stanford University** Professor Dick Swanson led research on Silicon solar cells from late 1970's.

7.4 Solar Thermal 1970-1979

In 1977 the International Energy Agency Solar Heating and Cooling Technology Collaboration Programme (IEA SHC) started and one key activity has been the presentation of the market data in the annual publication Solar Heat Worldwide. Solar Heat Worldwide was first published in the early 2000's, however, some countries were collecting data on the annual installed solar water panel installation capacity recorded in square metres (m²) since the 1970s. Over the last 10 to 20 years the IEA SHC has collected data on as many countries as possible along with doing estimates in some of the other countries. To show the growth in the industry this booklet will show in each decade the figures that have been collected by the IEA SHC. In the 1970's information was collected for Australia, Austria and USA only. Figures 23, 24 and 25 show the annual installation capacity for those three countries. These are shown on three separate graphs because the markets were different sizes and hence shows the growth in each market. (Note Canada data was obtained but only for 1979).

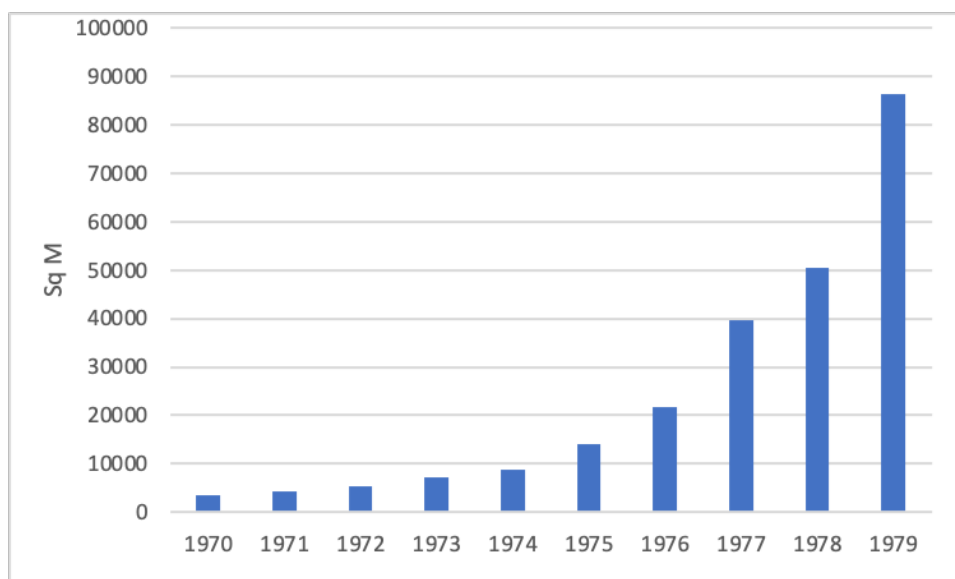


Figure 23: Australian annual installed solar water panel capacity 1970-1979

Source: IEA SHC

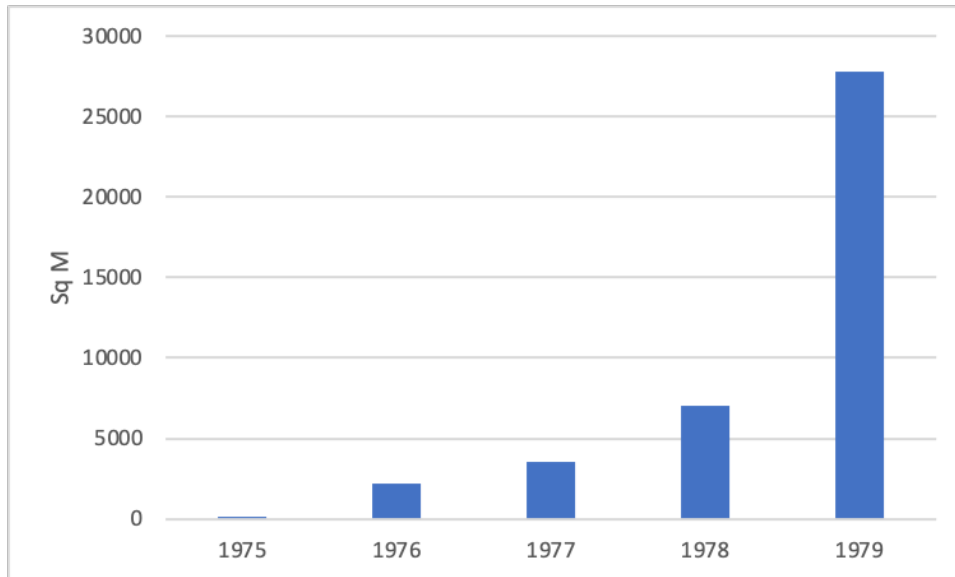


Figure 24: Austrian annual installed solar water panel capacity 1970-1979

Source: IEA SHC

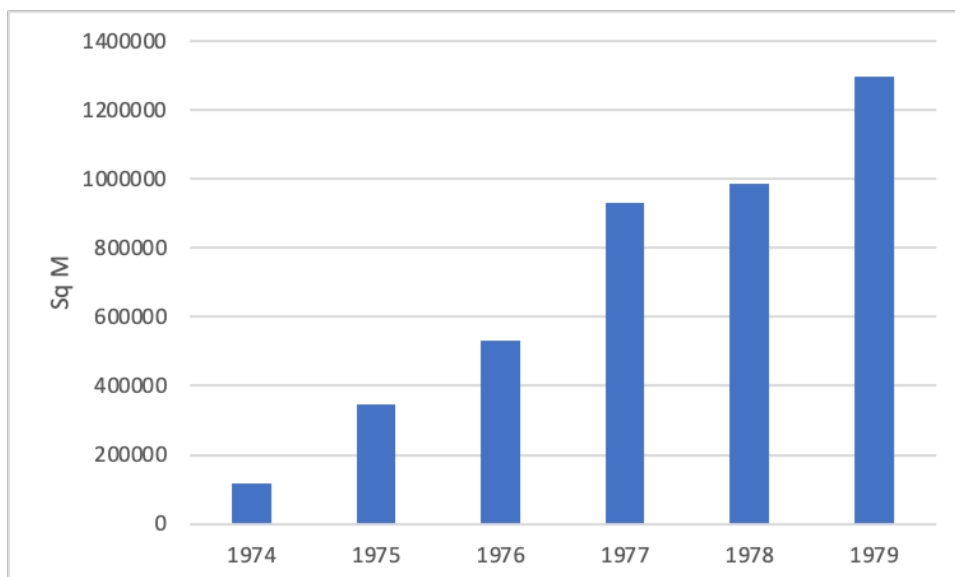


Figure 25: USA annual installed solar water panel capacity 1974-1979

Source: IEA SHC

1970s

- Bill Charters and colleagues at the University of Melbourne developed the solar boosted heat pump. The evaporator is an unglazed solar collector.

1974

- Duffie and Beckman published "Solar Energy Thermal Processes" first edition of a series of books to cover the engineering of solar thermal process.
- Development of TRNSYS (TRNSYS). 1975 marked the release of the first public version of TRNSYS, version 6. A method of simulation of solar processes and its application.
- Panos Lamaris establishes the 1st solar products manufacturing company in Greece and the European Union.

- **SOLE S.A.** produces the well-known solar water heater “Heliothermo”.
- George Löf oversaw the construction of a research house at Colorado State University that was the world’s first to also be cooled by solar energy.

1975

- Solar Thermal energy course for final year and Postgraduate students at UNSW commenced. At about the same time final year student at the University of Melbourne were also studying solar thermal energy.

1976

- First commercial demonstration in Australia of a 77 m² array (subsequently increased to 94 m²), with a 20 cubic metre thermal store was installed at Queanbeyan at a Coca Cola bottling plant.

1977

- Start of the International Energy Agency Solar Heating and Cooling Technology Collaboration Program. This International Collaborative Research program has completed more than 60 long term research tasks involving more than 20 countries worldwide. www.iea-shc.org
- Development and Demonstration Program’ for solar heating established in Denmark, leading to a large number of projects for the development of active and passive solar heating, including solar walls, as well as low-energy construction and storage technology, which paved the way for more commercial use of solar energy in the country. Source: <https://www.klimadebat.dk/handelsministeriets-program-1977-80-r336.php>
- **Calpak BP** (Greece), produce their Neo model, a thermosiphon system with a horizontal closed circuit tank.

1978

- The UK Solar Trade Association is founded, to represent the UK solar industry.
- The first central solar water heating system in a large hotel in Europe. This is “Marathon beach hotel” in Nea Makri-Attica-Greece.

1979

- The Greek Solar Thermal Industry Association EBHE is established.
- Founding of the Association of Danish Manufacturers of Solar Heating Systems (Dansk Solvarme).
- US President Jimmy Carter installs solar water heating on the Whitehouse.
- The Sunstrip absorber was first used in large collectors developed and used in an experimental building project with 2 900 m² roof-integrated collectors in Linköping 1979 Developed by Gränges, an old Swedish metal industry company, and later by Sunstrip AB, the Sunstrip absorber consisted of two aluminium sheets (about 150 mm wide) pressed together (in a rolling mill) with a copper pipe in between (diameter about 10 mm), and placed on a roll.
- Development of a selective surface for evacuated tube collectors by magnetron sputtering at University of Sydney Australia.
- Israel Requires all Buildings less than 10 storeys tall to include solar water heater. By 2005 an estimated 3% of Energy in Israel comes from solar water heaters.

7.5 CSP 1970-1979

1977

- The International Energy Agency (IEA) launched the Small Solar Power System projects – two 500 kW CSP projects – in Almeria, Spain, under an Implementing Agreement signed by 9 countries and lead by the US, Germany and Spain.
- The 1 MW CESA 1 project was initiated at the Plataforma Solar de Almería (PSA) in Spain, the site of the two IEA projects.
- CSP development in the US began with the opening of the US Department of Energy (DOE) and the creation of renewable energy incentives.

Late 1970s

- In the US, building on the Public Utility Regulatory Policies Act (PURPA) and the National Energy Act, which established policy and provided incentives for renewable energy development, States started offering incentives for renewable energy.

7.6 Solar Architecture Buildings 1970-1979

1973

- The University of Delaware, under the direction of Karl Boer and Maria Telkes, builds “Solar One,” one of the world’s first photovoltaic (PV) powered residences. The system is a PV/thermal hybrid. The roof-integrated arrays fed surplus power through a special meter to the utility during the day and purchased power from the utility at night. In addition to electricity, the arrays acted as flat-plate thermal collectors, with fans blowing the warm air from over the array to phase-change heat-storage bins. It is also the first instance of building integrated photovoltaics (BIPV).

1974

- Britain’s first active solar space heated house in Milton Keynes was opened.

1978

- MIT Solar V was erected in 1978 on the MIT campus and used as an experimental studio/classroom by the Department of Architecture. Unlike the first four solar houses, Solar V did not require mechanical equipment such as solar collectors, pumps or fans: all elements of solar heating were incorporated into the building materials.

1979

- Dr Doug Balcomb builds “Unit One” in Sante Fe New Mexico. 80%of its heating and cooling comes from Solar. It is known as “Unit One” because it is the first dwelling in a planned environmental community called First Village. Dr Balcomb was chair of American Solar Energy Society in 1979 and 1980.
- Steven Strong completed several passive solar buildings with integrated PV systems. This has become mainstream in the 21st century in particularly but not exclusively in the developed world.

7.7 PV in Developing Countries 1970-1979

Using solar to provide power, particularly lighting, for the billions of people without access to electricity was one of the first markets identified when the solar manufacturers started in the 1970s. One other key application was water pumping for the villages. The 1970s saw these markets being explored. International bodies like UNDP, EU Commission and others identify solar as a potential power source for unelectrified regions, in particular with d.c. solar home systems (SHS) that provided lighting and some services such as radio and sometimes television.

In the early 70s

- Yves Houssin from Paris was supplying school TV in villages in French speaking West Africa. To save having to replace batteries every few weeks he introduced solar power for charging the batteries.
- Patrick Jourde from the French Atomic Energy commission based in French Polynesia is given the task to provide electricity to the outer atolls and islands. **G.I.E. Solar** was established to assemble the components to provide solar power to a house including development of some energy efficient appliances. The systems sold from \$2000 to \$10,000 but there was a 20% subsidy and 5-year loans offered.

1973

- Dominique Campana, a graduate student in Paris in the 1970s, came up with the idea of applying solar cells to pump water. French physicist Jean Roger translated her concept into a working prototype on the Island of Corsica.

1976

- The **NASA Lewis Research Centre** started installing 83 photovoltaic power systems using solar modules produced by **Spectrolab** on every continent except Australia. These systems provided such diverse applications as vaccine refrigeration, room lighting, medical clinic lighting, telecommunications, water pumping, grain milling, and classroom television. The Centre completed the project in 1995, working on it from 1976-1985 and then again from 1992-1995.

Late 70s

- Father Bernard Verspieren had been running a mission in Mali and formed an NGO titled Mali Aqua Viva for providing wells for drinking water. After seeing the PV water pump in Corsica he introduced solar water pumping in Mali. The first system used Solar Power Corporation solar modules and pumps from Pompes Guinard. Later the pumps used were from Grundfos and the modules from many manufacturers.

1979

- In March 1979 Wolfgang Paltz organises on behalf of the EU commission a Governmental conference “The Sun in the Service of Development” in Italy. Regional seminars had been undertaken prior to the conference which raised the profile of solar as an option, these included:
 - Nairobi, Kenya in September 1978;
 - Bamako, Mali in September 1978;
 - Amman, Jordan in October 1978;
 - Caracas, Venezuela in October 1978; and
 - New Delhi, India in October 1978.

7.8 Research Pioneers 1970-1979



Bruce Anderson

Country: United States

Year Started Research: 1972

Title of Research: Solar Energy and Shelter Design

University: MIT

Still Active in Research: Yes

Bruce Anderson began his solar research career in 1973 with his MS thesis at MIT called “Solar Energy and Shelter Design.” He founded T.E.A. Inc (Total Environmental Action), which became one of the largest and best-known solar design, research, and education firms in the world. Among numerous other houses, beginning in 1975 the company built the Tyrrell House, the first house in the US to use the Trombe-Michel concrete passive wall; the first northern house to use Harold Hay’s passive water roof; the first house in the world to combine a version of Harry Thomason’s trickle roof system with several passive features (the “Goosebrook House”); and the “Brookhaven House”, a super-insulated passive “house for the masses” for Brookhaven National Laboratory. Its “Solar Home Design in Four Climates” won a national design competition in 1975 sponsored by the Research Corporation of the American Institute of Architects (AIA). The company’s research work began in 1976 with “Non-Conventional Incentives for the Adoption of Solar Buildings” for the National Science Foundation (NSF). Other examples include “Study of Photovoltaic Residential Retrofits” for US DOE; “Determination of the National Solar Bank Loan Table for Passive Solar Systems” for the US Housing and Urban Development Agency (HUD); and “Energy Saver Homes Point Rating System” for the Tennessee Valley Authority (TVA). His 1977 “Solar Energy: Fundamentals in Building Design” published by McGraw-Hill became a best-selling college textbook. The American Solar Energy Society honored him with its first “Outstanding Solar Contribution Award” in 1985. MIT Press published “Solar Building Architecture”, which he edited, volume 9 in the Series “Solar Heat Technologies: Fundamentals and Applications,” edited by Charles A. Bankston. Recently, Bruce co-invented a 1000°C solar heat platform and, as CEO of 247Solar Inc., is commercializing 247Solar Plants™, the platform’s first product. The Plants produce power and high-quality heat 24/7.



Steve Baer

Country: United States

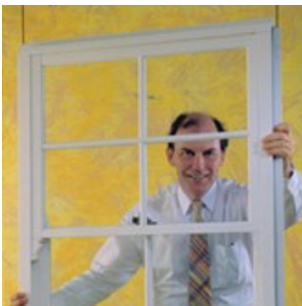
Year Started Research: 1975

Title of Research: The Zome House

University: In the field

Still Active in Research: Yes

Steve Baer (born 1938) is an American inventor and pioneer of passive solar technology. Baer helped popularize the use of Zomes. He took a number of solar power patents, wrote a number of books and publicized his work. Baer served on the board of directors of the U.S. Section of the International Solar Energy Society, and on the board of the New Mexico Solar Energy Association. He was the founder, Chairman of the Board, president, and Director of Research at Zomeworks Corporation. One of Zomeworks' inventions was the now-expired patented Beadwall, which consists of two sheets of glass with small styrofoam beads blown in the space between them by an air pump at night to insulate the window areas of the building (the beads being removed by vacuum action in the morning). The design is somewhat similar to the drum wall. Baer, Steve, Sunspots. Albuquerque, NM: Zomeworks. 1975 Baer, Steve (1977), "Corales Residence", Passive Solar Heating and Cooling: Conference and Workshop Proceedings, May 18–19, 1976, University of New Mexico, Albuquerque, New Mexico, Washington, D. C.: Energy Research and Development Administration: 200 Baer, Steve (1977), "Movable Insulation", Passive Solar Heating and Cooling: Conference and Workshop Proceedings, May 18–19, 1976, University of New Mexico, Albuquerque, New Mexico, Washington, D. C.: Energy Research and Development Administration: 70–72 Further details on Steve Baer's life and achievements can be found on the website https://en.wikipedia.org/wiki/Steve_Baer



John Ballinger

Country: Australia

Year Started Research/Industry: 1975

Title of Research: Experimental solar home at Broken Hill, New South Wales

University: University of New South Wales

Still Active in Research/Industry : No

Emeritus Professor John Ballinger, AM, FRAIA served as Professor of Architecture from 1993 to 1997, Head of School of Architecture 1990 to 1995 as well as chairman and founder of Solarch, National Solar Architecture Research Unit, from 1974 to 1996, all at the University of New South Wales (UNSW). He was also the inaugural Chairperson of the Australian and New Zealand Solar Energy Society (ANZSES) in 1985 and after almost a year chairing the interim management committee served for two subsequent full year terms as Chairman, having been elected unopposed on both occasions. Professor Ballinger subsequently served as the Society's Treasurer for a three year term ending in 1996. He was steward of the World Solar Challenge, the international solar car race from Darwin to Adelaide, around 3,000 km, from its inauguration in 1987 to 1993. In academia he was responsible for Solarch projects including the first experimental solar house in Australia and the first Solar Village in Australia, both in NSW. Solarch, in collaboration with industry, established the Australasian Windows Council which in turn initiated the Window Energy Rating Scheme (WERS) to complement the Nationwide House Energy Rating Scheme (NatHERS) which John also nurtured. NatHERS was immensely politically challenging due to the low level of inter-state consensus that pervaded the whole process. Before that, he served as chair of the Technical Advisory Committee to its forerunner, the Five Star Design Rating Scheme in the 1980s. Professor Ballinger retired in 1997 from the UNSW. He has over 50 solar efficient buildings and 150 publications to his name and was awarded the Order of Australia in 2000.



Dr Charles A. Bankston

Country: USA

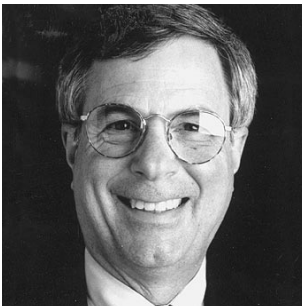
Year Started Research/Industry: early 1970's

Area of Research:

University: Los Alamos National Laboratory

Still Active in Research/Industry : No

Dr. Charles A. Bankston began his work in solar energy in the early 1970s while working at the Los Alamos National Laboratory. He was a member of a team of researchers who developed the national solar energy R&D plan for the US Department of Energy. Dr. Bankston then was assigned to DOE where he managed the solar collector R&D program. Dr. Bankston was a member of the International Energy Agency's Solar Heating and Cooling Program where he represented the US on a project that advanced long duration seasonal energy storage. In the 1980's Dr. Bankston formed the USH2O group that supported the market expansion of solar water heating in the US. In 1982, Dr. Bankston became the project director and editor in chief of a project that provided an assessment of the accomplishments and lessons learned from the R&D funded by the US Department of Energy in solar heat technologies from the early 1970s until the late 1980s. Dr. Bankston assembled a team of about 100 experts from the government labs, universities and the private sector who reviewed about 20 years of government funder R&D and summarized the results. He guided this review process and provided detailed technical advice to the team of writers to assure a high-quality product. The work was then published by MIT Press in 1997 as a ten-volume series.



Dr Allen Barnett

Country: USA

Year Started Research/Industry: 1975

Area of Research: Application of advanced materials science and technology.

University: University of Delaware

Still Active in Research/Industry : No

After selling his semiconductor company Xciton in 1975, Dr Allen Barnett joined the University of Delaware as a Professor of Electrical Engineering. Here he undertook research on the application of advanced material science and technology in particular specializing in thin-film materials and device design. He was Director of the Institute of Energy Conversion at the University of Delaware from 1976 to September 1979. It was here that he pioneered the development and manufacture of thin, crystalline silicon solar cells. In 1983 he left to become general manager of Astropower, Division of Astrosystems. However, while at Astropower he remained a professor at the University of Delaware He returned to University. In 2003 he returned to University of Delaware and led the US Very High Efficiency Solar cells Project. In 2011 he joined the University of New South wales School of Photovoltaic and Renewable Energy Engineering where he remained until 2018. He has authored or co-authored 157 technical publications and has been awarded 13 patents. He received the IEEE William R. Cherry Award in 1996 for outstanding contributions to Photovoltaic Science and Technology and the Karl W. Böer Solar Energy Medal of Merit in 2004. He has also been active in many organisations such as being on the Board of Directors of the SEIA (US) where he also been President of SEIA and Chairman of its Photovoltaics Division. From 1980 he had regularly presented testimony to the U.S. Congress on PV programs. He also served on the National Centre for Photovoltaics (NCPV) Advisory Board of NREL, as well as serving on conference committees and editorial boards.



Andrew Blakers

Country: Australia

Year Started Research: 1979

Title of Research: Photovoltaics

University: University of NSW AND Australian National University

Still Active in Research: Yes

Andrew Blakers is E2 Professor of Engineering at the Australian National University. He has held Humboldt, ARC QEII and ARC Senior Research Fellowships. He is a Fellow of the Academy of Technological Sciences & Engineering, the Institute of Energy and the Institute of Physics. He is a Life Member of the International Solar Energy Society and the Australian Conservation Foundation and is a Public Policy Fellow at ANU. In 1991 he founded the solar PV research group and laboratories at ANU (65 staff and PhD students). Leadership roles have included Foundation Director of the Centre for Sustainable Energy Systems at ANU, Node Director of the Australian Centre for Advanced Photovoltaics, Director of the ARC Centre for Solar Energy Systems, and Node Director of the Australian CRC for Renewable Energy. He has procured more than \$100 million in external research funding for ANU. His research interests are in the areas of silicon solar cells and renewable energy systems. He was responsible for the design and fabrication of silicon solar cells with world record efficiencies of 18% (1983), 19% (1984), 20% (1986) and 22% (1989). He was co-inventor of Sliver solar cell technology, the subject of a \$240 million commercialisation effort by Transform Solar. He was co-inventor of the PERC silicon solar cell, which has 70% of the global solar market and cumulative module sales of US\$50 billion. PERC deployment is about 70 Gigawatts per year, and it currently mitigating 0.7% of global Greenhouse gas emissions through displacement of coal. Prof Blakers is a leading figure in discussions of 100% renewable energy futures and is engaged in detailed analysis of energy systems with high (50-100%) penetration by wind and photovoltaics with support from pumped hydro energy storage for which he was co-winner of the 2018 Eureka Prize for Environmental Research.



Prof. Karl Böer (Deceased)

Country: USA

Year Started Research/Industry: 1972

Institute: University of Delaware's Institute of Energy Conversions (IEC)

Still Active in Research/Industry : No

In 1972 Prof. Karl Böer was the founding director of the University of Delaware's Institute of Energy Conversions (IEC) where he led the research on thin film cells. In 1973 he initiated the construction of the solar display house known as Solar One. In 1973 with investment from Shell he founded Solar Energy Systems to develop and manufacture cadmium sulfide solar cells but in 1975 he returned to the University of Delaware to continue his research. Professor Böer conducted research and published peer reviewed papers until age 91. His scientific contributions include more than 350 publications, 28 patents, and several books. He also served as President of the American Solar Energy Society, and as Editor-in-Chief of *Advances in Solar Energy*, which is a professional review journal that annually summarizes worldwide achievements in the field of solar energy. The prestigious Karl W. Böer Solar Energy Medal of Merit was created in his honor by the University of Delaware, in 1987. It is awarded to individuals who have made extraordinary, valuable, and enduring contributions in solar energy or other forms of renewable energy through research, development, or economic enterprise. Since 1993, the Medal has been awarded to an inspiring list of visionary researchers, entrepreneurs, and world leaders. Professor Böer has won numerous awards including the William Cherry Prize and the ISES Farrington Daniels Award (2003). Professor Böer was the driving force and editor of the "The Fifty Year History of the International Solar Energy Society and its National Sections" that was released in 2005.



Dominique Campana

Country: France

Year Started Research: 1973

Title of Research: Solar Water Pumping (exact title unknown)

University: University of Lyon

Still Active in Industry: Yes

Dominique Campana is accredited with designing the first PV water pump in Corsica France in 1973 as part of her thesis. She is now Director of International Affairs at ADEME, the French Environment and Energy Management Agency. For more than 30 years, she has dedicated her career to the promotion of energy efficiency and renewable energy, the protection of the environment and the fight against climate change. After starting as a research engineer at the Ecole des Mines in Paris, she joined ADEME in 1993. She has been involved in bilateral and multilateral cooperation programs, particularly on the themes of sustainable buildings and cities and access to energy in order to support the energy and ecological transition of many countries. She played a very active role in the international negotiations on climate and sustainable development, especially during the Paris Agreement at COP 21 or the Earth Summit (Rio + 20). She has also supported the development of green industries, in partnership with the Club ADEME International, which brings together 130 innovative eco-companies, leading French SMEs at the international level. She holds a Ph.D. in Physical Sciences and was awarded the title of “Knight of the National Order of Merit” in 2006 and “Knight of the Legion of Honor” in 2014.



Alvin Compaan

Country: United States

Year Started Research: 1971

Title of Research: Laser scribing creates monolithic thin-film arrays

University: University of Toledo, US

Still Active in Research: Yes

Alvin Compaan undertook research in Laser scribing creates monolithic thin-film arrays. The speed and accuracy of the lasers helped to integrate monolithic modules.

See article dated January 1st 2000 with the above heading.

References: A. D. Compaan, I. Matulionis, and S. Nakade, Optimization of Laser Scribing for thin-film PV Modules, “Final Technical Progress Report, NREL/SR-520-24842 (available from NTIS)



Ian Cowan

Country: Ireland

Year Started Research: 1978

Title of Research: Solar Pilot Test Facility

University: Institute for Industrial Research and Standards, Dublin

Still Active in Research: No

Ian Cowan's postgraduate research was concerned with mathematical modelling and computer simulation of the thermal response of buildings (PhD., 1977), which had applications in improving building design and control systems to facilitate optimization of energy use and thermal comfort, including use of renewable energy. On joining the Institute for Industrial Research and Standards in 1977, he assisted in a number of EC-funded projects then ongoing, such as round-robin collaborative testing of solar thermal panels, and modelling of energy flows in buildings with particular emphasis on casual solar gains. These projects led to the design and construction, initiated in 1978, of a Solar Pilot test Facility, one of eight in then various EEC countries. The project had its origins in the endeavour to bridge an important gap which had existed in the study of solar heating system performance: that between monitoring real installations, and computer simulation. Whilst both have their value, they also have restrictions: for instance the inevitable uncertainty in the determining parameters and difficulty in their variation in the former case, and the uncertainty in the accuracy of the modelling techniques in the latter. The adopted solution to the problem was the construction of Solar Pilot Test Facilities in various locations, and the development and validation of simulation models of solar systems using data so produced. The facilities had real collection and storage components (two subsystems: an identical reference system in each location, and specific national subsystems optimized for each location), but the thermal loads were simulated by computer-controlled heat exchangers, the load profiles being thus capable of variation with facility. The project commenced operation in 1979 and ran till 1983, during which data were collected in both inter-comparison and system-specific studies. Based upon these an advanced computer simulation model (EMGP2) was developed, as well as a simpler correlation model, to facilitate optimal solar system design under European conditions.



Mark Diesendorf

Country: Australia

Year Started Research: 1978

Title of Research: Renewable energy sources and storage

University: CSIRO

Still Active in Research: Yes

In 1978 Mark Diesendorf initiated a research program on RE within the CSIRO Division of Mathematics & Statistics and co-organised a national conference on Energy and People, which addressed energy policy as well as technologies. The book was published in 1979 by the Society for Social Responsibility in Science (A.C.T.). Initial research was on computer simulations and mathematical models of the integration of large-scale renewable energy into electricity grids, focusing on wind power. This was at a time when large wind turbines were at the experimental or pilot stage - there was no manufacturing industry. A paper entitled 'Renewable energy and Storage' was published in Nature in 1978. Under pressure from fossil fuel interests, CSIRO terminated all renewable energy research in 1982-83 and Mark was retrenched in 1985. He continued to do RE research at the Australian National University (1985-1986 and 1994-1996); the University of Technology Sydney, where he was Professor of Environmental Science and Founding Director of the Institute for Sustainable Futures (1996-2001); and UNSW Sydney (2004-present). Following nominal retirement in 2016, Mark has continued to research at UNSW Sydney as an honorary. His research at UNSW Sydney is partly on simulations of the operation of the Australian National Electricity Market with 100% renewable energy, partly on the energy return on energy invested in renewable energy and partly in energy policy. Although his principal research focus has been on large-scale renewable electricity in developed countries, he has also done some research with two of his PhD students on renewable energy, not just electricity, in developing countries.



William (Bill) Duff

Country: United States

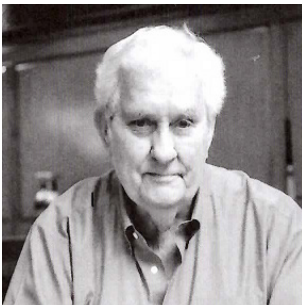
Year Started Research: 1972

Title of Research: Solar Heating, Cooling, Hot Water, IPH and Electric Power

University: Colorado State University Solar Energy Applications Laboratory

Still Active in Research: Yes

William Duff's solar energy career began in 1972, prior to large-scale Concentrating Solar Power (CSP) deployments, when his university was awarded a substantial National Science Foundation grant to identify solar thermal electric power systems (STEPS) delivering low cost electricity. Bill's approach optimized large-scale STEPS for flat plate, line focus, point focus and tower/heliostat solar collector concepts, accurately depicting installations in operation today. His approach required original research to create uniform parameterized performance and cost models. One of these was recognized by SPIE as one of the decade's best research contributions in optics. Bill's more than three decades long leadership in evacuated collector research began with a joint US/German project to evaluate US and German manufactured evacuated collectors in installations in both countries. During a sabbatical year with Philips Research Laboratories in Germany, he was selected to lead the ten-year eleven country International Energy Agency Solar Heating and Cooling Program Task VI where various evacuated collectors were tested in different installations. Seven years of leadership in Task XIV's Advanced Active Solar Domestic Hot Water Systems ensued. Bill spent more than five years with Roland Winston's group at the University of Chicago's Fermi Institute where they developed a novel integral CPC (ICPC) configuration compatible with evacuated tubular collectors. He fabricated and tested these ICPCs under NREL funding. Concurrently he brought together multiple funding sources and fellow researchers to form the Sacramento Demonstration installation to evaluate this concept. Other accomplishments include decades of solar residential and industrial building testing; economic and materials assessment; MOS PV cell, computer simulation, workshops and passive solar water pasteurization development; a Solar Energy Journal Associate Editorship; nearly 200 journal and conference papers published; more than 100 PhD and Masters students graduated; two solar energy companies founded and membership on various BODs.



John Paul Eberhard (Deceased)

Country: United States

Year Started Research: 1973

Title of Research: The American Institute of Architects (AIA) Research Corporation

University: The American Institute of Architects (AIA) Research Corporation

Still Active in Research: No

In 1973, John Paul Eberhard, FAIA, as President, transformed The American Institute of Architects (AIA) Research Corporation to focus on energy conservation. With a fledging budget of \$50,000 from the Ford Foundation, he built AIARC into a \$10M organization with more than 60 staff by 1978. He took this small arm of national AIA, that hardly anyone even knew about, and made it into an organization that explored solar and wind energy alternatives, urban planning issues and energy use, and influenced the use of "energy conscious design" educational programs in 350 firms across the U.S. Further information on John P. Eberhard's life and achievements can be found on the website <http://www.anfarch.org/grants/founding-president-john-p-eberhard-passes-away-at-93/>.



Nilufer Egrican

Country: Turkey

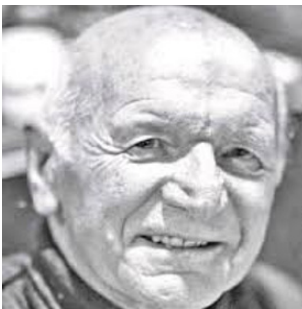
Year Started Research: 1975

Title of Research: A Thermodynamic and Heat Transfer Analysis of Solar Absorption Air-Conditioning Cycle

University: University of Maryland

Still Active in Research: Yes

Prof. Dr. A. Nilufer Egrican began her work in solar energy in 1975 at the University of Maryland when she did research on solar powered absorption cooling and on solar powered Rankine engines for solar cooling. From that time on, Dr. Egrican continued to work in the area of applied thermodynamics as it relates to solar thermal systems, such as passive solar heating, solar water and space heating. In 1982, Dr. Egrican began a teaching career at the Technical University of Istanbul where she rose from Assistant Professor to Dean of Engineering. Dr. Egrican then became a Professor and Rector of the Yeditepe University until she retired in 2011. During her tenure at these universities, Dr. Egrican advised many students who went on to careers in solar energy, she published a large number of research papers and made many presentations related to the thermodynamics of solar heating and cooling. Dr. Egrican formed a consulting company, Suntek International, where she continues to work on solar energy projects. Dr. Egrican is also very active in international associations and journals. She is President of the International Center for Applied Thermodynamics and is Editor of the International Journal of Applied Thermodynamics.



Keith Garzoli (Deceased)

Country: Australia

Year Started Research: 1975

Title of Research: Horticultural Greenhouse Technologies

University: Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Still Active in Research: No

From 1975, Dr Garzoli worked in Energy Research and related engineering technologies, firstly in the CSIRO and, for his last 12 years, in a part-time capacity, at the Australian National University. During his time at CSIRO he carried out extensive research into solar and renewable energy technologies and energy conservation technologies for buildings of all kinds. His Master's degree and Doctorate were both in these fields. He was awarded the International Horticultural Congress trust Award in 1982 and a Winston Churchill Memorial Fellowship in 1985. By the time he left CSIRO in 1989, he was Principal Research Scientist and Project Leader for CSIRO's Greenhouse Technologies project. In 1989, Dr Garzoli worked with the Energy Research Centre (ERC) at the Australian National University, and for 7 years he was Deputy Head of the ERC. Some of his research was in refrigeration and heat pump technology, renewable energy, energy conservation and energy storage. He continued to be involved in greenhouse technology, in particular in climate control and energy efficiency in greenhouse design and environment management, in geothermal heat pump technology, and in energy storage, using Phase Change Materials. He was chairman of the International Society for Horticultural Science for 8 years and was an accredited Energy Auditor during the life of the Commonwealth Government's Enterprise Energy Audit Program. Dr Garzoli succumbed to throat cancer late in 2010.



Biswajit Ghosh

Country: India

Year Started Research: 1978

Title of Research: CdTe Thin film Solar Cells

University: Jadavpur University, India

Still Active in Research: Yes

Prof Biswajit Ghosh started his research career as PhD Student in the field of CdTe Thin film solar cells at Jadavpur University, India in the year 1978. He has more than 42 years of experience in Teaching and Research in the field of Solar Photovoltaic. He was Professor and Director at School of Energy Studies, Jadavpur University, Visiting Professor at Kalinga Institute of Industrial Technology, Adjunct Professor, Manipal University and Leverhulme Visiting Professor at Newcastle University, UK. Presently he is serving as Vice-Chancellor of The Neotia University, Kolkata, India. He has worked as Visiting Research Scientist at University of Stuttgart, Germany; as Fellow, European Commission at Northumbria University, UK; as Academic Visitor at Imperial College, London; as Royal Society Overseas Scientist at University of Surrey, UK and as Visiting Professor at Newcastle University, UK. He has received D. Sc. (Engg.) from Jadavpur University in 2008 and D.Sc. (Honoris Causa) for outstanding contribution in Science, Engineering and Education by the National Institute of Technology, Agartala, in the year 2017. He was nominated for prestigious European award by World Renewable Energy Council for 'Edmond Becquerel Prize' and received Best Scientific Poster Award by the EU at 24th EU PVSEC, at Hamburg, Germany. Prof Biswajit Ghosh has 10 Indian Patent related to material coating and has supervised 35 PhD Thesis and published more than hundred research papers in International Journals & Conference Proceedings. He was advisor to the United Nation Industrial Organization (UNIDO) for Energy & Climate Change in general and Clean & Safe Energy Technology in particular. He has worked in countries of West Africa and Central Asia in implementing 'Clean & Safe Energy. He has designed, developed and implemented MWP Grid Integrated PV Plant at Gujarat, Tamil Nadu, Karnataka & Uttarakhand States of India.



Adolf Goetzberger ISES President 1991-1993

Country: Germany

Year Started Research: ca. 1970

Title of Research: Improving c-Si Solar cells and developing Solar Systems

University: Fraunhofer ISE and University of Freiburg

Still Active in Research: No

Prof Goetzberger received his Dr. rer. nat. degree in Physics from the University of Munich in 1955. He spent 10 years in the USA – five years with the Shockley Transistor Laboratory, Palo Alto, CA. and five years with Bell Telephone Laboratories, Murray Hill, NJ, where he published fundamental work about the Si-SiO₂- interface. In 1968, he returned to Germany to accept the position as Director of the Fraunhofer Institute for Applied Solid State Physics. He modernized and greatly expanded this institute. In 1981, he founded the Fraunhofer Institute for Solar Energy Systems in Freiburg which grew into one of the major solar energy laboratories in Europe. The institute is engaged in a broad spectrum of work in most aspects of solar energy conversion. Solar cell technology, solar materials research, thermal conversion, systems engineering, and energy storage are the main activities. In 1993, he retired as a director of the institute, but he carries on many publishing and advisory activities in the field of solar energy. He was President of the International Solar Energy Society from 1991-1993. He served on the Board of this society from 1987 to 1999. From 1993 to 1997 he was President of the German Solar Energy Society DGS. He has received many awards all in 1997 including The Daniel Farrington Award of the International Solar Energy Society; the Karl W. Boer Solar Energy Medal of Merit Award; The Alexandre Edmond Becquerel Prize of the European Commission and the William R. Cherry Award of the IEEE.



Martin Green

Country: Australia

Year Started Research: 1975

Title of Research: Silicon Solar Cells

University: University of New South Wales

Still Active in Research: Yes

UNSW Scientia Professor, and director of the Australian Centre for Advanced Photovoltaics, Martin Green, AM ForMemRS, is widely regarded as the world's foremost photovoltaic researcher and the most distinguished academic in crystalline silicon solar cell research working today. In a record-setting career in solar spanning almost 50 years, Dr Green has been the recipient of numerous Australian and international awards and prizes in recognition of his contributions to the field, including the Australia Prize, the James Cook Medal of the Royal Society of New South Wales and the coveted Global Energy Prize (2018), for his work having "revolutionised the efficiency and costs of solar photovoltaics, making this now the lowest cost option for bulk electricity supply". Prof. Green also serves as editor-in-chief of the journal, *Progress in Photovoltaics*. Professor Green has been known as "the father of photovoltaics" since he and his team's 1983 invention of the PERC solar cell at UNSW, which now accounts for 79% of all solar modules used in the world. Professor Green's team's solar cells were included in the first photovoltaic system in 1989. From these breakthroughs in solar cell technology, the global solar energy industry as we know it was born. Professor Green founded the Photovoltaics Centre of Excellence at UNSW. Now established as the School for Photovoltaics and Renewable Energy Engineering (SPREE), it hosts one of the world's leading solar research laboratories, which has held the world record for the most efficient solar cell for 30 of the last 35 years.



Hugo Grossi Gallegos

Country: Argentina **Year Started Research:** 1978

Title of Research: Measurements of solar irradiance

University: Argentina National Commission on Space Research (CNIE) and Argentina National University of Lujan (UNLu)

Still Active in Research: No

Hugo Grossi Gallegos was Director of Solarimetric Network in Argentina from 1980 up to its dissolution. He was coordinator of the Subregional Solar Resource Survey Project (Organization of American States, OAS, Multinational Project for the Environment and Natural Resources) 1992-1995, and author of "Solar Radiation Charts for Argentine Republic", 1997 [Argentine territory extends from 22°S to 55°S and it mostly offers favorable conditions for the use of solar energy. Measurements of solar radiation have taken place during the last forty years, particularly since the installation of a quality-controlled pyranometer network which began operations in 1979. The temporal and spatial variability of global radiation data and Sun brightness hours were analyzed: the first ones for the determination of the uncertainty level for a given precision, and the second one for the determination of the extrapolation error. Taking both of them into account, the monthly averages of measured (28 stations) and estimated (Angström type equations for 24 stations) global radiation, and using comparable values from neighbouring countries and satellite studies, it was possible to draw 13 charts with the spatial distribution from this alternative source]. Grossi Gallegos was Technical consultant in the "Solarimetric Atlas for Brazil", 2000; Reporter of the Working Group on Solar Radiation of the World Meteorological Organization (WMO-AR III), 2007-2009; International Coordinator of the Iberoamerican Network for Solarimetric (RISOL) in the Iberoamerican Program for Science and Technology for Development (CYTED), 1998-2001. He was the creator in 2002 of the Solar Radiation Study Group (GERSolar-UNLu), which he directed until 2011. He was external evaluator in the Sectorial Fund of Energy (SFE) of the National Agency for Research and Innovation (NARI) of the Republic of Uruguay, announcements 2013 and 2015. Hugo Grossi Gallegos has published 71 articles, 4 books, 4 chapters in books, 30 conference papers, 5 technical reports and gave 7 presentations and has directed, coordinated or acted as professor in national and international courses and delivered over 100 lectures.



Christian Gueymard

Country: United States

Year Started Research: 1973

Title of Research: Solar Radiation Modelling and Measurement for Advanced Solar Resource Applications

University: Florida Solar Energy Center

Still Active in Research: Yes

Since starting solar-related research in 1973 as a graduate student, Christian Gueymard developed an internationally recognized expertise in the fields of solar resource assessment, solar radiation modelling, radiometry, forecasting, atmospheric remote sensing, and their applications to various types of solar energy systems. Some of the solar radiation models he developed are being used widely by the international solar energy community. In particular, his SMARTS model has been selected by ASTM and IEC to promulgate spectral irradiance standards needed for photovoltaic cells testing and rating, among many other applications. Christian has been a Research Scientist at the Florida Solar Energy Center before founding Solar Consulting Services. This company offers expert assistance to public and private institutions involved in solar energy or building applications. He has been serving as Associate Editor of the Solar Energy journal since 2007, and regularly serves as referee for various scientific journals, conferences or doctoral theses. He has been involved with various technical committees for ASHRAE, ASTM, CIE, and the American Solar Energy Society. Christian has published 220+ scientific papers in refereed journals or conference proceedings, as well as 40+ research reports. He has received three “best paper” awards so far and has contributed to various books, including “Modeling Solar Radiation at the Earth’s Surface” (2008), “Solar Cells and their Applications” (2010), “Encyclopedia of Sustainability Science and Technology” (2012), “Solar Energy” (2013), “High Concentrator Photovoltaics” (2015), and “Solar Resources Mapping” (2019). In recent years, he has been involved in international projects, such as IEA-SHC Task 46 and IEA-PVPS Task 16, or Europe’s DNlcast, all related to solar resource prediction or forecasting and continues to collaborate with many scientists around the world, and to help students whenever possible. As of this writing (May 7, 2020), Google Scholar credits Christian with 11,531 total citations and a h-index of 51.



Subhendu Guha

Country: USA

Year Started Research: 1979

Area of Research: Amorphous silicon

University: TIFR, India; United Solar, MI, USA

Still Active in Research: Yes

Dr Subhendu Guha started his research on amorphous silicon material and solar cells at TIFR, Bombay in 1978. Since 1982, he has worked in the same field at Energy Conversion Devices and United Solar Ovonic in MI, USA making pioneering contributions. He has received many awards including World Technology Award, PVSEC Award, and Bright Light Award from US Department of Energy. He became the President of United Solar in 2001 where he led a team that showed consistently for a decade record solar cell efficiency using a-Si alloy technology. United Solar also emerged as the world’s largest manufacturer.



Ken Guthrie

Country: Australia

Year Started Research: 1978

Title of Research: The performance of a slatted convection suppression device

University: University of Melbourne

Still Active in Research: Yes

Ken Guthrie trained as a mechanical engineer 1972-75 and completed a Master of Engineering Science by research under the supervision of Bill Charters at the University of Melbourne. From 1980-82 he worked at Monash University and in 1983 he worked on the use of phase change materials in passive solar buildings in the UK. He managed the solar thermal program at the Victorian Solar Energy Council from 1984-90. In 1990 he set up the Energy systems group at the GFCV's Scientific Services Dept to facilitate more efficient use of heating in Victoria. In 1995 he joined the Sustainable Energy Authority of Victoria, leading the government energy efficiency program and later included renewable energy in his portfolio. After SEAV transitioned to Sustainability Victoria he provided advice across the Victorian Government regarding market and regulatory programs to support the deployment of Sustainable Energy Technologies as General Manager, Sustainable Environs. In 2012 Ken set up a specialist consulting service, Sustainable Energy Transformation undertaking work for organisations across AU and NZ including CSIRO and EECA and providing advice on solar farms for local government in Victoria. He is currently a Board Member of the APVI and Yarra Energy Foundation. Ken has been particularly active in Standards and International Energy Agency research collaboration: Member of Standards Australia's committee on solar water heating, CS028, from 1985. In 1989 he became Chair, a position that he still holds. Member of ISO tC180 since 1986 and Chair 1997 to 2017. In 2014 Standards Australia awarded Ken the Meritorious Contribution Award for his International Standards work. Since 2004 Ken has represented Australia at the IEA SHC program. In 2014 he was elected Chair of the Executive committee, serving two terms until 2018. He has been the Co-Chair of the IEA SHC/ISES SWC conference in Abu Dhabi in 2017 and a program Co-Chair in 2019.



Stephen Harrison

Country: Canada

Year Started Research/Industry: 1970's

Area of Research: Studies of Solar Collector Performance at NRC

University: National Research Center, Canada Queen's University, Canada QSBRI Canada

Still Active in Research/Industry : Yes

Dr. Harrison has 4 decades of experience in the development and evaluation of solar energy equipment. Author of numerous technical papers and patents, he is a founding partner and Director of Engineering at QSBR Innovations Inc. and director of the Solar Calorimetry Laboratory at Queen's University in Kingston, ON. He recently retired from teaching undergraduate classes and is now professor Emeritus. Despite retiring Dr. Harrison still runs the Queen's Solar Lab which supports the efforts of graduate students and post-doctoral researchers and undertakes applied research for industry and government partners. His experience includes 8 years as a research officer at the National Research Council of Canada, where he was involved in the development of both national and international standards for solar heating equipment. In 1999, he co-founded Enerworks Inc., a leading manufacturer of solar thermal products in North America, developing two patented technologies for the Enerworks, Integral Stagnation Control, a method to prevent stagnation in solar thermal collectors and Passive Back Flow, a method to prevent scaling in heat exchangers. In 2005, he became the Theme Leader for Solar Heating and Cooling within the Canadian Solar Buildings Research Network. The Network includes the participation of researchers at 11 universities across Canada. Dr. Harrison has also been the Faculty Advisor for the Queen's University Solar Vehicle Team since 1988 (now Queen's Solar Design Team) building more than a dozen solar vehicles and racing across the Australian outback and north American numerous times in those vehicles. Dr. Harrison was also a project lead on the USDOW Solar Decathlon Competition where his team place first overall in Engineering.



S Robert Hastings

Country: Switzerland

Year Started Research: 1975

Title of Research: Solar Architecture

University: National Bureau of Standards in USA and EMPA , ETH and AEU Ltd in Switzerland

Still Active in Research: No

In 1975, Robert made a career shift from conventional architecture to solar building research. At the US Center for Building Technology, with a colleague he wrote a handbook: Window Design Strategies to Conserve Energy (CBT Publication of the Year). His next project was leading "SUNCAT: Solar Use in Cities and Towns". His team of architects, economists and behavioural scientists explored urban planning ideas to capture sun on facades and in arcaded streets. In 1980, on a travel grant, he worked at the Building Physics Dept. of the Swiss EMPA. Meanwhile, the US halted federal solar research, so he gratefully accepted the Swiss offer to continue helping coordinate research for a foundation, NEFF. Subsequently, Dr. G. Schriber of the Federal Office of Energy asked him to represent Switzerland in a 4-year project: "Passive Solar Buildings" of the International Energy Agency and to lead a Swiss research program of the same name. Wanting to also teach, he moved to the Swiss ETH and offered a popular dipl. elective on solar buildings, as well as guest lecturing at 12 universities worldwide (Teacher of the Year Award at the Danube Univ.). He led further IEA programs: "Solar Commercial & Institutional Buildings", "Solar Air Systems" and Solar "Sustainable Housing" (UK Energy Institute Award). While working with experts from Europe, Asia and North America he co-authored ten books in German and English and gave 11 keynote talks at international conferences. One colleague, P. Holzer, was instrumental in his becoming Professor and Head of the Dept. of Buildings & Environment at the Danube University for two years. Finally, he founded Architecture, Energy and Environment Ltd. (AEU) which consulted with architects. Together with two partner firms the AEU developed a design for a solar neighbourhood of atria houses (1st prize in an EU design competition).



Rudolf Hezel

Country: Germany

Year Started Research: 1978

Title of Research: Photovoltaics

University: University University Erlangen-Nürnberg, Leibniz-University Hannover, ISFH

Still Active in Research: No

In 1978, as a new era in photovoltaics, low-temperature surface passivation of silicon solar cells was introduced by R. Hezel at the University Erlangen-Nürnberg. It is achieved by deposition of charged dielectric layers of silicon nitride (SiNx) and aluminium oxide (Al₂O₃) below 500°C. Both films became key components of present and future silicon solar cells. R. Hezel's further R&D work consisted in basic and applied research including Auger and Electron Energy Loss spectroscopy and electrical characterization of Si/insulator interfaces. Based on charged SiNx, the novel MIS-inversion layer solar cell (MIS-IL), invented by R. Hezel, was transferred to an industrial pilot line (1992 Innovation award of the German Industry). In 1994 450kW MIS-IL solar cells were installed in Europe's largest PV plant in Toledo (Spanish-German project). In 1994 R. Hezel became Professor at the Physics department of the Leibniz University Hannover and director of the Institute for Solar Energy Research (ISFH) at Hameln. From 1997 onward R. Hezel and co-workers developed fully nitride-passivated bifacial silicon solar cells, e.g. of the back-collecting type (Back OECO, 21.5% and 18.1% efficiencies). In 2002 a high-throughput in-line machine for large-scale plasma-deposition of SiNx films was developed at ISFH in cooperation with industrial partners. The high-quality SiNx passivation and antireflection layers paved the way to the first industrial mass-production of reliable solar cells, soon culminating in a world-wide boom of solar electricity. Back in 1985, as another highlight, R. Hezel introduced an innovative rear-surface configuration for solar cells with gridded base contacts and AL₂O₃ as low-temperature passivation between the line-shaped contact fingers in order to substitute the conventional high-temperature processed back-surface field (BSF). Decades later this novel structure, combined with SiNx, became the basic element of the next-generation industrial solar cell (PERC) with strongly increased efficiency.



Robert (Bob) Hill (Deceased)

Country: UK

Year Started Research: 1971

Title of Research: Thin Film Solar cells for Terrestrial Use

University: University of Northumbria at Newcastle (UNN)

Still Active in Research: No

Robert (Bob) Hill took a first degree in Physics at Imperial College, London, and then stayed to pursue a doctorate in Solid State Physics. He joined Newcastle Polytechnic, now the University of Northumbria at Newcastle (UNN), in 1971. His early work at UNN focused on thin-film solar cells for terrestrial use, exploring high-efficiency coatings. By 1978, Bob was working on satellite solar panels. In 1984 he became Professor of Opto-Electronics, and in the same year established, and became director of, the Newcastle Photovoltaics Applications Centre, a post which he continued to hold until his retirement in 1998. His personal academic output was large and influential, authoring and editing 12 books, including *The Future of Energy* (1994) and *Prospects for Photovoltaics: commercialisation, mass production and application for development* (1992), seven conference proceedings, some 200 papers in refereed journals and major conferences and over 100 commercial reports. He was also an active member of UK-ISES. In 1989 Bob was one of the founders of the British PV Association where he was chair from 1994 to 1995. He was a member of the Solar Energy Advisory Committee and the Technology Foresight Energy Committee, providing policy advice to the Government. He led the 12th European Photovoltaic Conference in 1994 and was involved in subsequent conferences. In 1998 Hill was a founding member of the inter-disciplinary Sustainable Cities Research Institute at the University of Northumbria, and Director of Renew North (the board for the Renewable Energy Agency for the North East), reflecting his long-held views on the need for a holistic approach to sustainable development. Bob was passionate about PV in Developing Countries. For the 10th EPVSEC in Lisbon, Bob, organised a workshop on PV for Developing Countries. In memory of Bob and his passion, and instigated by Wolfgang Palz, the Robert Hill Award for the Promotion of PV for Development was created.



Dietrich Holm

Country: South Africa

Year Started Research: 1970

Title of Research: Solar Passive Design

University: University of Pretoria

Still Active in Research: Yes

Prof Dieter Holm pioneered the first energy and water autonomous house on the African Continent. Designed in 1973, prior to the first energy crisis, it was built in 1974 using solar passive design, PV, biogas, rainwater harvesting, recycling and vegetation. His PhD at the University of Pretoria entitled "The thermal effect of leaf cover on outside walls" blazed a trail for low-cost environmentally friendly exterior insulation that automatically varies with the seasons, tempering the microclimate by 4°C in summer and 3°C in winter of semi-arid climates. As Head of Department Architecture he introduced an eco-systemics. His staff was the most highly qualified architectural department in the Commonwealth. He set a record by leading 18 Masters and 13 PhD degrees with concomitant publications in referred journals. His books are focussed on Solar Passive Building in the Developing World. The architectural practice Holm & Holm Architects, and its successors, won many professional competitions and awards of merit. He served as ISES Board Secretary and contributed to the success of the ISES SWC in Johannesburg. He was commissioned to write an ISES White Paper "Renewable Energy for the Developing World" which has been translated into many languages and honoured with the Special Service Award This was followed by Life Membership awarded after having served as Vice-President for Conferences. His pioneer contribution to Prof. Attie van Niekerk's "Navorsing op Verligting van Armoede" (NOVA) was acknowledged with the Eskom ETA Energy Efficiency Award. This work renders government low cost housing and informal settlements thermally tolerable, thereby reducing air pollution and enhancing health. He co-founded the "Southern African Solar Thermal Training & Demonstration Initiative" (SOLTRAIN) covering 6 countries and producing 3000 trainees, 326 demo projects, 3533 MWh of energy and saving 1222 tons CO₂eq to date. Currently he serves as director of ZZZ, a leading fresh product farming initiative, applying ecological systems theory through "Natuurboerdery."



Michael Holtz

Country: United States

Year Started Research: 1974

Title of Research: Application of Solar Energy in K-12 Schools, but involved in considerably more and varied research than this first project

University: American Institute of Architects (AIA) Research Corporation

Still Active in Research: Yes

Michael Holtz, FAIA has been at the forefront of architectural and energy research, development and sustainable design consulting since 1972. He has been associated with LightLouver LLC as co-founder and CEO (2005 to Present); Architectural Energy Corporation as co-founder and President / CEO (1982 – 2009); the Solar Energy Research Institute (now known as National Renewable Energy Laboratory) as Chief of the Building Systems Research Branch, and as Acting Director of the Buildings Division (1978 – 1982); the AIA Research Corporation as Program Manager and Director of Solar Energy Programs (1972 – 1978); the National Bureau of Standards (now known as the National Institute for Standards and Technology) as a research architect (1972); and, since 1976, his own architectural practice. In 1975, he authored the first major U.S. publication on solar energy and housing design, *Solar Dwelling Design Concepts*. He established and managed comprehensive research programs in all aspects of solar energy including solar access, sustainable community planning, passive solar heating and cooling, daylighting design and analysis, design tool development and evaluation, urban applications, and federal program planning and analysis. He has been central to planning and managing numerous international programs in passive and hybrid heating and cooling and building energy analysis tools, including the SOLERAS U.S.-Saudi Arabia Solar Research Program, the NATO/CCMS pilot project on passive systems, and the U.S.- Italy Passive Multi-Family Housing Program. Mr. Holtz served from 1980 to 1989 as the Operating Agent for the IEA Task on “Passive and Hybrid Solar Low Energy Buildings”. From 1989 to 2005, he served as the Operating Agent on IEA Task 12, entitled “Building Energy Analysis and Design Tools for Solar Applications;” and as the Operating Agent of IEA Task 22, “Building Energy Analysis Tools”. Mr. Holtz was elected in to the College of Fellows of the American Institute of Architects and of the American Solar Energy Society.



Sigrid Jannsen

Country: Germany

Year Started Research: 1974

Research Topic: Bionenergy

Institute: Free University of Berlin (Germany)

Still Active in Research : No

Professor Sigrid Jannsen's activities in renewable energies started in 1974. Her scientific focus was on waste water treatment and in particular on the energetic use of biological wastes. From 1974 to 2001 she was a Full Professor for General Microbiology at University of Oldenburg, Germany. After her retirement Sigrid Jannsen was strongly involved in educational projects at the school level. 1995 – 2005 she was President of the German Solar Energy Society, DGS. In this capacity she worked intensively on the promotion of renewables, led several international projects on the dissemination of renewables and was chair of large international congresses. 2008 – 2012 Prof. Jannsen worked in Singapore as Scientific Information Officer at the newly founded Solar Energy Research Institute of Singapore, SERIS. Prof Jannsen has been in charge of various international EU projects and the organisation of numerous international conferences. Prof Jannsen is currently the vice president is of the non-profit organisation The International Solar Energy Society e.V.



Peter Jolly

Country: Australia

Year Started Research: 1979

Title of Research: Optimization of Solar Drying Systems

University: University of West Indies (Trinidad),

University of Queensland

Still Active in Research: No

Peter Jolly completed his first degree in Mechanical Engineering at Melbourne University in 1975, doing his final year thesis project, under the guidance of Professor Bill Charters, on the storage of hydrogen for motor vehicles. After a brief career in the mining industry, he undertook his PhD studies at The University of The West Indies under the guidance of Professor Satcunanathan, Trinidad campus in solar drying systems. Upon returning to in Australia in 1982 he took up a position in The University of Queensland's newly formed Solar Energy Research Centre, continuing research into drying systems and other areas of solar thermal applications. These were seminal years, being actively involved in ANSES, conducting many research projects and supervising post graduate students. One paper investigated the Energy Return on Energy Invested (ERoEI) of both PV and Wind power generators. This was one of the first papers in this area, and it clearly showed these renewables technologies had a favourable ERoEI. In 1990 Peter went to Singapore, to take-up a position in commercial refrigeration and air conditioning. One of key projects undertaken, was to lead a team of engineers to convert the company's container refrigeration fleet to operate with ozone friendly refrigerants. This project lead onto other opportunities in the commercial field, becoming the R&D Manager for Carrier Refrigeration Systems in Singapore and then Chief Engineer for Data Centre Air Conditions systems for Emerson in Shenzhen China. In 2008 Peter returned to Australia and worked for a small mining company with interests in Nickel and Cobalt mining, key metals used in Lithium ion batteries for the emerging electric vehicle industry. Peter is presently employed as an Industrial Fellow at The University of Queensland, undertaking research in energy efficient greenhouses. Peter has published 25 refereed journal papers, 33 conferences papers and numerous commercial reports.



Lawrence L Kazmerski

Country: United States

Year Started Research: 1971

Title of Research: Thin Film PV-Copper Indium diselenids (CIS)

University: University of Maine

Still Active in Research: Yes

Lawrence L. Kazmerski is Emeritus Research-Staff Member of the National Renewable Energy Laboratory, Golden, Colorado, having last served as Executive Director Science and Technology Partnerships at NREL 2009-2013. He is currently Fellow at the University of Colorado Boulder, Renewable and Sustainable Energy Institute (RASEI). Kazmerski's 50-year professional career in solar energy includes serving as the founding Director of the National Center for Photovoltaics (NCPV) for the period 1999-2008. He received his BSEE (1967), MSEE (1968) and Ph.D. (1970) in electrical engineering, University of Notre Dame. He served as Postdoc with the Atomic-Energy-Commission, Notre-Dame Radiation Research Laboratory (1971). He was on the electrical-engineering faculty at the University of Maine before coming to the Solar Energy Research Institute (SERI-which became NREL, 1991) in 1977. His research at Maine included NSF/ERDA-funded work in thin-film photovoltaics and the report of the first thin-film copper-indium-diselenide (CIS) solar cell. He was SERI's/NREL's first staff member in photovoltaics, hired specifically to establish research in PV materials/device characterization; efforts he led for more than 20-years. Kazmerski has >340 publications and >200 invited talks. He holds 4-patents for instrument development, resulting in 4-R&D-100 Awards. He has been recognized with several international awards, including the World-PV Prize, IEEE-William R. Cherry Award, AVS-Peter Mark Memorial Award, ASES-Charles Greeley Abbot Award, and ISES Christopher A. Weeks Award. He received the ISES-Farrington Daniels Award (2019) for his contributions to advancing solar-energy research. He is a Fellow of the IEEE, APS, AVS, and ASES. Kazmerski is Visiting-Professor (Energy) at the Pontifícia Universidade Católica de Minas Gerais (Brasil) and the Gandhi Distinguished Visiting-Professor of Electrical Engineering, Indian Institute of Technology-Bombay (IIT-B), working with their PV efforts. Kazmerski is Distinguished Faculty of the Strömstad Akademi, Sweden. In 2017, Kazmerski was appointed as Distinguished Lecturer for the IEEE Electron Devices Society (EDS). Kazmerski is a member of the U.S. National Academy of Engineering. He was elected as foreign member of the Indian Academy of Engineering (2018).



Stephen Kaneff (1926-2015)

Country: Australia

Year Started Research: 1971

Title of Research: Solar Thermal Power

University: Department of Engineering Physics of the Research School of Physical Sciences, Australian National University, Canberra, Australia

Still Active in Research: No

Emeritus Professor Stephen Kaneff established the field of solar energy research at the Australian National University (ANU) in 1970-71. From an early stage Kaneff settled on dish concentrators operating in distributed fields as the strategic choice. Stephen Kaneff led a number of key major projects in the following decades. Professor Kaneff graduated from the University of Adelaide with a PhD in Engineering in 1956. In the following decade he held positions with the University of Adelaide and was a Carnegie Fellow. In 1966, Kaneff took up the position of Professorial Fellow at the ANU Research School of Physical Sciences. Five years later he was appointed Professor and Head of the Department of Engineering Physics, a position he maintained until his retirement in 1991. The White Cliffs Power Station was arguably the world's first commercial solar energy power station. It was designed and built by Kaneff and his team after being formally commissioned by the NSW Government in 1979. The solar thermal power station provided a base for research and allowed the successful demonstration of the economic and technical viability of solar power. The station was fully functional in 1981 and provided power to the White Cliffs settlement for over a decade, being finally decommissioned in 1994. In 2006, the solar power station was declared an Australian national engineering heritage site. It has presently been reopened as a working educational museum. Professor Kaneff's life-long commitment to full-time research and development activities in benign energy sources and applications (amounting to a 40 plus year legacy) continued after his retirement as Head of the Energy Research Centre. His contribution has helped establish Australia as an international leader in solar energy research.



Joseph Kohler

Country: United States

Year Started Research: 1977

Title of Research: Passive Solar Performance Modeling; Investigation of Glazing to Mass Ratio

University: Total Environmental Action, Harrisville, NH

Still Active in Research: No

Dr. Joseph Kohler was an Assistant Professor in the Chemical Engineering Department at Worcester Polytechnic Institute when he became interested in energy conservation and passive solar energy while teaching a course in Environmental Engineering. In 1977 he resigned his teaching position and joined Total Environmental Action (TEA) in Harrisville, NH. Joe worked on the computer simulation of passive solar buildings in a research project sponsored by Brookhaven National Labs. He also developed TEANET, a thermal network program that ran on a programmable calculator and was used to model the dynamic performance of passive thermal mass systems. Joe then collaborated with Dan Lewis to develop TEASOL, a more versatile thermal network simulation that calculated the annual energy use of passive solar buildings using actual weather data. Using TEASOL they determined the amount of thermal mass required for various glass areas in passive solar buildings in various areas of the country. The results were published in the "Passive Principles" series for Solar Age Magazine in the early 1980's. In addition, Joe was a reviewer for the early HUD Solar Grants and was a frequent presenter at various Solar Conferences. Joe and Dan later founded Kohler and Lewis, a mechanical engineering firm that specialized in designing energy efficient HVAC systems. They were among the first engineers to design energy recovery ventilation systems for schools. They also designed large biomass heating systems using wood chips and pellets and were among the first engineers to specify air source heat pump systems. Joe and his wife Mona Anderson built a super-insulated "net zero" stone house in 1979, providing electrical power with a micro hydro system and a small PV array. The off grid micro hydro system was still in operation 40 years later, and the PV system was significantly enlarged and grid connected.



Robert Le Chevalier

Country: United States

Year Started Research: 1974

Title of Research: Solar Heating and Cooling Technologies and promotion of Renewable Energy

University: Honeywell Inc., Energy Research and Development Administration

Still Active in Research: No

In 1974, Robert Le Chevalier served as a Senior Systems & Research Scientist at Honeywell, Inc in the design/development of solar heating/cooling systems and components. He served as Project Engineer in the design and development of a Transportable Solar Energy Laboratory under contract to the US National Science Foundation (NSF). Two different solar cooling concepts were designed for this laboratory. Powered by solar heated water at 200 degrees F produced by the laboratory's 600 sq ft. solar collector array, one design was a 3 ton absorption cycle air conditioner and the other a Rankine Cycle Engine driving a 3 ton compression cycle air conditioner. The NSF mission for this transportable laboratory was to collect solar heating and cooling data under all US climate conditions and to promote renewable energy technologies. This laboratory travelled the US for 3 years to all 48 continental states. At each site, solar heating/cooling and solar insolation data were collected. On this tour, he also served as NSF emissary in the promotion of solar heating and cooling and all other renewable energy technologies. A broad range of renewable technologies were displayed in this laboratory. In 1976, he joined the US ERDA serving as Program Manager for the Solar Heating/Cooling research program, developing research plans and formulating and directing research projects. In 1979 founded a solar heating and cooling research/commercial firm in Denver. He served as lead designer, designing and constructing residential and commercial solar systems throughout the Denver region including a residential cooling system. Systems were instrumented and successfully validated his system design analyses. In 1982, he served as consultant to the Office of Energy, Puerto Rico Commonwealth, exploring suitable solar applications for use in the Puerto Rican climate. In this role he designed a solar cooling system suitable for hot, humid climates. In 1983, he re-joined the US Dept. of Energy, San Francisco, and served as Program Manager for solar heating/cooling research.



Trevor Lee

Country: Australia

Year Started Research: 1975

Title of Research: Solar Energy in Architecture

University: University of Melbourne

Still Active in Research: Yes

Trevor Lee is an architect who has directed himself to energy issues in the built environment since his graduation with honours from the University of Melbourne in 1976. From 1985 to 1989, as the Senior Architect for Energy Management of the Commonwealth's construction authority (then called the Department of Construction), he prepared a series of in-house publications including those on setting energy targets for new buildings. From 1989 until 1995 he served as editor of "Solar Progress", the quarterly journal of the Australian and New Zealand Solar Energy Society, (ANZSES) and from 1996 to 1998 was chair of that organisation. He was also a founding director and later Vice-President of the Sustainable Energy Industry Association (SEIA) now the Clean Energy Council, CEC). He has also served as an executive director of Australian Ethical Investment Ltd, (ASX code AEF) manager of unit trust and superannuation funds now totalling over Au\$4.8 billion, from 1991 until 2003 and as a non-executive director for 2004. He served as technical adviser to the ACT Government for the first four years of its ground-breaking mandatory house energy efficiency rating (EER) scheme (applied both at building approval stage for new dwellings and at the advertising for sale stage for existing dwellings). He is also co-author of the Australian Solar Radiation Data Handbook (ASRDH) 1995 and its full revision in 2005 for ANZSES as well as providing technical direction for the updating of the Australian Climate Data Bank for 201 locations in ACDB (NatHERS), TMY2 and EPW formats. Trevor is now the Managing Director of Exemplary Energy, specialising in developing generic (Reference Meteorological Years, RMYs) and specialised weather and climate data for building and renewable energy system simulation. These include Real Time (Meteorological) Years (RTYs), P10 and P90 extreme meteorological years and Ersatz Future Meteorological Years (EFMYs).



Daniel C. Lewis

Country: United States

Year Started Research: 1974

Title of Research: Passive Solar Principles

University: Total Environmental Action, Harrisville, NH

Still Active in Research: No

Daniel Lewis, PE became interested in solar energy while a physics major at Bard College. He became a student member of the International Solar Energy Society in 1974 while at Bard. After Bard he attended UMASS Amherst where as a research assistant he worked on computer modelling of Ocean Thermal Energy Conversion power plants. He received a Masters in Mechanical Engineering and joined Total Environmental Engineering in Harrisville, NH in 1978. He was head of Consulting Services in the Design Department at TEA. Dan Lewis and Joe Kohler developed TEASOL, a thermal network mainframe-based computer model based on Joe's work with TEANET. This model was used to simulate the hourly energy performance of passive solar houses and was the tool used to develop the "Passive Principles" series of articles they wrote for Solar Age Magazine in the early 1980's. In addition, Dan was a reviewer for the early HUD Solar Grants issued under the Carter Administration. He helped develop a solar curriculum for the Tennessee Valley Authority, worked on the Brookhaven house for Brookhaven National Labs, and was a frequent presenter at solar conferences. Dan Lewis and Joe Kohler later founded Kohler and Lewis, a mechanical engineering firm that specialized in designing energy efficient HVAC systems. They were among the very first engineers to utilize energy recovery ventilation systems for schools and to utilize mini-split heat pump systems for heating in the Northeast. Kohler and Lewis designed the mechanical systems for many LEED projects and several Net-Zero and (successful) Living Building Challenge projects. Dan and his wife Lesle are retired and live in New Hampshire. They have a PV system and recently become part of an electric utility pilot project to study the impact of battery storage systems on electric utility peak's.



Eduardo Lorenzo

Country: Spain

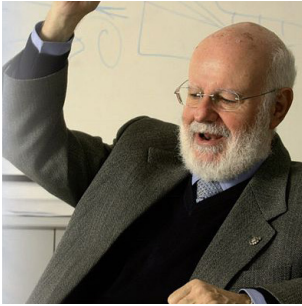
Year Started Research: 1979

Title of Research: Professor - PV Systems

University: Solar Energy Institute - Universidad Politécnica de Madrid

Still Active in Research: Yes

Professor Eduardo Lorenzo began his research in 1979 at the Solar Energy Institute of UPM in the field of photovoltaic concentration technology. He was one of the pioneers in bifacial PV module technology. His first article on the subject dates from 1984, allowing the transfer to the industrial sector through the creation of the Isofoton company, and installing the first bifacial systems between 1984 and 1989, some of them still in operation today. However, this early industrial production and practical use of bifacial PV modules has passed into oblivion. - But his truly pioneering character is shown in its decision in 1984 to focus its research on the PV system as a system, founding the Photovoltaic Systems Research Group (GSFV). Possibly one of the first to make this decision in the world. His first project dates from 1984 in Senegal. He was a pioneer in PV rural electrification with Solar Home Systems, for example in Sierra del Segura (Spain, 1987) or in the High Plateau in El Alto (Bolivia 1994), also in PV pumping systems, participating in the Regional Sahel Program in 1993. He also led the awakening of grid-connected PV systems with the world's first PV plant of more than 1MWp in Toledo, in which he designed one of the first horizontal north-south trackers that is still in operation. And he took advantage of the boom in the grid-connection market in Spain between 2005 and 2008 to lead quality control of more than 1GWp accumulated of PV plants not only in Spain but in more than 15 countries around the world, turning the GSFV into a benchmark in this matter. He began his career with PV modules of less than 30Wp in Spain and now he is researching on 400MWp PV plants in Mexico. This is the exciting life of a pioneer: you know where you start but you cannot imagine where you end.



Antonio Luque Lopez

Country: Spain

Year Started Research: 1976

Title of Research: Invention of the bifacial solar cell

University: Solar Energy Institute – Technical University of Madrid

Still Active in Research: Yes

Antonio Luque is a Spanish scientist and entrepreneur in photovoltaic solar energy. He graduated in Telecommunications Engineering at Technical University of Madrid (UPM) in 1964. He obtained his PhD in 1966, presenting the first laser developed in Spain. He soon became professor of physical electronics at the School of Telecommunication Engineering at UPM. His early research in photovoltaic devices in the mid 70s led to the foundation in 1979 of the Solar Energy Institute (IES) at UPM, one of the oldest research institutions worldwide fully devoted to photovoltaics. Prof. Luque's scientific work has been focused on reducing the cost of solar energy through the invention of photovoltaic novel concepts. In 1976, he invented the bifacial solar cell concept, able to convert the light received in both sides of the cell. In 1997, he invented the intermediate band solar cell, one of the very few solar cell concepts with potential to overcome the Shockley-Queisser limit and topic of research in many international centers. He has also worked on solar cells and optics for concentrator photovoltaics (CPV), publishing the first monograph in English language on the subject. Among other prizes, he has been awarded the Spanish National Research Prize (1987), the Alexandre-Edmond Becquerel Prize awarded by the European Commission (1992) and the IEEE William Cherry prize for research in solar energy (2006). He is also Doctor Honoris Causa by several universities and member of the Russian Academy of Science. Founder and chairman of the board of directors of Isofotón, company that manufactured and industrialized bifacial solar cells since the early 80s and one of the largest silicon PV module manufacturers in the early 2000. In 2006 he founded Centesil, a public-private partnership aimed at developing manufacturing techniques for solar-grade silicon, as well as the Institute for Photovoltaic Concentrator Systems (ISFOC), to launch worldwide the industrialization of CPV.



Erik Lysen

Country: Netherlands

Year Started Research: 1977

Title of Research: "Eindeloze Energie" (Endless Energy).

University: University of Eindhoven

Still Active in Research: Yes

Erik Lysen already started on renewable energy during his study at the University of Eindhoven. In 1977 he wrote a book on renewable energy inspired by the report of the Club of Rome. This has inspired many Dutchmen to become active in the field of renewable energy. He had several jobs as consultant. In 1992 he joined the Netherlands Energy Agency Novem where he was head of the Solar Thermal and the PV program. The PV program grew fast under his management. In 1996 he introduced the concept of the Trias Energetica at Eurosun in Freiburg. He also was one of the founders of the IEA PVPS program. He tried to get the ISES headquarters to the Netherlands, but Freiburg had a slightly better offer. He later worked in the University, as chairman of Holland Solar and chairman of the Research Board for research in the field of renewables and the built environment. In 2017 Erik received a royal distinction from the Minister of Economic Affairs (Henk Kamp). He is still active as adviser for the government of Sri Lanka.



Nobel Mezri

Country: France

Year Started Research: 1975

Title of Research: The solar heating and cooling applied to building and industry

University: University of Lyon (France) at the Institute of National Applied Sciences (INSA).

Still Active in Research: Yes

Nobel Mezri studied at the department of concrete, structures and thermal buildings part of civil engineering section of the National Institute of Applied Sciences (INSA) (University of Lyon, France). There, the topic of solar thermal research had been invented and proposed by Mezri in his thesis and would become the focus of his future industrial programmes as well as his patents. His first patent subsequently was called “Buildings shelled in structural-thermal solar” and was obtained in 1982. His doctoral research had lasted five years (1976 - 1980) and was exclusively self-funded, as, at this time, there were no research credits available on renewable energy. After his thesis, in 1993, he founded, among others, his own laboratory named MEZRI THERMOSOLAIRE which allowed him to diversify and improve his scientific and technological inventions and innovations in the field of solar and hybrid energy for the benefit of the carbon-free industry. In 2006, the European Commission chose his work on solar thermal as a reference programme for the building and industry sectors in Europe. With this, his research has served to initiate the European and planetary dynamic in terms of the energy transition, clean technology and the fight against global warming. In 2004, his patents and his carbon-free technologies allowed him to create his first solar thermal engineering company, followed by his company MEZRI THERMOSOLAIRE INDUSTRY in 2010. Mezri has had 45 years of high-tech solar experience adding value to his fight against global warming.



David Mills ISES President 1997-99

Country: Australia

Year Started Research: 1976

Title of Research: Prism Solar Concentrators, Non-Imaging Optics, Double Cermet Solar Absorbers, Linear Fresnel Reflector, Concentrators

University: University of NSW (UNSW), University of Sydney

Still Active in Research: No

Dr David Mills is a former ISES Vice-President (1995-97) and President (1997-99). He studied as masters and doctoral student at UNSW School of Physics from 1976-1980 in the areas of ideal asymmetrical non-imaging optical concentration systems such as the novel prism PV concentrator, and developed both asymmetrical and symmetrical reflector concentrating thermal systems. After graduating in 1980, he moved to the University of Sydney and he developed a pressurised water solar cooker design in the early 1980s. He obtained funding for and managed the development of advanced germanium and double cermet coatings for evacuated tube systems between and 1989 and 2004, working with Dr. Q-C Zhang. The double cermet coatings represented a very new and much lower emissivity design that became widely used in Chinese-manufactured evacuated tubes after 2004. David also developed improved linear Fresnel reflector concentrating systems in the early 1990s with Prof. Graham Morrison which were patented and demonstrated by the SHP and Ausra companies of which he was a co-founder, and commercial plants were built in Australia, USA and India. David also worked with his former student Dr Philipp Schramek and the CSIRO on advanced high density tower heliostat designs using a horizontal rotation axis and software driven collision avoidance which were subsequently built by the CSIRO and influenced later tower developments. After retirement in 2009, David delivered a well-attended conceptual paper co-authored by Dr. Weili Cheng at ISES 2011 illustrating that inflexible baseload power such as produced by coal was completely unnecessary if flexible designs like wind or solar with energy storage were available; this important flexibility argument afterward became fully appreciated by the renewable energy industry after the paper's graphs were quickly reproduced in the IEA2011 Perspectives publication and by other academic authors. David received an award from ANZSES as a Solar Pioneer in 2011 and was made a Member of the Order of Australia in 2015 for service to Physics and Solar Energy.



Ove Christen Mørck

Country: Denmark

Year Started Research: 1978

Title of Research: IEA Solar Heating and Cooling Programme - Task 1 - Investigation of the Performance of Solar Heating and Cooling Systems

University: Technical University of Denmark / Thermal Insulation Laboratory

Still Active in Research: No

Ove Christen Mørck (OM) has worked with planning and implementation of Energy Conservation and Renewable Energy integration in buildings, and environmental issues in Denmark and other European countries since 1974. First as a student, then as a researcher at the Technical University. Working here OM was Operating Agent for the mentioned project within IEA SHC. He also coordinated several EU research projects first for simulation and later for implementation of solar heating systems. Besides leading Task 1 OM has participated in Task 2, 5, 8 and 19. Later he participated in a number of research projects under the IEA EBC programme: 36, 56 and 75. Together with some colleagues from TUD OM established the company Cenergia Energy Consultants in which he has undertaken project leadership of and participated in a number of research, planning and implementation projects nationally and internationally. This work has been continued after Cenergia was bought by Kuben Management, where he has run national and international R&D&D projects. He has done several studies and projects directly assisting the Danish Energy Agency with planning and programme evaluation tasks. OM was leading the project when the Danish Energy Agency introduced energy labelling of buildings as the first country in Europe. OM has a profound knowledge on energy conservation and renewable energy technologies suitable for the built environment.



Don Morel

Country: United States

Year Started Research: 1971

Title of Research: Organic PV

University: Esso Research and Engineering Corporate Research Labs

Still Active in Research: Yes

Don Morel completed his PhD in Physics in 1971 at Tulane University and was hired by Elliot Berman who had formed a program at Exxon Research Labs in New Jersey to develop PV for terrestrial use. The program consisted of a research effort to develop thin-film organic solar cell technology and formation of a company in Boston, Solar Power Corporation, to manufacture Si PV panels. He was primarily involved with organic PV R&D in New Jersey, and he and his colleagues advanced the efficiency of organic solar cells to the 1% level. Subsequently the research was extended to a-Si and Se thin-film technologies. In 1981 he joined the newly-formed PV company, ARCO Solar, as Director of Advanced Research. His responsibilities included a-Si, CdTe and CIGS thin-film technologies. Subsequently he became Vice-President of Research with responsibilities that included scaling up a-Si to pre-manufacturing levels and formation of joint ventures with Siemens and Showa Shell. Activities in the research program also included development of a-Si based tandem devices and hybrid tandems between a-Si and CIGS technologies. In 1989 he joined the University of South Florida as Professor of Electrical Engineering. Together with his faculty colleague, Chris Ferekides, he established a 3000 ft² laboratory dedicated to the fabrication and characterization of thin-film electronic materials with primary emphasis on PV. Materials and devices under investigation included CIGS and related alloys containing Sn and Zn, CdTe, CdSe, ZnSeTe, transparent conductors, II-VI and I-III-VI₂ – based tandem devices, III-V LED's and thin film transistors. During the period 2004 -2009 he served as Chairman of the Electrical Engineering Department. He is currently an active member of the faculty and continues PV research.



Heinrich Morf

Country: Switzerland

Year Started Research: 1979

Title of Research: see publications

University: private

Still Active in Research: Yes

Heinrich Morf has been pursuing private research interests related to solar energy for many years as shown in his list of publications. (1979-now). He was a Reviewer for Solar Energy. (2010-2015). Member of COST – European Cooperation in the field of Scientific and Technical Research, Action ES1002, WIRE – Weather Intelligence for Renewable Energies. (2011-2014). Hochschule für Technik Rapperswil HSR, Institute for Solar Technology, Rapperswil, Switzerland. (04/04-12/04). Design and implementation of a computer simulation model for a façade element (solar collector without cover). His publications include: Regression by Integration applied to Ångström-Prescott-type relations. Proceedings of the International Solar Energy Society: Eurosun 2018; Regression by Integration demonstrated on Ångström-Prescott-type relations. Renewable Energy 127 (2018); Sunshine and cloud cover prediction based on Markov processes. Solar Energy 110 (2014); The parameterization of cloud cover. Energy Procedia 57(2014). A stochastic solar irradiance model adjusted on the Ångström-Prescott regression. Solar Energy 87(2013); The stochastic two-state cloud cover model (STSCCM). Solar Energy 85 (2011); The stochastic two-state irradiance model (STSIM). Solar Energy 62, (1998); A Stochastic Model for the Simulation of Solar Energy. Prize winning paper in a contest promoted by ESCA, a leading Brazilian engineering and automation firm in Portuguese (1984).



Graham Morrison

Country: Australia

Year Started Research: 1975

Title of Research: Solar thermal energy

University: University of New South Wales

Still Active in Research: Yes

Graham Morrison established solar thermal energy research at the University of New South Wales Sydney Australia in the 1975. Morrison researched and developed solar thermal energy products ranging from domestic solar water heaters to high temperature solar steam generation systems. The measurement and modelling techniques he developed were adopted as Australian and International Standards for rating the performance of solar collectors and solar water heating systems. He was actively involved with industry on the development of solar and heat pump water heaters and collaborated with the University of Sydney on the development of the first prototype of the horizontal tank solar water heater with plug-in evacuated tubes (now the most widely used solar water heater design in the world). Morrison developed computer simulation packages ranging from thermosyphon solar water heaters to large scale solar thermal power systems. He commercialised a range of solar thermal energy modelling packages including the Poolheat for designing solar and heat pump swimming pool heating systems and the TRNSYS extension package TRNAUS for modelling solar water heating system performance. He has a publication record spanning 45 years on solar thermal energy processes in International Journals and conference proceedings. Morrison contributed to United Nations Development Program solar thermal energy projects in China, Indonesia and India including the design and development of solar thermal energy laboratories in Beijing, Wuhan and Kunming China. He was also actively involved in UNDP funded postgraduate solar thermal energy training programs for Engineers in Indonesia, India, China, Thailand and Eritrea. After retiring as Director of the Solar Thermal Energy Group at UNSW in 2005 Morrison co-founded a company Solar Heat & Power with David Mills and developed the first large scale solar steam generation system supplying high pressure steam to the Liddell coal fired power plant in the Hunter Valley NSW.



Frederick Morse

Country: United States

Year Started Research: 1970

Title of Research: Management of Solar Energy R&D

University: US National Science Foundation and US Department of Energy

Still Active in Research: Yes

Frederick Morse first became involved in renewable energy issues in the late 1960s when he served as Executive Director of the White House Assessment of Solar Energy as a National Energy Resource. He then went to the National Science Foundation to help put together the solar energy R&D program that was recommended in that report. In 1976 he joined the US Department of Energy where he played a significant role in defining and managing the Solar Heating and Cooling, Photovoltaics and Concentrating Solar-thermal Power (CSP) programs. Frederick has served on the Boards of the American Solar Energy Society and the International Solar Energy Society collectively for decades. In the late 1970s he helped form the U.S. Passive Solar Industry Council and the U. S. Solar Energy Industries Association where he was a Board member for many years and chaired the Utility-Scale Solar Power Division. Frederick was active in the International Energy Agency where he helped to form, and Chair, the Solar Heating and Cooling Program and helped form the Photovoltaic Power Systems and Demand-Side Management Programs. He left the Department of Energy in 1989 and formed a renewable energy consulting company. In 2007 he became the Senior Advisor, US Operations for Abengoa Solar, Inc. where led the company's business development activities in the US. He played a key role in the development and financing of the Solana and Mojave CSP plants, each 280 MW with a combined investment of about \$4 Billion. Frederick is still active and working hard to re-open the CSP market in the US. He is a graduate of Rensselaer Polytechnic Institute, received an M.S. in Nuclear Engineering from MIT and a PhD in Mechanical Engineering from Stanford University.



Urs Walter Muntwyler

Country: Switzerland

Year Started Research: 1975

Title of Research: Application with thin film solar cells/ PV applications

University: Gewerbeschule Solothurn/ Ingenieurbüro Muntwyler/ PV LAB BUAS

Still Active in Research: Yes

Urs Walter Muntwyler's interest in PV started in 1975 with a search of applications for thin film solar cells - there were not many. In 1982 he got his engineering diploma with a work on "Maximum Power Tracker for PV". From 1982 he worked in the telecom company Hasler AG in a Pilot- and Demonstration program with PV and wind energy for telecommunication- and remote electrical power supplies (Hospitals in Rwanda 1984/86 and 87). In 1985 Urs Walter was the organizer of the first solar car race in the world, the "Tour de Sol 85" crossing Switzerland with solar energy, a successful PR Tour for solar energy. He organized this race up to 1992. The Tour de Sol races produced several spin-offs as: solar gasoline stations in 1986; grid connected solar cars in 1987; decentralized grid connected PV installations from 1986 on; the "first feed in tariff for PV" in Switzerland in Burgdorf in 1989; solar cars for everyday use 1986; light weight electric cars as the concept of the Smart car (now Mercedes Benz); Solar and PV companies as Solectria (US), Brusa AG (CH), Holinger Solar AG (CH), TWIKE AG (CH) etc. He held yearly conferences on the technique of solar cars and PV (with an annual conference book) were held in conjunction with a public exhibition called "Solarsalon" up to 1998. They presented solar cars, solar technologies, solar boats and in the last year in 1998, "solar planes" as the "Icarus" and other solar planes. His first book on PV was "Praxis mit Solarzellen" in the Franzis Verlag (Germany), it had 6 editions. In 1992 he prepared the course for "Planning of PV installations" for the governmental Swiss "program for the acceleration of renewable energies PACER". Since 2010 Urs Walter is Professor for PV system technologies and leader of the PV LAB of the Berner Fachhochschule. Their research activities are in the fields of "long term behaviour of PV installations", PV inverter measurement, PV2X and PV oriented buildings (PVOB) - www.pvtest.ch. From 1998 to 2018 he was chair of the technical collaboration program of the International Energy Agency IEA on "Hybrid and electric vehicles" (www.ieahev.org).



Shyam S. Nandwani

Country: Costa Rica

Year Started Research: 1977

Title of Research: Utilization and Promotion of Solar Energy, mainly Thermal Applications

University: Center of Energy Studies, Indian Institute of Technology, Delhi, India. Since Aug. 1978, Laboratorio del Energia Solar, Universidad Nacional, Heredia, Costa Rica

Still Active in Research: Yes

Shyam S. Nandwani completed his Ph.D. on Mossbauer Spectroscopy at IIT Roorkee, India, 1973. However due to the energy crisis, he started Solar Energy Research at IIT Delhi, India in 1977. In Aug. 1978 he moved to Costa Rica as Visiting Prof. to work on Applications (mainly thermal) of Solar Energy. Although he worked primarily as researcher and promotor of Solar Energy, from Feb. 1979 he did more work on Solar Cooking and got a patent in 1983. He has published about 20 articles on Solar Cooking, as well as publishing a book in Spanish, Horno/ Cocina Solar in 1992. Shyam Nandwani attended the ISES conference organised at Delhi, in Feb. 1978 and has been a member of ISES since 1982. He was Founder and President of Asociacion Costarricense de Energia Solar (ACES) during 1985-1996. Now he is an Honorary Member the new Asociacion ACESOLAR. He has published about 70 articles in journals and has attended 50 conferences in 40 countries. Shyam S. Nandwani retired in Feb. 2013 but continues to promote solar energy.



Monica Oliphant **ISES President 2008-2009**

Country: Australia

Year Started Research: 1977

Title of Research: Solar thermal energy research, heat pipe solar concentrators

University: Flinders University

Still Active in Research/Industry: Yes

Monica Oliphant played a very active role in ANZSES and AUSES; she joined the ISES board in 1997 and is still a member; and she was president of ISES in 2007-2009. Monica first became interested in renewable energy, and in particular solar energy, when she worked at Flinders University on solar thermal energy research, heat pipe solar concentrators, from 1977 to 1981. As a senior research scientist with the Electricity Trust of South Australia (ETSA) from 1981 to 2000, she undertook ground-breaking research into the role of renewable energy, energy efficiency and consumer behaviour in demand management for power networks. Also, she was involved in the SA 30 site wind resource monitoring program of 1984 -1988. The collected data showed where high wind energy potential sites existed and enabled developers to get off to a quick start in 2003 once State and Federal subsidies became available. Monica Oliphant runs her own Consultancy and is an Adj/A Professor at the University of South Australia and a University Fellow at Charles Darwin University. She has participated on many Australian Federal and State Government Committees, including the Mandatory Renewable Energy Target (MRET) Review Committee which introduced, amongst other things, a 15 year RECs deeming incentive for PV in 2003 and was team leader of a group looking into the feasibility of establishing a UN University in renewable energy in China. Awards received are an AO in the 2015 Queen's Birthday Honours List in recognition of her work in Renewable Energy, 2016 Senior South Australian of the Year and in 2018 received an Honorary Doctorate of the University of South Australia. She is also Patron of crowd funding Community Power group CORENA (Citizens Own Renewable Energy Network Australia).



Takhir Razykov

Country: Uzbekistan

Year Started Research: 1972

Title of Research: Technology and physics of thin film solar cells

University: Physical-technical institute, Uzbekistan Academy of Sciences

Still Active in Research: Yes

Takhir Razykov developed revolutionary novel and low cost and simple chemical molecular beam deposition method in the atmospheric pressure gas flow for fabrication of binary, ternary and multinary chalcogenide semiconductors films. Structural, morphological, optical, electrical and photoelectrical properties of II-VI, IV-VI and V-VI films and heterojunctions were investigated. High efficiency chalcogenides based thin film solar cells were fabricated.



Markus Real

Country: Switzerland

Year Started Research: 1975

Area of Research: Solar Power Plants

Institute: Federal Reactor Research Institute (EIR)

Still Active in Research/Industry: Yes

Markus Real studied engineering at the ETH from 1969 to 1974, did his doctorate under Peter Baccini, and began his first position in 1975 at the Federal Reactor Research Institute (EIR), now the Paul Scherrer Institute (PSI), with the planning of large solar power plants and pioneering work in the solar power plant sector. From 1975 to 1981, Real set up the solar power plant department at EIR and initiated the development of the first solar power plants in Almería / Spain in 1975. On behalf of the Swiss Federal Office for Energy, Real represented the burgeoning Swiss industrial interests in solar power plant construction. Sulzer was able to build the first sodium-cooled solar receiver for a test facility in Almería. In 1978 Real developed with the help of Claus Fröhlich, Head of the World Radiation Center in Davos, a simple apparatus the help of which not only determined the relative distribution of the strongly concentrated solar radiation in the MW / m² range could be determined, absolute values accurate to 1.5%, a development which brought the former EIR several measurement orders for solar tower power plants. The simplicity of the technology was convincing. Real was able to win the management of the institute to give him a free hand for the development of the photovoltaic system technology and for the purchase of the solar cells. The 1.5 kW solar modules from Arco were still very expensive back then. In November 1979 the first solar system, installed on the tool shed in front of the canteen, was connected to the grid for the first time and fed photovoltaically generated solar power into a European power grid. The EIR was a thermally oriented research facility and with the aim of further developing photovoltaics and wind power plants, Real founded Alpha Real AG in 1982.



Daniel Reif

Country: United States

Year Started Research: 1979

Title of Research: Solar Retrofit

University: Total Environmental Action (TEA) and Center for Ecological Technology (CET)

Still Active in Research: No

Daniel Reif is author of the books “Solar Retrofit: Adding Solar To Your Home” (Brick House Publishing Co., 1981), and “Passive Solar Water Heaters” (Brick House Publishing Co., 1983). In 1982, he founded Design Works, Inc., in Amherst, Massachusetts, to market his invention the “Solar Card,” a low cost solar siting and shading evaluation device. The Solar Card was also popular as a gardening and photography tool. The following year, he invented and marketed the “3-D Home Kit,” a three-dimensional, custom model building kit to help homeowners and designers integrate passive solar into their house designs. The kit provides complete poster-board materials with illustrations of various model building materials to construct a detailed, 1/4-inch scale model of your own design. A light is then used to simulate the movement of the sun. The “3-D Home Kit” is still a bestselling architectural design and education tool. Reif’s early solar training, design and building experience was as a team member at Total Environmental Action (TEA) in Harrisville, New Hampshire and Center for Ecological Technology (CET) in Pittsfield, Massachusetts, New England Project SUEDE (Solar Utilization, Economic Development and Employment). He currently lives in a passive solar home that he designed and built in 1980 in Amherst, Massachusetts. Reif graduated from Pratt Institute School of Architecture in 1971.



Dave Renné ISES President 2010-2019

Country: United States

Year Started Research: 1977

Title of Research: Solar and Wind Resource Assessments

University: American Institute of Architects (AIA) Research Corporation

Still Active in Research: Yes

DaveRenné has worked in renewable energy R&D programs for over 43 years. After graduating from Colorado State University (Fort Collins, Colorado, USA) with a Masters in Atmospheric Sciences and a PhD in Earth Resources in 1975, he started his renewable energy career at the U.S. Pacific Northwest National Laboratory (Richland, Washington USA) in 1977. He worked primarily on wind resource assessment programs, both in the U.S. and internationally. He was one of the early program area leaders to support the U.S. Department of Energy’s Wind Characteristics Program Element. He focused on wind resource assessments, wind monitoring programs, and wind turbine wake studies. He moved to the U.S. National Renewable Energy Laboratory (Golden, Colorado USA) in 1991 to manage NREL’s solar resource assessment activities and to work on a number of international renewable energy programs. He managed the development of the National Solar Radiation Database, first produced in the mid-1990’s, and subsequently updated several times. He introduced the use of satellite-derived solar resource estimates into the NSRDB as well as other solar resource programs at NREL. Following his retirement in 2012 he continues to remain engaged in renewable energy programs through his consultancy, Dave Renné Renewables. He is currently a Senior Consultant to Clean Power Research, and has consulted with the World Bank, the International Renewable Energy Agency (IRENA), the Asian Development Bank, and several private-sector organizations. He was involved in the early development of the Word Bank’s Global Solar Atlas as well as the IRENA Global Atlas. He served as Treasurer on the Board of the American Solar Energy Society for many years. From 2010 – 2019 he was President of the International Solar Energy Society and continues to serve on their Board. He has been an Associate Editor of the Solar Energy Journal for the past 15 years.



Graeme Robertson (1944-1996)

Country: New Zealand

Year Started Research: 1970's

Title of Research: Passive Solar architecture

University: University of Auckland

Still Active in Research: No

Graeme Robertson was person of action, energy, passion for the environment. As senior lecturer School of Architecture, University of Auckland and member of the Australia and New Zealand Solar Energy Society (ANZSES) for decades, he made his mark not just on those around him, but importantly with students and the world at large. He had vision and passion, right from a schoolboy when he would trudge to school, hand full of books and a bag full of Ban the Bomb leaflets! He was, from the beginning, impatient to impart his enthusiasm to save the planet to everyone. Active within the Passive and Low Energy Architecture (PLEA) groups of ANZSES and ISES, he had an absolute confidence that the next generation of students would find the solutions for a sustainable world. He championed energy efficiency, renewable energy and passive solar design in all buildings, particularly commercial buildings, as well as being an acknowledged world leader in sustainability. In 1991, Graeme published his seminal article Environmental response, in Architecture New Zealand, where he considered that the greenhouse effect and the associated global warming must be taken into account and not ignored anymore, arguing that architects needed to become part of the sustainable movement. He underlined that global warming was not a Third World tropical rainforest problem, which was a common misunderstanding, but rather a problem that was created by developed countries. Graeme was a generator of legends, and his contribution to New Zealand's NZIA Environmental Policy and the Environmental Position Papers set a standard which the rest of the world has followed.



Roberto Roman (1945 -2019)

Country: Chile

Year Started Research: 1965

Title of Research: Solar Energy

University: Universidad de Chile

Still Active in Research: No

Roberto Hernán Román Latorre, was by profession a Civil Mechanical Engineer, specialized in Solar Energy in Argentina, with postgraduate studies at the Heliophysics Department of the University of Provence, France and at the International Center for Theoretical Physics of Trieste, Italy; He was associate professor in the Department of Mechanical Engineering of the Faculty of Physical and Mathematical Sciences of the University of Chile and researcher at the Solar Energy Research Center (SERC-Chile), vice president of membership affairs of the International Solar Energy Society (ISES), and researcher and consultant in renewable energies both nationally and internationally, as well as the creator of EcoMaipo, an organization dedicated to education, training and bringing renewable energy to less favored sectors. Roberto Román entered the University of Chile in the 1960s, served as an academic at the Faculty of Physical Sciences and Mathematics until he was 74 years old. The professor and researcher, was much loved by his students and his peers, trained several generations of students, guiding professor of more than a hundred theses considered by his closest circle, as a passionate about "solar energy" and "teaching", in addition to his teaching role, he held various positions of responsibility, in the academy he was elected as the first director of its academic unit" Department of Mechanical Engineering "a position that he held twice more in 1996 and 2004. Internationally he was an ISES member since 1979 and was on the ISES board of Directors in 1991, 2010, 2012 and 2016. He also held the Vice Presidency of ISES Membership Affairs 2011-2012.



Harald N Røstvik

Country: Norway

Year Started Research: 1975

Title of Research: Architect MNAL - professor. Life long solar work: Buildings, villages, cities, cars, planes.

University: Private practice SunLab, Bergen School of Architecture, University of Stavanger

Still Active in Research: Yes

Professor Røstvik is a true pioneer. Since 1975 he has been engaged in research, design, publication and dissemination to share information about the solar potential. He has designed solar systems or buildings in Sri Lanka, Mali, Italy, Cyprus, Sweden and Norway. He has written ten books about the transfer from between fossil fuels to solar. Written thousands of articles, spoken at numerous conferences and tutored thousands of students mostly on Master but also on Phd level. He was the first Norwegian engaging in Tour the Sol in Switzerland by creating media attention to it since 1984. He designed Europe's first modern renewable energy based solar building with state Housing bank standard at Building for the Future exhibition in Stavanger, Norway in 1988 ("Chanelle"). He designed with Peter Opsvik "Butterfly", a third world city solar taxi in 1995. His book "The Sunshine Revolution" and the video in 1992 sold in 52 countries and was read by 4 presidents of the world. He is still active at 71 years old and the university UiS just renewed his contract for teaching till 2024. Two years ago - at 69 - he won the prize of the best Master level teacher at the Faculty of Science and Technology (UiS). Selected among all students at the faculty. They claimed; "he loves his work, believes in the future and installs hope in the students to compete the "no-hope-future mentality many possess."



Valeriano Ruiz

Country: Spain

Year Started Research: 1970's

Title of Research: Thermodynamics/Solar Thermal

University: University of Seville

Still Active in Research: Yes

Valeriano Ruiz was professor on thermodynamics at the Industrial Engineer School – University of Seville – when the CSP demonstration plants at the Almeria Solar Platform (PSA) were built in the early 80's. He was teaching on solar concentrating technologies at those early times and was a permanent source of human talent for the PSA. In fact, some of his students became directors at the PSA at certain points in time. He was a tireless advocate for concentrating solar applications for both power and heat. He participated in previous projects to the PS10 CSP plant, built by Abengoa, which was supported to a large extent by Valeriano's arguments. In 2004 he was founder of the Spanish CSP industry association, Protermosolar, along with half-dozen Spanish CSP developers and he was its first president until 2012. The Spanish Feed in Tariff for CSP plants, which allow the largest deployment of CSP in the world – 50 plants totalling 2,3 GW – had his clear footprint. This favourable regulation, which enabled the investment decisions, were seriously threatened by the government in 2009 and 2010. He, as president of Protermosolar played a key role in the hard negotiation process with the government to settle reasonable conditions to complete the construction of the complete Spanish fleet. He was the driving force behind the creation of the Andalusian Renewable Research Center in 2008 and appointed president. He published a lot of articles enhancing the appreciation of CSP plants by policy makers. He wrote the book "Solar Thermal Electricity, so far so close" in 2009 and was the editor of the collective book "Solar Thermal Power, History of a research success" focusing on the creation of the PSA, which become a reference book for the sector. He is still providing valuable reflections on CSP technology and supporting projects on solar process heat.



Gerhard Schriber

Country: Switzerland

Year Started Research: 1978

Title of Research: Promote research of renewable energies

University: Swiss Swiss Federal Office of Energy

Still Active in Research: No

The physicist, Gerhard Schriber joined the Swiss Federal Office of Energy (BFE) in 1978. His assignment was to initiate and promote research of renewable energies. In 1984 he became the head of the newly established BFE Energy Research Section. Together with his team, he clearly structured Swiss energy research and initiated an expert network among universities, industries, financial institutions. This led to a fruitful culture of collaboration that continues to this day. In connection with his work – mainly in the field of solar research and other renewable energies – Dr. Schriber became a member of several important national research institutions, among them the Federal Energy Research Commission, the Swiss National Foundation, the ETH-Council, the Science Council, the National Energy Research Foundation and the Innovation Promotion Agency. Dr. Schriber is a strong supporter of international collaboration in energy research. Whenever possible he embedded Swiss research in international frameworks. The International Energy Agency (IEA) provided ideal opportunities for this. As the Swiss representative he played an active and sometimes leading role in several IEA research programs. He was elected to chair the IEA Solar Heating and Cooling Program and the IEA Hydrogen Program. He was also a member of the IEA Renewable Working Party (REWP) and later the IEA Commission of Energy research and Technology (CERT). As an active retired person, he lectures in a school of engineering, where he has introduced a course 'Energy and Environment'.



Jean-Marc Suter

Country: Switzerland

Year Started Research: 1977

Title of Research: Potential and limits of solar thermal technology in the different climate zones of Switzerland / System optimization

University: Swiss Federal Institute for Reactor Research (EIR), today the Paul-Scherrer Institute

Still Active in Research: No

The first test method for the thermal performance of solar collectors has been developed. Solar collectors of the Swiss market have been tested. About 30 solar systems for hot water preparation, space heating and/or swimming pool heating of the pioneering period have been monitored and analysed. Reasons for reduced solar system performance have been identified. The factors for optimal performance have been classified according to their relevance. Design recommendations for the practice have been worked out. Knowledge transfer to the Swiss stakeholders of the solar thermal market was initiated. Jean-Marc Suter has been teaching for 25 years at the University of Applied Sciences in Basel. 500 architects and engineers got the information in the framework of a one-year course on renewable energy and energy efficiency in buildings. In addition, knowledge transfer to the international solar energy community took and is still taking place through his participation with ISO/TC180 "Solar energy" and CEN/TC312 "Solar thermal systems and their components" since 1989. In particular, he has been the convenor of the Working Group that created the first version of ISO 9488 "Solar energy – Vocabulary". Jean-Marc also led the project team that worked out the series of standards EN 12977 "Solar thermal systems – Custom-built systems". Nowadays, he is representing the solar thermal community in CEN/TC164/WG2 "Water supply – Internal systems and components". This Working Group is revising EN 806, the basic standard dealing in particular with drinking water hygiene requirements, e.g. protection against Legionella proliferation.



Richard Swanson

Country: USA

Year Started Research: 1974

Research Topic: Semiconductor properties of silicon relevant for better understanding the operation of silicon solar cells.

Institute: Stanford University

Still Active in Research :

In 1974, Prof. Swanson received an IBM post-doctoral fellowship at Stanford University to study techniques for solar-electric power generation. In 1976, he joined the faculty at Stanford as assistant professor of Electrical Engineering and obtained funding from the Electric Power Research Institute to investigate thermophotovoltaic energy conversion for solar applications. Since then, he has been actively involved in photovoltaic research and industrialization. He was promoted to Associate Professor in 1982. At Stanford Prof. Swanson supervised 13 doctoral students, many of whom are active in the photovoltaics industry. His areas of research have generally involved investigation into the semiconductor properties of silicon relevant for better understanding the operation of silicon solar cells. This has included studies of heavy doping effects, surface recombination, minority carrier transport, gettering, defect recombination kinetics, Auger recombination, and light-trapping. These studies helped pave the way for steady improvement in silicon solar cell performance. Prof. Swanson and his group conceived and developed the point-contact solar cell. Laboratory version of these cells achieved 28 percent conversion efficiency in concentrator cells and 23 percent large-area one-sun cells. In 1991 Prof. Swanson resigned from his faculty position to devote full time to SunPower Corporation, a company he founded to develop and commercialize cost-effective photovoltaic power systems. Prof. Swanson has received widespread recognition for his work. In 2002, he was awarded the William R. Cherry award by the IEEE for outstanding contributions to the photovoltaic field, in 2006 he was awarded the Becquerel Award from European Commission and in 2011 the Karl Boer Solar Energy Medal of Merit.



Yiannis Tripanagnostopoulos

Country: Greece

Year Started Research: 1978

Title of Research: Novel Solar Collector

University: University of Patras / Solar Energy Laboratory

Still Active in Research: No

Dr. Tripanagnostopoulos started work as an Assistant at the University of Patras in 1978 and, after open elections, was elected a Professor in the Physics Department at the University of Patras and Director of the Environmental Sciences Department for post-graduate studies in 2014. Yiannis was a long standing member of ISES, ASES, ISHS and the Greek Societies of Solar Energy and Wind Energy, and in 2015 he was made a member of the Academy of Sciences and Arts of the Republic of SPRSKA. Throughout his more than 35 year research career, his work spanned in the fields of Solar Energy Systems, Renewable Energy Sources (RES) and the Environmental Impact of RES. His particular interests included: liquid and air solar thermal collectors, thermosiphonic and Integrated Collector Storage (ICS) solar water heaters, solar air collectors, Compound Parabolic Concentrator (CPC) collectors, concentrating systems e.g. Fresnel lens, and passive solar energy systems. His research later expanded to cover: photovoltaics, hybrid photovoltaic/thermal (PV/T) solar energy systems, concentrating photovoltaics (CPV), and concentrating PV/T systems (CPVT). There was also an applied element to his work: combined solar energy and wind energy systems, integration aspects of RES in buildings and on the energy control of building atria and greenhouses, and applications of RES to industrial and agricultural sectors. In many of these areas, his contributions are considered pioneering. He published 40 journal papers, 114 international conference papers, and 45 national conference papers; work which received more than 1800 citations. Alongside his own publication activities, he contributed substantially to the peer-review system and reviewed many papers for international scientific journals such as Renewable Energy, Solar Energy, Energy, Solar Energy Materials and Solar Cells, Applied Thermal Engineering, and for many international and national conferences.



Ioannis Tsipouridis

Country: Greece

Year Started Research: 1977

Title of Research: Enhancement of solar cell efficiency by infra-red absorption

University: Fuel and Energy Dept., Houldsworth School of Applied Sciences, The University of Leeds, UK.

Still Active in Research: Yes

A new approach to the photoelectrochemical conversion of solar energy has been investigated. A new cell configuration was tested in an attempt to enhance the efficiency of a solar cell by infra-red absorption. The cell designs tested succeeded in utilizing the thermal effect of the infra-red region of the incident radiation to further improve the cell's operational characteristics. The advantages of this novel cell design are twofold. Firstly, it achieves power output enhancement by infra-red absorption and secondly it simplifies cell design since previously, means had to be provided for the filtering out of infra-red radiation in order to spare the solar cell of its harmful thermal effect. Therefore, the new cell utilises both the photo and thermal effects of the incident radiation and can be thus termed a Thermophotoelectrochemical cell. The use of this configuration increased the cell's efficiency energy conversion by 130%. It was further attempted to investigate the electrochemistry of a photogalvanic and a photovoltaic cell in an effort to improve the cells operational characteristics, and to ultimately combine the photogalvanic and photovoltaic responses in order to create a Thermophotogalvanovoltaic electrochemical cell, which was expected to have improved characteristics. This novel cell was expected to be responsive to the infra-red (thermal), the visible (galvanic) and the ultra-violet (voltaic) regions of the incident radiation. The present work failed to add the two photo responses, but the investigation produced results upon which further research could be based for the eventual creation of the photogalvanovoltaic cell which could store as well directly convert light energy to electrical energy. The reproducibility of results, the cell's stability, and the lack of time degradation of the cell's response were also investigated and were found to be very good. The efficiency of conversion was found to be 0.45%, while the maximum photovoltage obtained was 0.75V, both values comparing very well with those found in literature.



John Twidell

Country: United Kingdom

Year Started Research: 1976

Title of Research: Appropriate technology and renewable energy

University: Universities of the South Pacific (Suva, Fiji) and Strathclyde (Glasgow, UK)

Still Active in Research: No

John Twidell's research started for benefits in appropriate technology. Early topics with graduate PhD and MSc students included solar crop drying, microhydro power, wind power, combined heat and power and energy surveys. Major projects with EU and UK funding for equipment and research fellows included (i) monitoring passive-solar, low-energy buildings fitted with transparent insulation to accommodate 300 students in Glasgow; (ii) using large scale test-cells to monitor and model solar building fitments; (iii) installing and operating wind turbines for island communities; (iv) operating an innovative 3 MW wind turbine, and; (v) arranging conferences for 'Energy for Rural and Island Communities'. A textbook 'Renewable Energy Resources' was written with colleague A.D. (Tony) Weir, and is now in its 4th edition.



Lorin Vant-Hull

Country: United States

Year Started Research: 1972

Title of Research: Solar Thermal Power Systems based on Optical Transmission --Solar Tower or Central Receiver

University: University of Houston

Still Active in Research: Yes

Professor Vant-Hull was Principal Investigator on the first modern feasibility study of the central receiver concept. This involves the optical transmission of sunlight reflected from thousands of large mirrors (30-100 sq m), which are tracked to concentrate the sunlight onto an elevated central receiver. With a concentration of over 1000 suns, energy is absorbed and efficiently transferred to a working fluid at 500 to 800+ deg C. Typically, molten salt is used so the hot fluid remains at atmospheric temperature and can conveniently be stored in a hot and a warm tank. When needed, hot salt is heat exchanged to generate steam suitable for a utility scale turbine and dispatchable electricity is provided to the grid. Vant-Hull was responsible for the development of computer codes which provided sun positions, solar intensity, cosine effects on the heliostats, shading and blocking of heliostats, and solar flux density distributions on the receiver. After noting that radial arrays performed best, the radial-stagger configuration was developed to minimize S&B effects. With support from MacDonnell Douglas, we also developed appropriate cost models including variation with appropriate parameters such as tower height, power level, receiver size, etc. allowing for detailed cost-effective optimization of the system. Thus, the external receiver with a surround field is found to perform better on an annual basis than any flat plate or cavity receiver. He provided design assistance to most of the major players in the 1980-2010 time frame and has served on numerous NSF, Sandia, NREL, and DOE proposal review panels and program reviews. In addition, he was selected to participate in President Carter's Scientist Exchange program with Russia. Vant-Hull has also been an associate Editor of the Journal of Solar Energy since 1974 and has authored numerous peer-reviewed papers, innumerable proceedings papers and progress reports, has authored four book chapters, and is co-editor on one of the books.



Sudhanshu Varma

Country: Canada

Year Started Research: 1975

Title of Research: Development of Schottky Barrier / MOS Solar Cells

University: Indian Institute of Technology - Kanpur, India

Still Active in Research: No

Dr. Sudhanshu Varma is a Materials Scientist with specialization in fabrication and characterization of semiconductor materials and devices for solar cell applications. He has been involved in the solar photovoltaic field for the past 45 years. He started solar cell research at the Indian Institute of Technology, Kanpur in India in 1975 during his M. Tech. program. His initial research was aimed at fabrication and characterization of thin films, and Schottky Barrier / MOS solar cells. Over the next eight years, he diversified his research at IIT Kanpur to include fabrication and characterization of p-n homojunction and heterojunction solar cells, studying the performance of solar cells under concentration, and deposition and characterization of Tin Oxide and Indium Tin Oxide antireflection coatings and transparent-conductor-oxide-semiconductor surface barrier devices (solar cells) - which led to his Ph. D. in Materials Science. Dr. Varma transitioned to solar industry in India in 1983 by joining Central Electronics Ltd, where he got involved in solar module production technology, solar module testing and managing commercial solar module production. He moved to Canada in 1984 and joined TPK Solar Systems in Ottawa where he became involved in the development of commercial p-n junction silicon solar cells and solar module manufacturing technologies, commercial production of solar modules, and international technology transfer while setting up turnkey production lines for customers in different countries. He also conducted research on screen printed antireflection coatings as well as screen printed diffusion sources aimed at developing manufacturing technology for all screen printed solar cells. Moreover, he became involved in the development of customized solar cell and module manufacturing and testing equipment. He also conducted research on spray deposition of antireflection coatings and diffusion sources.



Sigurd Wagner

Country: USA

Year Started Research: 1973

Title of Research: CuInSe₂/CdS heterojunction photovoltaic detectors

University: Bell Telephone Laboratories

Still Active in Research: Yes

Sigurd Wagner is Professor Emeritus of Electrical Engineering and Senior Scholar at Princeton University, where he has been working since 1980. He received his Ph.D. in physical chemistry in 1968 from the University of Vienna in Austria, came to the US as a post-doc at Ohio State University, worked at the Bell Telephone Laboratories from 1970 to 1978, and organised solar cell research as the founding chief of the Photovoltaic Research Branch at the Solar Energy Research Institute (SERI, now NREL) from 1978 to 1980. At Bell Labs he pioneered the fabrication of junction devices from chalcopyrites, a class of ternary compound semiconductors. Intense interest in green light-emitting diodes led to the p-CuGaS₂/n-CdS heterojunction (1973). The p-CuInSe₂/n-CdS heterojunction photodetector was motivated by then-anticipated, GaAs laser-based, fiber-optical communications (1974); this device's surprisingly high, broadband, quantum efficiency made it an efficient solar cell (1975). Solar cells of CuInS₂, CuGaSe₂, the quaternary compound Cu₂CdSnS₄, and InP followed, as well as isotype heterojunctions and photochemical electrodes. In 1978 Wagner joined SERI to initiate and organize its solar cell research program. Pursuing his primary interest in research he moved to Princeton in 1980, focused until the mid-1990s on hydrogenated amorphous silicon for solar cells, then transitioned to a program on a-Si thin-film transistors. TFTs became the vehicles for foundational experiments on large-area electronics made of flexible, shapeable, and elastically stretchable optoelectronic surfaces, including their basic design rules and architecture. Wagner is considered to be the father of the field of electronic skins. At present he is working with his colleagues Jim Sturm and Naveen Verma on complete large-area hybrid thin-film/CMOS systems for sensing applications. He continues to enjoy and greatly benefit from collaborations with colleagues and students, which still extend to occasional excursions into solar cell research.



Zhiqiang Yin

Country: China

Year Started Research: 1978

Title of Research: Solar Thermal

University: Tsinghua University

Still Active in Research: Yes

Yin Zhiqiang, is a Professor at Tsinghua University, Beijing and is the Chief Scientist for Tsinghua Solar Ltd., Beijing, China, and has been working on solar thermal since 1978. He invented "Al-N/Al selective absorbing surface" using a single-cathode magnetron sputtering, which has optimum solar absorptance and emittance with low cost. He also invented the "Water-in-glass" close-coupled solar water heater, and "E-W" direction of tubes of solar collectors and systems. He and co-workers developed the production line for manufacturing all-glass evacuated collector tube, all-glass evacuated tube collector and systems. He is the first author of three China national standards—"All glass evacuated solar collector tube", "Test methods for thermal performance of domestic solar water heating systems" and "Specification of domestic solar water heating systems" which are useful for supporting the developments of solar thermal industry. Today he is the project leader of ISO 22975-4 Solar Energy – Collector components and materials Part 4: Glazing material durability and performance. The Solar Water Heater industry has realized commercialization and has solar water heater's production chain including borosilicate glass 3.3 tube, sputtering coaters, machinery tools, welding machine and polyurethane casting machine, etc. China has total installed capacity of solar collectors in operation of approximately 374 million m², 2013, which was around the world market share of 70.0%, saving about 43 million tce. All-glass evacuated tubular collectors have over 80% of the domestic market share in China and have been exported to many countries in the world. China has been the biggest producer and user of solar water heaters since the 1990s, and solar thermal conversion is environmentally friendly, especially the contribution to mitigate CO₂ emission.



Martin Zogg

Country: Switzerland

Year Started Research: 1975

Title of Research: Computer simulation of solar water heating

University: University of Applied Sciences, Burgdorf

Still Active in Research: No

The widely diverging predictions for the usefulness of solar water heating motivated Martin Zogg, professor in process engineering at the University of Applied Sciences in Burgdorf (Bern), to the first dynamic simulation of a complete thermal solar system in Europe. In 1975/1977 Zogg developed a pioneering program based on hourly meteorological data. Because there were no experimental data available even the collector efficiency had to be calculated. As confirmed by later validations, the pioneering program was already able to reproduce the dynamic behaviour of a solar hot water heating system quite precisely. This made it possible for the first time to determine the profitability of solar hot water systems and to design such systems in a well-founded way. In 1977 Zogg published his calculation models in detail. That aroused the interest of Gerhard Schriber, the later head of the Swiss Energy Research Program. He enabled the further development by several projects at the University of Applied Sciences in Burgdorf. Under the direction of Zogg and Roland Hungerbühler, Medard Rieder and Markus Arnet as scientific assistants the following upgrades were made:

1981 Integration of experimentally determined collector efficiencies;

1982-1983 Thermally stratified storage tank, analytical solutions, improved solar radiation conversion;

1984 Systems with two stratified storage tanks and further control concepts;

1985 Validation on experimental reference systems;

1986-1987 Dimensionless number method for assessments without simulation, simulation of thermosiphon systems;

1988 Integration of systems with combined water and space heating.

However, the ten-year path to a general recognition as a planning tool was quite painful. The turning point came with the validation of the simulation programs on reference systems. The practitioners were amazed that the calculated results matched the measured results within the scope of the measurement accuracy. Today, Zogg's ideas live on in the much more advanced and extended program "Polysun".

7.9 Industry Pioneers 1970-1979



Jennifer Adams

Country: United States

Year joined industry: 1977

Company first worked for: Total Environmental Action

Technology area: Solar Thermal

Still active in the industry: No

Jennifer A Adams began working in the solar industry in 1977 after hearing a representative from Total Environmental Action in Harrisville, NH come to speak at her college. After graduation, she began work there as a designer and specifier and researcher, alongside the earliest pioneers in the solar industry: Bruce Anderson, Daniel Scully, Paul Sullivan, Charles Michael, and Doug Mahone. Along with engineers Peter Temple, Joe Kohler, and Dan Lewis, she researched and illustrated MODEL-TEA: A Construction Manual, a step by step guide for sizing and constructing passive and active solar panels. In 1981, Jennifer A Adams became Building Editor for Solar Age Magazine and a contributing editor to Renewable Energy News and to Progressive Builder. She has been a contributing writer and editor to numerous magazines, including New Shelter Magazine, Popular Science, The Construction Specifier Magazine, Practical Homeowner, and the AIA Journal. She is the author of Solar Churches and author of Building Details for Energy Conservation; co-author of Solar Heating: A Construction Manual, Study of Photovoltaic Residential Retrofits, The New Solar Home Book, Ecologue: The Environmental Catalogue and Consumer's Guide for a Safe Earth; and editor of Solar Energy Handbook, 2nd Edition, The New Solar Home Book, Fuel Savers, and Passive Solar Energy. Since retiring from the solar industry, she has put her knowledge and experience into designing and building homes for Habitat for Humanity.



Tapio Alvesalo

Country: Finland

Year joined industry: 1979

Company first worked for: Neste

Technology area: PV

Still active in the industry: Yes

Tapio Alvesalo joined Neste in 1979 and from 1983-1989 Dr. Alvesalo headed Neste Battery Division's strategic R&D on advanced energy storage technologies and electric vehicle concepts. While in this role he saw the potential between the PV industry and the work being undertaken in storage and electric vehicles. He proposed that Neste enter that market and 1986 Neste launched a new business called Neste Advanced Power Systems (NAPS). He was the Chief Executive Officer of NAPS from 1986-1998. He was also the Chairman of the Board of NAPS International from 1998- 2004. NAPS developed and marketed advanced energy systems based on solar electricity, wind, hydrogen and fuel cell technologies and supplied products to over hundred countries world-wide. From 1993-1998 Dr. Alvesalo chaired the Finnish National Research Program on Advanced Energy Systems and Technologies. He was also on the on the Board of the European Industry Association (EPIA) for many years and was twice chairman . He was also a Member of the Board of the Finnish Academies of Technology. In 1993 Dr. Alvesalo was awarded the Medal of Honour, Knight First Class under the Order of the Lion of Finland, granted by the President of the Republic of Finland. In 2000, after the merger of Neste Oy with the national power company IVO Oy and the subsequent formation of the Nordic leading energy company, Fortum Corporation, Dr. Alvesalo was appointed Vice President, Corporate Technology. After his retirement in 2004 he was invited to direct the Finnish Millennium Prize Foundation and he acted as Secretary General during 2004-2009. He later was a board member of the Finnish Solar company known as Solnet.



Bruce Anderson

Country: United States

Year joined industry: 1972

Company first worked for: T.E.A. Inc (Total Environmental Action, Inc.)

Technology area: Solar Architecture/Buildings

Still active in the industry: Yes

Bruce Anderson began his solar industry career in 1973 with his MS thesis at MIT called “Solar Energy and Shelter Design”. He founded T.E.A. Inc. (Total Environmental Action), which became one of the largest and best-known solar design, research, and education firms in the world. It designed more than a dozen distinguished breakthrough solar buildings and consulted on 100s more. Its dozens of education classes and countless publications trained thousands of people. T.E.A.’s Foundation weatherized low-income dwellings. He co-founded SolarVision Inc., which published “Solar Age” magazine from 1976 to 1986 and which was the official magazine of the American Solar Energy Society (ASES); followed by the newsletter “Solar Industry Bulletin”; the newspaper “Renewable Energy News”; the quarterly “Solar Products Specifications Guide”; and numerous solar catalogs and books. He self-published “The Solar Home Book”, which became an international best seller and created Brick House Publishing, which published numerous energy books. In 1981 it published his “Passive Solar Energy”, which was the first book on passive solar. His 1977 “Solar Energy: Fundamentals in Building Design” published by McGraw-Hill became a best-selling college textbook. His books have been translated into several languages. The American Solar Energy Society honored him with its first “Outstanding Solar Contribution Award” in 1985. MIT Press published “Solar Building Architecture”, which he edited and which is volume 9 in the Series “Solar Heat Technologies: Fundamentals and Applications,” edited by Charles A. Bankston. He was the founding Vice-Chair of the New England Solar Energy Association in 1975, was a director of ASES, and was a founding Chair of the New England Clean Energy Council in 2006. Recently, Bruce co-invented a 1000oC solar heat platform and, as CEO of 247Solar Inc., is commercializing 247Solar Plants™, the platform’s first product. The Plants produce power and high-quality heat 24/7.

Gad Assaf

Country: Israel

Year joined industry: in the 1970’s

Company first worked for: Weizmann Institute of Science

Technology area: Solar Thermal

Still active in the industry: Yes

Gad Assaf is a physicist initially interested in atmospheric phenomena. In early 1970’ still at the Weizmann Institute he got interested in solar Ponds and was able to describe the flow in a mass of water stratified by a density gradient where a current at a certain density would mix with the surrounding water. This was important because it made possible to extract the hot brine at one end of the pond and return it at the other end without the need for a large heat exchanger at the bottom of the pond and related temperature drop. In 1975 he joined Ormat and was instrumental in the 5 MW Solar Pond Power Plant Project. US Patent 4,337,0711 (1987) Solar Power Station. Later he established the theory of the solar tower proposed originally by Carlson in 1975. US Patent 4,801,811 (1989) Generation of Electricity in an Arid Environment Using Ducts. Finally he proposed a power system using the vapor pressure difference between brines at different concentrations US Patent 4,617,800 (1987). After leaving Ormat, Assaf joined AGAM Systems Ltd where he developed other energy conversion devices.



Hubert Aulich

Country: Germany

Year joined industry: 1974

Company first worked for: Siemens Central Research Laboratories

Technology area: PV

Still active in the industry:

Dr Aulich joined the Central Research Laboratories of Siemens AG in Munich, Germany, in 1974 where he worked in various positions in the field of optical fibre communication and photovoltaics. From 1988 to 1991 he was managing director at PV Electric, a joint venture of Siemens Solar GmbH, Germany, and Arco Solar, USA, where he was responsible for the commercialisation of amorphous silicon thin film technology. In 1992 he became managing director at Siemens Solar GmbH where he was responsible for technology of thin film and crystalline silicon solar cells. He was senior vice president for technology and research for the Siemens Solar Group responsible for research and development in thin film and crystalline silicon solar cells as well as for systems application for Germany, USA and Japan. In 1997 he founded PV Silicon GmbH with his partner Dr Friedrich Wilhelm Schulze. In 2002 PV Silicon merged with Crystalox to PV Crystalox Solar GmbH and he became a member of the Board. At PV Crystalox he had responsibility for the German operations including the production and sales of wafers and was appointed as a director of the Company in 2007. In 2008 he became chairman of the five-year long project SolarValley Mitteldeutschland which involves 35 companies, five universities and nine research institutes working on the entire crystalline silicon value chain with the aim of reducing the cost of solar electricity to below that of conventional power. In 2014 he was founder and president of SC Sustainable Concepts GmbH which provided solar powered water purifiers for developing countries. In 2018 he found PVWater International Ltd. in Nigeria, a joint venture between SC Sustainable Concepts and KXN Nigeria.



Teun Bokhoven

Country: Netherlands

Year joined industry: 1979

Company first worked for: Solair Systems

Technology area: PV

Still active in the industry: Yes

Teun Bokhoven graduated in 1977 from UTS Utrecht as a civil engineer. In 1979 he started his own company Solair Systems, and subsequently merged the company to become ZEN. In 1983 he was one of the founders of the Dutch association Holland Solar. Since that time, he has been active in the national and international trade associations. In 1995 he managed to get the solar thermal industry to sign a long term agreement with the Dutch government to stimulate the market. Currently director of ConSolair Ltd. From 2001 - Chairman of the NVDE (Dutch Renewable Energy Association) - an umbrella organisation of all Dutch Renewable Energy associations (wind, solar, bio-energy, geothermal and energy storage, heat pumps and water-energy) and companies - united over the entire supply chain. The main objective of the NVDE is to create a robust and active energy transition where all renewable options will develop strongly in order to transfer our energy system with urgency towards a 100% renewable energy system. Since 2012, Teun has been heading the board of the Top Consortium for Knowledge and Innovation. TKI0 is a public-private-partnership which aims to boost the innovation process for energy saving and renewables, in particular solar energy in the built environment and incorporates this in a smart energy system. TKI Urban Energy focuses on break-through innovations which will have a significant contribution to energy reduction as well as strengthening the position of the Dutch industry and knowledge sector.



Anil Cabraal

Country: United States

Year joined industry: 1978

Company first worked for: DHR Inc.

Technology area: Renewable energy project development and investment

Still active in the industry: Yes

Anil Cabraal's work in photovoltaics began in 1978 when he led a multi-country PV for agriculture market assessment in developing countries study for NASA Lewis Research Center. Quite a challenge when PV was \$20/Wp! That led to his lifelong fascination with PV for off-grid applications in developing countries – examining opportunities and supporting PV market development in communications, rural small industries and in rural water supply. Anil's projects helped mobilize hundreds of millions of dollars in development finance for off-grid PV in Indonesia, Sri Lanka, China, Myanmar, India, Bangladesh, Indonesia, Tanzania, Liberia, among others. In 1990, he began working with Bud Annan of US Department of Energy, to identify investment opportunities for PV for the World Bank. Anil joined the World Bank's Asia Alternative Energy Program in 1992 and led the World Bank's strategy to meet the 2004 Bonn Commitment to increase lending for renewable energy and efficiency by 20 percent a year over five years. They succeeded spectacularly – with lending rising from under \$2 million prior to 2004, to \$3 billion in 2010. He is particularly proud of collaborating with Peter Varadi, the founder of Solarex Inc., and launching the Photovoltaic Global Approval Program – It was the first quality labelling program for off-grid PV, later adopted by IECCE. Anil was a co-founder of the World Bank/IFC Lighting Africa Program to support a massive expansion of the commercial market for off-grid solar/LED lighting in Africa. It has now morphed into the Lighting Global Program benefitting hundreds of million people with increased access to off-grid electricity. He was honored to receive the Professor Robert Hill Award for his contributions to photovoltaics for development at the European Photovoltaics and Solar Energy Conference and Exhibition in 2005. The 40+ year journey continues... developing renewable energy investment projects in Myanmar, Bangladesh, Liberia, among others.



Giovanni Cimini

Country: Italy

Year joined industry: 1979

Company first worked for: Farfisa

Technology area: PV

Still active in the industry: Yes

In the '70s two friends, Giovanni Cimini and Bruno Olivieri, at that time students, began to build artisanal amplifiers and loudspeakers for their city's music groups and some primordial electric bikes with the CRA brand so as to allow trips on weekends during the 1973 oil crisis. Following the good results obtained by their first attempts, they founded, in 1979, the CRA Elettronica based in the Cimini's garage. In 1984 CRA Elettronica changes its name to Western CO. Promising results did not take long and during the 90's they developed an integrated solar energy production and storage system that gave rise to the well-known Leonardo System range on the market today. From that moment on and under the visionary leadership of Mr. Cimini, Western CO. is constantly dedicated to developing products for energy independence and the widespread production of energy from renewable sources.



Gilbert Cohen

Country: United States

Year joined industry: 1977

Company first worked for: The Scientific Research Foundation

Technology area: Concentrating Solar Power (CSP)

Still active in the industry: Yes

Mr. Cohen has been making strides in the Solar Energy field for more than four decades. His career in Solar Energy began as a Staff Engineer at the Scientific Research Foundation headed by a true pioneer, his mentor Dr. Harry Z. Tabor in 1977. At this position he was involved in various research and development (R&D) activities including Solar ponds, Solar water heaters, molten salt storage, selective surfaces, and novel parabolic solar collectors design. In 1986 Mr. Cohen joined the CSP industry and was involved of the development of the Solar Electric Generating Systems (SEGS) installed in California. From 1991 to 1999, he held the position of Technical Services Manager with the SEGS maintenance and operation company (KJC Operating Company). In 2000, Mr. Cohen contributed at the creation of Solargenix Energy (formally Duke Solar); an entity dedicated to the development, design and construction of Solar Power plants. As its Vice President of engineering, he played an instrumental role in the development of Nevada Solar One recognized at the time as the largest solar plant built since 1991. Between 2005 and 2008, as Senior VP of Acciona Solar Power, Mr. Cohen was the chief technology officer responsible for the engineering, operations, research, development and dissemination of solar thermal energy technologies. In 2008, he established his own engineering firm (Eliassol Energy) and was responsible for the design and deployment of several large solar projects in Spain, United States, Israel, India ... In 2002, Mr. Cohen's contributions as a Solar Energy industry leader were acknowledged with the prestigious Hoyt Clarke Hottel Award. This award bestowed by the American Solar Energy Society, honors individuals who made significant contributions to the field of solar energy. Mr. Cohen authored several Solar Energy papers and technical reports; he also owns several patents in Solar Energy.



Luis Crespo

Country: Spain

Year joined industry: 1977

Company first worked for: Construcciones Aeronáuticas S.A. (Now part of EADS- European Aeronautic Defense and Space Company)

Technology area: Solar Thermal

Still active in the industry: Yes

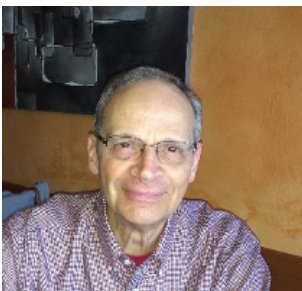
Luis Crespo began working in CASA/EADS and founded – aged 25 – the Solar Department, starting to develop components and applications for concentrated solar systems. He designed the first European heliostat, which still receives the visitors at the PSA (Plataforma Solar de Almería). He was the system responsible in the international consortium that built the CRS IEA plant in Almería, which was connected to the grid in 1981. Then he moved to the laboratory of the Spanish utilities (ASINEL) as head of the New Energy Technology department. He was manager of the first 1 MW wind turbine in Spain and technical director of the Spanish-German GAST project, aiming to design a 20 MW high temperature air cooled CSP plant and its core components. In 1985 he was appointed director of the Spanish Renewable Energy Institute (IER) launching a large number of R&D projects in PV, CSP, Wind and Biomass within European and Spanish programs. He negotiated the PSA IEA projects transfer to the IER, converting the PSA in the largest CSP lab at world level. The interest in commercial deployment of renewables declined around 1990 and he then switched to innovation management and financial fields always having renewables in focus. The dawn of CSP technology happened in 2007 and he was called to come back to his roots directing the Spanish (Protermosolar) and European (ESTELA) CSP industry associations. He is still president of Protermosolar. He contributed to build 50 CSP plants (2,3 GW) – the largest fleet at world level – which are performing as expected after 10 years of operation. More recently he succeeded to include 5 new GW of CSP plants in the Spanish Climate and Energy plan – submitted to the EU Commission – as an essential piece for the Energy Transition. This was a great achievement after a long professional career.



William D'Alessandro

Country: United States
Year joined industry: 1978
Company first worked for: Solavision
Technology area: Media (Renewables)
Still active in the industry: No

William D'Alessandro was editor of the award-winning magazine *Solar Age*, and the monthly newspaper *Renewable Energy News*. He was also editor of numerous other solar, photovoltaic, and wind energy business publications from 1978 through 1987. *Solar Age* was the largest and most widely read magazine in its field. For five years it served as the official magazine of the American Section of the International Solar Energy Society. One year during the 1980s, *Solar Age* was the fastest-growing subscription publication in the USA. The magazine achieved many journalism firsts, including coverage of radon gases, super-insulation, passive solar energy and design and modelling tools, the emerging photovoltaics industry, and business developments in solar heating and cooling. D'Alessandro later reported on energy and environmental management for Cutter Information Corp. and Wolters Kluwer publishing companies. He founded Victor House News Co. and was executive editor of *Crosslands Bulletin*, an international newsletter on environmental policies and regulations in the European Union. D'Alessandro graduated cum laude from Suffolk University Law School. He is a retired member of the legal bar in the state of New Hampshire.



Edgar DeMeo

Country: United States
Year joined industry: 1974
Company first worked for: Electric Power Research Institute
Technology area: PV
Still active in the industry: Yes

Edgar (Ed) DeMeo was introduced to solar photovoltaics (PV) in the early 1970s while on the Engineering Division faculty at Brown University. In the summer of 1974, he served as a visiting staff member at the recently formed Electric Power Research Institute (EPRI) with responsibility for planning EPRI's original program in PV research and application for utility power production. Over the next year he continued to consult for the institute, and in 1976 joined the EPRI staff to manage and expand its portfolio of contracted PV projects. These included research at universities to develop high efficiency PV devices—both flat-plate and sunlight-concentrating options—as well as utility system assessments to estimate cost and performance targets that could lead to large-scale use of PV power generation for the nation. He subsequently assumed responsibility for EPRI's entire Solar Power Program, which included, in addition to PV, solar thermal conversion and wind power. In 1999 he left EPRI to form an independent consulting firm, Renewable Energy Consulting Services, Inc., through which he has since provided technical and management support to several government programs in renewable energy—most notably the DOE-NREL wind energy program. Over the past 15 years, he has served on the management teams for several national assessments of the expected costs and benefits of large contributions of wind and other renewables to the nation's electricity needs. He continues to provide consultant support to the federal wind program, though at a reduced level over the past two years. Ed welcomes more time for activities with family and friends, riding his bike, and continuing to indulge his model trains hobby!



Brian England

Country: Australia

Year joined industry: 1976

Company first worked for: Self Sufficiency Supplies

Technology area: PV

Still active in the industry: Yes

Brian England set up the current business, Self Sufficiency Supplies, in 1976 when the industry was in its infancy. Initially solar installs were mainly solar hot water but as the cost of PV fell from \$100/Watt to \$40/Watt to \$15/Watt, PV progressively became more viable, especially for remote properties. Also sold were wind generators, hydroelectric generators and a large range of 'back to the land' equipment for rural autonomy. Catalogues were printed and equipment sold and shipped nationally. Throughout the 70's and early 80's he worked with the Lead Association of Australia and then with David Rand from the CSIRO to develop batteries specific to the solar industry as there were none up until then. This work resulted in Lucas Industries in New Zealand manufacturing the PVStor battery for BP Solar. He started another business (Powerstore Pty Ltd) in the 80's designing, manufacturing, retailing and wholesaling inverter/chargers, solar charge controllers and battery chargers, which became a joint venture in China in 1989. Early PV panels sold were Philips, Solarex and Tideland, followed by BP Solar and Arco. Early panel sizes were typically 20-30W with increases in panel wattages each year. Balance of system components were in their infancy, and with some notable exceptions were unreliable or not fit for purpose. The first sine wave inverter sold was the Honeywell battery-driven alternator with an efficiency of around 60%. From early days it became apparent that the design criteria available, especially for stand-alone systems, was inadequate, as the theory and the reality of consumer experience was very different. Brian created design programs which are still used today, now incorporating battery storage for grid systems. He won an industry award in 2015 for a unique stand-alone 3-phase power system running a crematorium and chapel, the first in the world. Co-founder of ATRAA (Appropriate Technology Retailers Association of Australia) in 1979 and involved in industry representation through its various incarnations of SEIAA (Solar Energy Industry Association of Australia), BCSE (Australian Business Council for Sustainable Energy) and CEC (Clean Energy Council). Currently National Chairman of SEIA (Solar Energy Industries Association).



Charlie Gay

Country: United States

Year joined industry: 1974

Company first worked for: Spectrolab

Technology area: PV

Still active in the industry: Yes

Dr. Gay has over 45 years of experience in renewable energy. Currently, he serves on the Sandia National Laboratory Energy and Homeland Security External Advisory Board and leads the Greenstar Foundation. He has significant private-sector experience, including past tenures as president of Applied Solar for Applied Materials, chairman of the technology advisory board for SunPower Corp, president and chief executive officer of ASE Americas, president and chief operating officer of Siemens Solar Industries, and president of ARCO Solar. Dr. Gay's public service includes Director of the Department of Energy's Solar Energy Technologies Office and Director of the National Renewable Energy Laboratory. He is creator of the Greenstar Foundation, an organization that delivers solar power and internet access to villages scaling microenterprise in the developing world. Charlie has a Ph.D. in chemistry from the University of California, Riverside. He holds numerous patents for solar devices, won the Gold Medal for Achievement from the World Renewable Energy Congress, was elected to the U.S. National Academy of Engineering in 2013 for leadership in the development of the global photovoltaic industry and in 2019 won the Charles Greeley Abbot Award from the American Solar Energy Society.



Harry Gordon

Country: United States

Year joined industry: 1974

Company first worked for: Burt Hill Kosar Rittelmann Associates

Technology area: Solar Architecture/Buildings

Still active in the industry: Yes

In 1974, Harry Gordon was a member of the design team for the largest active solar heating and cooling demonstration project in the world at that time, the Towns School in Atlanta GA, funded by the 1974 Solar Heating and Cooling Demonstration Act. Under subcontract to Westinghouse Corporation, he performed all of the solar performance calculations and produced the construction drawings for this successful demonstration project. He designed many other active solar installations for non-residential buildings, including office buildings, banks, apartment buildings, schools, and recreation centers. In 1979, he led the Technical Support team for the US DOE Passive Non-residential Experimental Buildings Program. Under his technical leadership, 19 non-residential passive solar heating, cooling, and daylighting buildings were constructed and their energy performance, construction cost, and occupant response were monitored. He presented these results in the Plenary at the ISES World Congress in Hamburg, Germany in 1987. He was the primary author of the book *Commercial Building Design*, documenting the success of this program. This book (Van Nostrand Reinhold, 1988) won the Progressive Architecture Research Award. He was the primary author of chapters on Non-residential Solar Buildings in *ASES Advances in Solar Energy, Volume 3* (Karl Boer, Editor, Plenum Press, 1986) and *Solar Building Architecture* (Bruce Anderson, Editor, MIT Press, 1990). Harry Gordon was selected by US DOE as the US Representative to IEA Task XI of the International Solar Heating and Cooling Program. His work on the use of Atria for passive heating, cooling, and daylighting was published in *Passive Solar Commercial and Institutional Buildings* (S. R. Hastings, Editor, John Wiley & Sons, 1994). In 1993, as a founding member of the AIA Committee On The Environment, he led the Heating and Cooling Team of the Greening of the White House, announced by President Bill Clinton in his Earth Day Presentation.



Mark Hertel

Country: United States

Year joined industry: 1976

Company first worked for: Honolulu Gas Equipment Company

Technology area: Solar Thermal

Still active in the industry: Yes

Mark Hertel began his solar career in high school by designing a solar heated house inspired by Jack Thomason(?). After college he took a job helping Honolulu Gas Company enter the solar water heating business in 1976 when solar was taking off in Hawaii. He worked with Cully Judd and Rick Reed at Inter-Island Solar Supply to put together a system that went on to be the biggest seller in Hawaii. In 1993 he went to work for IISS and their new panel manufacturing venture, SunEarth, where he served as Senior Engineer. That effort led to appointments to the SRCC Board and President of the Hawaii Solar Energy Association, Chair of ASHRAE TC6.7 Solar Energy Utilization where he oversaw the rewrite of the ASHRAE Handbook solar chapters to include SRCC and international organizations. In 2019 he received a Distinguished Service Award from ASHRAE. All this while living in Hawaii where he will retire at the end of 2020.



Winfried Hoffman

Country: Germany

Year joined industry: 1979

Company first worked for: Nukum

Technology area: PV

Still active in the industry: Yes

Dr. Winfried Hoffmann joined the R & D group for thin film solar cells at NUKEM (RWE) in 1979 and took over its leadership in 1985. He initiated the Joint-Venture in the photovoltaic field between NUKEM and Daimler-Benz Aerospace to form "Angewandte Solarenergie – ASE GmbH" in 1994, where he served as Managing Director. In the same year the acquisition of 100 % shares of Mobil Solar as a subsidiary company was done with special focus on their developed ribbon EFG technology. In the late 90s, the company was renamed RWE Solar and was one of the worldwide 5 biggest production companies. In October 2002, the joint venture between RWE Solutions and SCHOTT, the RWE SCHOTT Solar GmbH, was formed, where he served as Chairman of the Board. Effective in 2005, SCHOTT acquired the shares of RWE Solutions and the company was renamed SCHOTT Solar GmbH, where he was member of the Management Committee. In 2007, he joined Applied Materials to become Chief Technology Officer and Vice President of the Solar Business Group and member of the Management Board of the German based Applied Materials GmbH. From November 2010 he formed his own consulting company Applied Solar Expertise. He served many years as member of the Board of the German Solar Economy Association (BSW Solar), lastly as president. From 1997-2014 he served as member of the board EPIA half of that time as president. He has been a member of many boards including Fraunhofer Institute for Solar Energy Systems ISE and the Helmholtz Center in Berlin (HZB) and the Institute for Solar Energy Research in Hameln (ISFH). In 2012 he received the John Bonda prize from EPIA and the prestigious Becquerel Prize. The World Renewable Energy Network (WREN) awarded him as a "Solar Pioneer" in 2014.



Steve Hogan

Country: United States

Year joined industry: 1978

Company first worked for: SERI

Technology area: PV

Still active in the industry: Yes

Steve Hogan joined SERI in initial days of organization, studying solar cell thick film contacts and silicon solar cells. He moved to Spire Solar in 1984 and worked for over 30 years in design of production equipment, set up of turnkey PV manufacturing plants and specialized in solar cell and module testing technology. Steve continues to work in standards through IEEE, IEC, and ASTM.



Stephen Ingrouille

Country: Australia

Year joined industry: 1978

Company first worked for: Going Solar

Technology area: PV

Still active in the industry: No

In 1976, Stephen Ingrouille called a public meeting in Carlton, Melbourne, which led to the establishment of a community group called the Alternative Technology Co-operative (later named Renew). The goals, in promoting renewable energy, were to establish a newsletter, a magazine, a radio program, a workshop and a retail outlet. All of these goals were achieved, with the retail outlet becoming a private business. Going Solar started in 1978 and in 1979 was one of the four founding members of the Appropriate Technology Retailers Association of Australia (ATRAA). By the early 1980s Going Solar had become a leading wholesaler in Victoria, helping to establish the PV industry with dealer training nights, mentoring, advocacy, and through promoting industry awards for 'best practice'. Stephen also taught Solar Hot Water (Certificate IV) at three TAFE colleges and tutored on renewables with the Council of Adult Education for over 10 years. In 1998 Going Solar, with the assistance of the dealer network, held a Sustainable Living Fair at Musk in Central Victoria. This led to the establishment of the Sustainable Living Foundation and the Sustainable Living Festivals. In August 2006 Stephen won the Melbourne Award which recognised thirty years of 'Contribution to Environment'. With changes in the PV industry Going Solar returned to retail, focusing on PV and Solar Hot Water. In February 2020, after almost 42 years at the helm, Stephen retired when Going Solar was sold to one of their contract installers. Renew, the Sustainable Living Foundation, the Sustainable Living Festivals and Going Solar Pty Ltd all continue to this day.



Josef Jenni

Country: Switzerland

Year joined industry: 1976

Company first worked for: Jenni-Sonnenenergie-Steuerungen (Jenni solar energy management)

Technology area: Solar Thermal

Still active in the industry: Yes

Josef Jenni is founder and CEO of Jenni Energietechnik AG, a company with a 44 year history in RE. In 1975, he built his first solar collector and installed it on the roof of his parent's house. A year later he founded Jenni-Sonnen-Steuerungen (Jenni Solar Controls) after completing a degree in electrical engineering. 1978 he founded Jenni Energietechnik AG with four employees which focused on manufacturing steel tanks «Swiss Solartank» for storing hot water generated by RE such as solar and wood. Around 30 000 tanks with volumes ranging from 500 to 200 000 litres have been manufactured ever since. Josef Jenni achieved worldwide attention with the first 100% solar heated house built in 1989. In the meantime, this so-called concept of a solar house (a house that covers at least 50% of its heating and warm water demand with solar energy) has been copied over 2000 times (most often in Germany). In 2007 Jenni Energietechnik built the first 100% solar heated 8 family home on its premises. The company offers consulting to end customer for renovation of heating systems and in this context sells renewable heating systems that can be combined with the Swiss Solartank. He lives a very modest life privately and has been an activist for renewable energies and the environment all his life. From early on, he saw solar energy as a viable alternative. In 1973, as a young student, he started a popular initiative that asked for 12 car-free Sundays. In an attempt to push the solar industry out of a slump, he came up with the idea of the Tour de Sol, a solar vehicle race that ended up being carried out annually from 1985 to 1993. From 2006 to 2012, Josef Jenni was active as a representative in the government of the canton of Bern. He focused his terms of office on energy and environment related issues.



David Katz

Country: United States

Year joined industry: 1979

Company first worked for: Alternative Energy Engineering (AEE)

Technology area: PV

Still active in the industry: Yes

David Katz, was the founder and former CEO of AEE Solar Inc., which is now part of SunRun, and is the current president of Tamarack Solar Products and Backwoods Solar Electric Systems. David is also the cofounder and technical advisor of Simusolar Ltd., a company that provides solar water pumps to farmers in rural Tanzania and Uganda, east Africa. Katz founded Alternative Energy Engineering in 1979 one of the first companies in the US selling off-grid solar electric power systems. David printed his first catalog in 1981, and today the AEE Solar catalog is widely regarded as the one of the industry's most useful solar PV resources. Katz sold Alternative Energy Engineering to Idaho Power in 1999 and it became part of Applied Power Corporation (APC), where he was the director of sales. APC was acquired by Schott Glass in 2000 and was renamed Schott Applied Power Corp. Katz served as Schott's director of purchasing where he convinced Sharp to sell their solar modules in the US, causing a large drop in module pricing. In 2002 Katz purchased the company from Schott and renamed it AEE Solar. In 2005 AEE Solar was acquired by Mainstream Energy Corporation, of which Katz was the CEO and a shareholder. He is a key figure in the USA off-grid community having helped thousands of remote homeowners electrify their homes. His pioneering work in solar water pumping and micro-hydro power systems are unparalleled. David is a hands-on tinkerer, preferring to personally test/review virtually all the products that appear in the AEE Solar catalog. In his spare time, he is an inventor and has developed products including a solar powered ATM with wireless communications used at outdoor solar and concert events. Katz's graduated from the University of Maryland in 1973 with a degree in Electrical Engineering.



Polaris Lamaris

Country: Greece

Year joined industry: 1974

Company first worked for: SOLE SA

Technology area: SOLAR THERMAL

Still active in the industry: Yes

Panos Lamaris is considered the solar pioneer in Greece. A native Cypriot, he moved to Athens in the early 1970s – and brought the solar technology with him from his home island. In 1974 he founded his own company called Sole, a manufacturer of solar thermal systems and collectors, and in 1978 he became a founding member of EBHE - The Greek Solar Industry Association, where he held the president position for 13 years. Through his activity the Greek solar industry has become the first globally, with a booming in sales in the mid 80's whereas solar markets were collapsing in other European countries. His impact on the solar thermal industry went beyond the borders of Greece and in 1992 he became a founding member of Solar Heat Europe/ESTIF and its first president, being re-elected for another two terms and holding the position for a total of 6 years. During his presidency, the first European detailed market study on solar thermal systems "SUN IN ACTION I" was published. Between 1994-2003 Panos Lamaris was part of the Center of Renewable Energy Sources (CRES) initially as a Board of Directors member, and later on as a Vice President of the Board. He was also the president of CEN TC 312 (Comité Europé EN de Normalisation) from 1995-2001 and during his presidency, the common European testing and certification standards EN 12975-1-2 and EN 12976-1-2 were established. In addition, a substantial contribution was given for the preparation of the "White Paper" on renewable energy sources by the EU. In 1999 he was awarded by ISES for his 25 years pioneering in the field of Solar Thermal Energy and his contribution to the development of the European Renewable Energy Plan.



Alan Langworthy

Country: Australia

Year joined industry: 1974

Company first worked for: National Energy Office then Energy Systems International

Technology area: Wind

Still active in the industry: Yes

In 2010 Alan Langworthy was awarded the Clunies Ross Medal from the Australian Academy of Technological Science and Engineering; for the “application of science and technology for the economical, social and environmental benefit of Australia”. Alan began work on wind diesel power systems in the early 1970’s and installed Australia’s first large domestic wind turbine to power his rural property. As the Executive Secretary to the New Energy Technical Standing Committee of the National Energy Research Development and Demonstration Council of Australia’s Federal Government Energy Office he undertook global research into renewable energy solutions. Moving into the private sector Alan formed Energy Systems International Pty Ltd to design, market and install small scale wind and solar systems to rural Australia. Selling this company to Pacific Dunlop Pty Ltd he began, Powercorp Pty Ltd in 1988 specifically to automate and develop larger remote diesel power stations in inland Australia. Powercorp not only automated existing diesel power stations but also developed new technology to enable the high penetration of wind turbine output into these systems. This work led to the invention of the PowerStore (a flywheel based grid support device) and a unique power system wide control system. Alan was able to build commercial wind and/or solar diesel power stations that saw up to 100% renewable energy integration. These systems were built around the world from Antarctica to the Azores. In 2011 Alan sold the Powercorp business to ABB. After a 3-year contract with ABB to assist their new business Alan left to reform his private consulting business. In parallel with the above work Alan was contracted by the ENERCON wind turbine company over a 12-year period to represent them in Australia. He sold and installed over 150MW of Australia’s first grid connected wind farms. He offers a global perspective on renewable energy systems and an intimate knowledge of diesel power stations. Alan has recently completed his appointment as Chair of the Expert Panel advising the Northern Territory Government on a Roadmap to Renewable Energy aimed at achieving 50% renewable energy injection.



Anoop Mathur

Country: USA

Year joined industry: 1977

Company first worked for: Honeywell Inc

Technology area: Solar Thermal

Still active in the industry: Yes

Anoop Mathur worked on the design team that developed the first 10MW Solar Power Tower, specifically focusing on thermal energy storage using phase change in inorganic salts (PCMs) and later with thermocline storage using Caloria HT-43 and rock. Later he worked on the 10MW Soleras (joint cooperation between US and Saudi Arabia) Photovoltaic project that used solar cells made by Solarex cells and Hexcel parabolic solar collectors. Also, in 1979 he tested several reflective solar films at the Desert Sunshine Exposure Grounds near Phoenix, Arizona. He collected field data on an evacuated tube solar collector that used black absorber coating developed by Honeywell and reflective film developed by 3M. Honeywell discontinued its work on solar in January 1981, when US administration under President Reagan defunded all commercial work at DOE. After developing and directing advanced technologies in control and sensing at Honeywell, he left Honeywell in 2008, and founded Terrafore Inc. with a goal to pursue research on phase change thermal storage. In 2013, Terrafore succeeded in solving the low heat transfer problem with PCM storage by successfully encapsulating the PCM salt in small capsules. The patented method is described on their website www.terraforetechnologies.com. He supported a student at Virginia Tech receive his PhD enhancing the mathematical modeling for cascading several encapsulated PCMs in a single container which improved the effective use of phase change heat. Several papers were published on this topic. Subsequently, they also solved the issue with degradation of thermocline by modifying the design of the storage container and using a predictive controller. Using this patented method, thermocline is maintained automatically with multiple charge and discharge cycles. Anoop Mathur is still active in the field of thermal storage developing PCM solutions for storing energy for hot water and space heating in commercial buildings.



E. Kenneth May (1949-2020)

Country: USA

Year joined industry: 1979

Company first worked for: Industrial Solar Technology Corporation

Technology area: Solar Thermal

Still active in the industry: No

Ken May) was a pioneer in the development and deployment of commercial and industrial solar thermal technology between 1979 and 2020. Mr. May began his solar career at the US Solar Energy Research Institute in 1979. At SERI he analyzed the technical and economic benefits of direct steam generation in parabolic troughs - which led to a multi-million-dollar research effort in Europe - and co-authored the first publication of tools and techniques for designers of large solar thermal installations.

In 1983, Mr. May and Mr. Randy Gee founded Industrial Solar Technology Corp. (IST) where they developed an innovative parabolic trough technology capable of unattended operation and deployed commercial projects in several countries. For much of its history, IST was one of just a few companies in the world developing parabolic troughs for industrial and commercial applications. In 2000, Mr. May and Mr. Gee were the first recipients of ASES Hoyt Clarke Hottel Award "for unique contribution to make solar thermal technology a commercial reality". In 2006 IST's parabolic trough business was acquired by Abengoa, where Mr. May directed the Abengoa Solar Industrial Systems division. IST's infrastructure and experience helped Abengoa to contract and construct the groundbreaking Solana and Mojave CSP plants. Mr. May also authored and advised two of the company's first major US DoE-sponsored research contracts, which developed a next-generation large-aperture collector and other innovative CSP technologies that remain "state-of-the-art" to this day. Under Mr. May's direction, the IST technology also continued to evolve for Industrial Process Heat applications. Abengoa deployed IST-derived systems worldwide including the largest parabolic trough process heat system in the US (2008) and the largest in the world (Chile 2012). Mr. May retired in 2015, remaining active as an advisor and consultant to the solar thermal industry until his death in October of 2020.



Paul Maycock

Country: USA **Year joined industry:** 1975

Company first worked for: US Department of Energy

Technology area: PV

Still active in the industry: No

In 1975 after first working at the Office of Naval Research followed by 15 years at Texas instruments Paul Maycock was appointed the Director of Photovoltaics Energy Systems Division within the US Department of Energy. President Carter provided a large budget for the renewable energy sector and Paul managed the funding of research and development projects and particularly in the area of reducing the costs within the PV industry . After President Reagan reduced the budgets Paul left and founded PV Energy Systems , the consulting company he operated until he retired in 2002. During the 80's and 90's Paul published the monthly newsletter the "PV News". This was where many in the industry kept up to date with the developments within the PV industry before the establishment of the many magazines (and internet sources) available today. Paul also worked on many consulting projects and also published many reports. In 1985 he co-authored the book "A guide to the Photovoltaic Revolution" . He also supported Neville Williams with the establishment of the Solar Electric Light fund (SELF) and SELCO and was nonexecutive chairman of SELF for many years.



Bernard McNelis

Country: United Kingdom

Year joined industry: 1973

Company first worked for: Solar Power Corporation

Technology area: PV

Still active in the industry: Yes

Bernard joined Solar Power Corporation in 1973. At the same time, he became one of the founding members of the UK Section of the International Solar Energy Society. After SPC folded, he worked at Solar Energy Developments (SED), architects, and General Technology Systems (GTS), engineers. He worked on solar heating, long-term energy storage and solar thermal power generation. 1978 when he went to Mali on an EC mission with Wolfgang Palz, he visited the first PV pumps just installed in Africa, with EC money, and met the force behind them, Père Bernard Verspieren. He saw first-hand the impact of clean water on poor people. That was the start of his obsession with PV for developing countries. Bernard was one of the three founders of IT Power. With Anthony Derrick and Peter Fraenkel, he started work for the World Bank on the Global Solar Pumping Programme in 1979, and incorporated IT Power in 1981. The final output of this big (at the time) project was the "Solar Pumping Handbook". Through IT Power, Bernard was involved in PV projects across the globe undertaking work with probably every major donor in the world. Meanwhile IT Power continued to expand and established offices in India, China and Australia. IT Power received the Queen's Award for Export Achievement in 1989. Bernard has been an active member of many committees within various organisations including UK Section of -ISES, ISES, EPIA, IEC and was the driver behind IEA-PVPS launching a task in 1999 that was focussed on PV in developing countries. IT Power was the operating agent with Bernard as the chairperson. Over the last 45+ years Bernard has attended many conferences and been on the organising committee of many of them.

t



Heinrich Morf

Country: Switzerland

Year joined industry: 1979

Company first worked for: Solartec Indústria e Comércio Ltda., São Paulo, Brazil

Technology area: Solar Thermal

Still active in the industry: No

Heinrich Morf started and operated the company Solartec Industria e Comércio Ltda., São Paulo, Brazil (2/1979-10/1982). He was the owner of the company, developed its constitution. He successfully negotiated for financial support from the government owned development banks BADESC (State of São Paulo) and BNDE (Brazil). He developed a complete product line for solar water heating, including collectors, reservoirs, auxiliary heaters and controls. Heinrich worked on many projects and implementation of large size solar water heating systems, including: Nestle Ituiutaba (MG), 100 m²; Pirelli, Santo André (SP), 70 m²; and, IQR (Ciba-Geigy), Resende (RJ), 50 m². The company reached a peak turnover of \$400K (USD) with a staff of 15 people in 1980, but was deactivated in 1982 due to a total collapse of the market.



Mike Nicklas ISES President 2010-2019

Country: United States

Year joined industry: 1972

Company first worked for: Innovative Design

Technology area: Solar Architecture.Buildings

Still active in the industry: Yes

Michael Nicklas, FAIA, graduated from NC State University with a Bachelor of Architecture in 1972, afterwards created his own company in San Salvador, Bahamas doing low-income design-build housing systems. Later, he interned with George Ellingwood and Dean Best and his career began its focus on energy-efficient buildings. Mike founded Innovative Design in 1977. By 1979, they had built about 4,000 passive solar homes. By 2015, it was estimated that their 4,755 buildings had saved around \$139 million in energy costs, over 1.6 billion kWh, 1.1 mt of CO₂, and reduced peak demand by around 54 MW. Many of these were school buildings, designed to also harvest rainwater, use PV to lower energy costs and their carbon footprint. In 2006, the US EPA awarded Innovative Design the national Energy Star Award; they have been the recipients of numbers sustainable design awards. Mike served on the Board of Directors of the NC Sustainable Energy Association, American Solar Energy Society and the International Solar Energy Society (ISES) every year from 1979 to 2005; ISES Vice President ISES 1991 – 1993 and President 1993-1995; in 1992 presented with an ISES Special Service Award for his tireless work as ISES-UNCED chair, putting the ISES principals of solar energy for all before influential people and organisations. Mike initiated many significant efforts, from implementing solar tax credits in NC legislature to global efforts lobbying for energy-efficiency and solar energy within the UN Earth Summit's Agenda 21. Mike's extensive knowledge has made him a valued resource. Appointments include NC Energy Policy Council, UNC Kenan-Flagler Business School Advisory Board, NC Solar Center chairman, US Office of Technology Assessment Renewable Energy Advisory Board, AIA Environment Steering Committee, NC Trade and Industrial Education Advisory Committee, NC Governor's Task Force on Solar Law and ASHRAE Advanced Energy Design Guide for K-12 Schools Committee.



Thomas Nordmann

Country: Switzerland

Year joined industry: 1975

Company first worked for: Eidgenössisches Institut für Reaktorforschung (EIR) today PSI

Technology area: PV

Still active in the industry: Yes

Thomas Nordmann has been working for solar energy for 45 years. In 1974 he was working in the development, research and conversion of thermals applications and collector testing in government research (Paul Scherrer Institute) and for the Swiss energy industry. In 1985 Nordmann founded his own enterprise named «TNC Consulting AG». He developed and built the world's first 100 kW PV noise barrier installation along a Swiss motorway (1989) and has since planned, engineered and installed a total PV-capacity of approx. 3 MWp in Switzerland and Europe. He developed the world's first bifacial PV noise barrier pilot project in Zurich with 12 kWp in 1997 and 2008 a bifacial PV noise barrier along the railway in Münsingen, Bern. Nordmann was president of the Swiss Solar Industry Association (SOFAS) from 1992-1999 and vice-president of the Swiss national organisation «Swissolar» till March 2002 and for his contribution to the development of solar energy he received three times the Swiss solar prize (1994, 1998 and 1999) and the European solar prize (1997). From 2004 – 2018 Nordmann and his Company have been Swiss Expert in PVPS Task 2 now Task 13 for Performance and Reliability of Photovoltaic Systems. In 2008 he was co-founder of ZSSAG, an independent power producer of today 18 PV installations. He is the inventor of Swiss - and EU Patent for Floating photovoltaic unit 17. 9. 2009 The first floating PV Paper: Large Scale Hybrid PV Hydro Electricity Production in Floating Devices oral Paper at the 24th EUPVSEC 21.-24.9.2009, Hamburg, Germany. In 2012 he founded the project company HydroSun AG with the aim to develop floating PVTNCALL is a new energy management product to coordinate all energy applications incl. electromobility in a building developed by TNC. The first commercial projects have been launched 2020. Thomas Nordmann has published more than 140 Papers and publications in his career since 1974 and was Chairman of the PV Symposium Staffelstein/Germany 2008, 2013 and 2018.



David Oppenheim (Deceased)

Country: Australia

Year joined industry: 1974

Company first worked for: Yunken Freeman Architects

Technology area: Solar Architecture/Buildings

Still active in the industry: No

David studied architecture at the University of Melbourne, when architectural sciences were strong, and students and practitioners thought that positive contributions to human well-being could be made through architecture. After graduation David worked at Yunken Freeman Architects and then Whitford and Peck Architects. However, David had a vision of the sort of work that he wanted to do – solar architecture. True to that vision, he made his way to the leading international solar practice, Solar Energy Developments, in the UK, from 1977 to 1979. He wrote *Small Solar Buildings in Cool Northern Climates*, published by Architectural Press in 1981. David is best known as the director of two architectural practices, (1980 – 2007), firstly Taylor Oppenheim Architects and then Sustainable Built Environments (SBE). David maintained continuous active involvement in many professional societies that sought to advance built environment sustainability. He was a member of many professional organisations and committees, including the RAIA, ANZSES, the IEA and the Olympic Co-ordination Authority Expert Advisory Panel. He was an inaugural member of the RAIA's National Environment Committee and the Environment Design Guide Planning and Development Committee, and lectured at many universities, especially Deakin University – where, for more than ten years, he coordinated and taught design and building science units. David was a distinguished Australian architect who was respected and awarded, nationally and internationally, and a sustainability pioneer with strong roots in architectural science and quantitative assessment. He was also deeply spiritual and reflective, in his work as a designer and in his relations to family and friends. With this spirituality came a deep sense of ethics that was evident in his personal and professional life. The RAIA established an annual sustainable architecture competition and award in his memory.



Rick Reed

Country: United States

Year joined industry: 1979

Company first worked for: The Solaray Corporation, Honolulu, HI.

Technology area: Policy

Still active in the industry: Yes

Rick Reed began his career in 1970-80 with the Department of Energy's Western Solar Utilization Network as a Hawaii-based site officer. His private sector career began in 1982 with The Solaray Corporation (dba Inter-Island Solar Supply and SunEarth Inc.) He served Solaray and its operating companies as the GM, President, CEO, Chief Strategy Officer and Director during my career. He is currently a Solaray director.

Rick Reed has been an elected director of Hawaii Solar Energy Association, the California Solar and Storage Assn. (CALSSA, formerly CALSEIA), SEIA and the SRCC. He is a multi-term past president of the HSEA and CALSSA. He is a founding member of the Hawaii Renewable Energy Alliance (HREA) and the University of Hawaii Energy Policy Forum. He is one of the four founding members of EchoFirst, a hybrid PV thermal product manufacturer. that was acquired by SunEdison in 2014.



Steve Sawyer (1956-2019)

Country: Netherlands

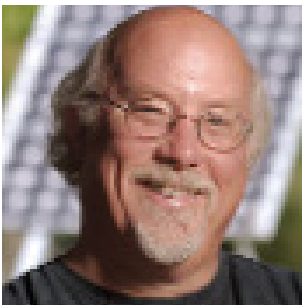
Year joined industry: 1978

Company first worked for: Greenpeace International

Technology area: The renewable energy transition, but in later years specifically wind

Still active in the industry: No

Steve Sawyer had a distinguished career as an anti-nuclear and climate campaigner, Executive Director of Greenpeace International, and the first General Secretary of The Global Wind Energy Council (GWEC). During his time at Greenpeace he faced personal danger on numerous occasions, before steering the organisation towards an increased emphasis on the issue of climate change and greater engagement with the nascent renewable energy industry. In the run-up to the Rio Earth Summit in 1992, in his role as Executive Director, he catalyzed and supported the organization's landmark publication "Towards a Fossil Free Future Energy Future: The Next Transition." He went on to contribute to many of the organization's studies and campaigns in support of a renewable energy future. He joined GWEC as its first General Secretary in 2007, as he was convinced that the wind industry would play a fundamental role in replacing greenhouse gas emissions and in leading the transition to a new energy system. He also supported the work of many individuals and organizations in the field. He was a founding member of the REN21 Renewable Energy Policy Network and remained on its steering committee until his death. He was also a founding member of the IEA's Renewable Industry Advisory Board and served on the steering committee of the International Renewable Energy Agency (IRENA) Coalition for Action. During Steve's tenure at the head of GWEC, global wind installations grew from 74GW to 539GW and became one of the world's most important energy sources. He contributed significantly to the development of the wind industry in places such as India, China, Brazil and South Africa. He was a prominent speaker in public and private forums, wrote innumerable articles, blogs and position papers, and was a mentor to many young people in the field.



John Schaeffer

Country: United States

Year joined industry: 1976

Company first worked for: Real Goods Trading Company

Technology area: PV

Still active in the industry: Yes

John Schaeffer graduated from UC Berkeley in 1971 from whence he moved to an archetypal 'commune' in Mendocino County and pioneered off-the-grid living. After living on the commune for several years with kerosene lamps and no refrigeration, Schaeffer began to experiment with some crude battery powered systems, employing his Volkswagen bug to charge a spare battery while he drove. In 1976, Schaeffer experimented with hand made wind generators (55 gallon drums cut in half) and added some 12 volt lighting and a 12 volt television to his rustic off-the-grid cabin. Noticing the giant influx of people escaping city life in the late 1970s, Schaeffer created the 'Real Goods Trading Company' and it took off like a rocket. Soon there were 3 Real Goods stores in Northern California and the clientele consisted of off-the-grid pioneers, many of whom were illicit Cannabis growers. In 1978 Schaeffer located 9 watt PV panels that were space program rejects that sold for \$100 per watt, and they sold like hot cakes. The only people that could afford this kind of electricity in the backwoods were Cannabis growers and consequently the solar industry and the Cannabis industry in California became inextricably linked. Schaeffer went on to establish the Real Goods Solar Living Center in Hopland California that was a demonstration laboratory for all things sustainable including renewable energy, regenerative agriculture, alternatively powered vehicles, etc. The Solar Living Center hosted over 5 million visitors from its inception in 1996 until Schaeffer sold it in 2019 to Cannabis entrepreneurs at Flow Kana. Over those several decades, the nonprofit Solar Living Institute, an offshoot of Real Goods, trained thousands into the solar industry, in natural building, and in regenerative agriculture. Real Goods was a pioneer of photovoltaics and solar energy in the USA, and its legacy lives on.



Wolfgang Schiel

Country: Germany

Year joined industry: 1979

Company first worked for: Schlaich Bergermann und Partner (www.sbp.de)

Technology area: Solar Thermal

Still active in the industry: No

Wolfgang Schiel's working career involved Design and detailing of solar thermal power plants: Dish/Stirling systems (3...50 kW), parabolic trough collectors, heliostats. He was involved in the development of opto- electronic measuring systems for qualification of concentrating solar collectors. He was involved with the Solar Updraft Tower (SUT) Manzanares, Spain pilot plant which produced 50 kW with a collector surface of 45,000 m², tower height of 194 m. It operated from 1982 – 1989 and he undertook supervision and scientific evaluation. He undertook the conceptual design, design and optical analyses of photovoltaic concentrator for CPV system 1, Pune, India. He was the technical lead in the development of parabolic trough collectors for large scale commercial plants (EuroTrough, HelioTrough, UltimateTrough) used in commercial plants in Spain, Egypt, India, Kuwait, Saudi Arabia and China (>10 plants, > 500 MW). His team twice winner of the IEA SolarPACES technology innovation award (2013 & 2010) and in 2016 he was winner of IEA SolarPACES 'Lifetime Achievement Award'. Schiel has undertaken projects in Germany, USA, Spain, Saudi Arabia, India, Italy, France, Egypt, Chile, Australia. He has published numerous scientific papers and technical magazine articles and contributed to the following books: Concentrating solar power (CSP) technology: Developments and applications of Dish Stirling Systems, 2012, Woodhead Publishing, Cambridge, UK, Philadelphia, USA; Lovegrove and Stein: Parabolic Dish Systems; Springer Encyclopedia of Physical Science and Technology: Solar Chimneys, 2002.



William Shurcliff (1909-2006)

Country: United States

Year joined industry: 1978

Company first worked for: William Shurcliff (himself)

Technology area: Solar Architecture/Buildings

Still active in the industry: No

William Asahel Shurcliff was an American physicist. He received his BA cum laude in 1930, a PhD in Physics in 1934, and a degree in Business Administration in 1935, all from Harvard University. In the 1930s he worked at the Spectrophotometric Laboratory at the Calco Chemical Division of the American Cyanamid Company. In the 1970s and 1980s, he became an advocate for passive solar building design and superinsulation. He self-published a long series of books that compiled every passive solar building he could learn about, significantly raising public and industry awareness. He wrote and published the following three books. 1978: Solar Heated Buildings of North America: 120 Outstanding Examples, Brick House Publishing. 1979: New Inventions in Low Cost Solar Heating: 100 Daring Schemes Tried and Untried, Brick House Publishing. 1981: Super Insulated Houses and Double Envelope Houses: A Survey of Principles and Practice, Brick House Publishing.



Scott Sklar

Country: United States

Year joined industry: Mid 1970's

Company first worked for: Aide to a US Senator

Technology area: All Renewable Energy

Still active in the industry: Yes

Scott Sklar began his energy career as an aide to Senator Jacob K. Javits (NY) (1970-79) where he focused on energy and military matters for nine years. During his Senate tenure, he cofounded the Congressional Solar Caucus that led many of the innovative legislation promoting renewable energy in the 1970's. From 1980-1983 he was Washington Director and Acting Research Director of the National Center for Appropriate Technology (NCAT), founded by Mike Mansfield and EF Shumacher. From 1983 to 1984 he was Political Director of The Solar Lobby (1983-1984), a renewable energy advocacy organization founded by the nine major national environmental organizations. From 1985 to 2000 Scott simultaneously ran two Washington, DC-based trade associations, as Executive Director of both the Solar Energy Industries Association (SEIA) and the National Bio Energy Industries Association (BEIA). In 1995 Scott founded the Stella Group, Ltd and has been its President since 2000. The Stella Group is a strategic policy and clean technology optimization firm facilitating clean distributed energy utilization which includes advanced batteries and controls, energy efficiency, fuel cells, geexchange, heat engines, microhydropower (and freeflow, tidal, wave), modular biomass, photovoltaics, small wind, and solar thermal (including daylighting, water heating, industrial preheat, building air-conditioning, and electric power generation. The Stella Group, Ltd. Is one of the very few companies that blends distributed energy technologies, aggregates financing (including leasing), with a focus on system standardization. Scott is also an Adjunct Professor at The George Washington University teaching two unique interdisciplinary courses on sustainable energy, and an Affiliated Professor with CATIE, an international graduate university located in Costa Rica focused on sustainability for Latin America. He serves as Energy Lead of GWU's Environmental and Energy Management Institute (EEMI) and serves as Acting Director of GWU's Solar Institute. Sklar is also the co-author of two books, "The Forbidden Fuel" and "Consumer Guide to Solar Energy".



Guy Smekens

Country: Belgium

Year joined industry: 1976

Company first worked for: Energies Nouvelles et Environnement (ENE)

Technology area: PV

Still active in the industry: Yes

In 1976 Guy Smekens started Energies Nouvelles et Environnement (ENE) with two other friend , Spigniew Szawlowsky and Rene Grosjean. They manufactured cells/modules and in the 70's and 80's focussed on the markets in Asia and Africa. Smekens invested in HCT Shaping Systems and was one of first manufacturers to acquire one of the wire saws from Shaping Systems. In 1990 the company entered the space cell business and slowly withdrew from the terrestrial market. Guy was one of the founding directors of EPIA in 1985 where he served as treasurer for many years. At one stage he sold the business but then bought it back from the liquidators within a year.



Steven J Strong

Country: United States

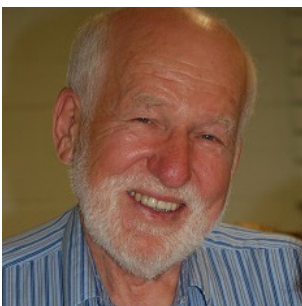
Year joined industry: 1974

Company first worked for: Solar Design Associates

Technology area: Architecture/Buildings/PV

Still active in the industry: Yes

Steven J. Strong founded Solar Design Associates, Inc in 1974 .Drawing on his background in engineering and architecture, he has earned the firm an international reputation for the pioneering integration of renewable energy systems with environmentally responsive building design - completing projects in Europe, Asia, the Middle East, Africa, Latin America, Canada, the Caribbean and across the US from Maine to Hawaii. Over the last four decades, he has designed dozens of homes and buildings powered by solar electricity. In 1979, he designed the world's first all-solar, Zero-Net-Energy residence that exported a surplus of solar electricity to the utility grid via what has since become known as 'Net Metering". In 1984, working with New England Electric, he completed the world's first PV-powered neighbourhood in central Massachusetts. In 1996, he worked with Olympic village architects to power the 1996 Summer Games in Atlanta with solar electricity using the world's largest roof-top PV power system. He designed and oversaw the installation of three solar energy systems at the White House in Washington, DC. His firm consults to private and public clients and architects in the design of solar-powered buildings as well as to utilities on large-scale solar implementation. He represented the US on the International Energy Agency's expert working group on Solar Electricity in the Built Environment for 8 years and has served as an advisor on energy and environmental issues to 3 Governors, 8 US Senators and 4 presidential candidates as well as a number of US Congressmen, State Senators and Representatives and electric utilities. He is an author of numerous books including his first -The Solar Electric House in 1994. He has been recognised with numerous awards including The ASES Charles Greeley Abbot award - for lifetime achievement in advancing solar energy (2001). In 2007, TIME recognised Steven as "An Innovator Building a Greener World".



Dr Raye Thomas

Country: Canada

Year joined industry: 1973

Company first worked for: TPK Solar Systems

Technology area: PV

Still active in the industry: No

Raye Thomas started a research project at Carleton University in 1973 to develop an "inversion layer" solar-cell based on MOS technology. Achieving over 10% efficiency in 1975, with support of Canada's National Research Council, reached 18% in 1978.Two partners and Dr Thomas incorporated TPK Solar Systems in 1979 to commercialize the technology. TPK developed a production-ready diffused silicon solar cell and module manufacturing technology. In 1984, Dr Thomas left academia to promote PV around the world. TPK supplied the first grid-connected system in Canada at the Kortright Centre in 1983. The modules had degraded less than 1% when it was dismantled in 2017. In 1984 TPK provided turnkey silicon solar cell and module manufacturing lines to India's Central Electronics Limited, and Yunnan Semiconductor Device Factory of Kunming, China. In 1987 and 1988, TPK supplied turnkey PV module lines to Sri Lanka (Power & Sun Ltd) and Zimbabwe (Solarcomm).TPK closed in 1988. Dr Thomas continued through new companies to provide equipment, technology, modules and systems to many countries including multi-crystalline solar cell production lines to Norway and Taiwan (2003-2004). The first 25 kWp of the 75 kWp rooftop grid-connected PV system at the Hugh J. MacMillan Re-Hab Centre in Toronto was the largest in Canada prior to 1995. Dr Thomas also supported the industry in many ways. He was a part of IEC TC82 working group to develop the IEC 61215 module performance testing standard and co-founded Canadian Solar Industries Association (CanSIA President 1994-1995). He co-authored the CanMET Photovoltaics System Design Manual and wrote the "Photovoltaic Systems: A Buyer's Guide" in 1989. Raye retired in 2013 after a 232 kWp DC FIT system I designed for the Riverdale Mill in Inglewood won the Best Solar Project Award at CanSIA's 2012 Conference.



Sam Vanderhoof

Country: United States

Year joined industry: 1976

Company first worked for: Independent Power Company

Technology area: PV

Still active in the industry: Yes

A pioneer in the solar industry, Sam Vanderhoof has served as a corporate executive at Petra Solar, SMA America, Schott Solar, Trace Engineering/Xantrex and Kyocera Solar. Sam's career includes developing cutting edge technology and market strategy, specializing in power inverters, on and off-grid PV, and micro-grid projects, both domestic and internationally. Sam is currently CEO of Recycle PV Solar, a US company engaged in the collection, re-use and recycling of solar PV modules. www.recyclepvsolar.com



Andreas Wagner

Country: Germany

Year joined industry: 1979

Company first worked for: Wagner & Co Solartechnik GmbH in D-35091 Cölbe (near Frankfurt)

Technology area: PV

Still active in the industry: No

As a group of students Andreas Wagner and friends started a company in 1979 for renewable energy systems. It was a collective group of 9 persons with equal shares developing cost effective DIY solar systems. Andreas' specific role as an engineer of heat and energy was to develop these systems and to be one of the CEOs. Even that it was only a DIY system, they reached a very high energy output with their solar hot water system in German competition tests. Later on, they changed the distribution system and built up a network of solar installers, who mounted their systems in Germany and neighbour countries. They still continued to develop high efficient and reliable solar systems including drain back or thermosiphon systems with thermostatic overheating protection or big ST plants. As CEO Andreas was also a board member of the German solar industry association (BSW), responsible for standards and certification. From the early nineteen-eighties he was involved in different working groups for solar standardisation, including the European founder group for the Solar Keymark (the European solar certification system). The PV-part of the Wagner & Co business grew rapidly. At the height of the company's development in 2011 there were approx. 280 employees with a turnover of 300 mio €/a. About 90 of the staff were owners of the company, as the company was only owned by the employees. After the market depression for PV-systems the company went bankrupt. In 2014 Andreas developed a solar electric hot water system for small and medium demand in the new company "AWASOL GmbH". It is called "SELACAL Solar System" and is a combination of PV-modules with an electric hot water tank, which minimizes the installation costs and improves the thermal reliability. Today Andreas is still active in energy politics, especially to promote the CO2 tax, because as long as gas and oil stays cheap, we will not make the change.



Luke Williams

Country: Australia

Year joined industry: 1973

Company first worked for: SunTrap/Hot Water systems Pty Ltd

Technology area: PV

Still active in the industry: Yes

Luke Williams started working in the industry at the age of 16, in 1973 for his father's solar hot water and space heating business. He founded LJW Solar Pty Limited, in the early eighties, designing and installing photovoltaic and wind energy systems for a wide range of public and business clients. He has since become one of Australia's leading experts in the field of photovoltaic installation, lecturing to electricians, project developers and TAFE students across the country and offering training courses for all those who want to enter the industry. His systems powered rural properties without access to the electricity grid and his work can be seen throughout country Australia, in hotels, farms, National Parks, ordinary houses and holiday houses. Having installed the second ever grid interactive solar system in NSW, he has begun to install an increasing number of these systems, for private and commercial clients, who want to reduce their ecological footprints. For the past 30 years he has been running his country property exclusively on solar energy, from the big family home, to the workshop where he pre-built Photovoltaic systems for his clients. Ranging from off Grid power supplies of all sizes, grid systems, hybrid systems, pumping systems, systems for water recycled on gardens and orchards and solar water distillation unit. Then installed these on site. Luke truly walks the climate change path and can prove to anyone through past experience that you can operate anything, from a bank of computers to MIG welding and heavy-duty manufacturing equipment, normal everyday properties, entirely on solar power. As a Solar man of the first hour, he is accredited as a renewable energy system designer and installer with the Clean Energy Council, the National Accreditation Scheme for industry practitioners, and was one of the founding members of its forerunner, the Solar Energy Industry Association in 1993.



Neville Williams

Country: United States

Year joined industry: 1979

Company first worked for: 1979 at DOE

Technology area: PV

Still active in the industry: No

Neville Williams, a former journalist, first became interested in solar energy at the U.S. DOE during the Carter Administration. Ten years later, still interested in the possible future of solar PV, he founded the Solar Electric Light Fund in Washington, DC, which during the first seven years launched solar rural electrification projects in 11 countries. Then, he founded the Solar Electric Light Company (SELCO), a commercial enterprise, and co-founded SELCO-India with Dr. Harish Hande. Both organizations continue to operate today, but have grown much larger. In 2005, Williams founded a U.S. domestic PV solar, sales, and installation company, Standard Solar, in Maryland. He retired at age 65 once investors provided funds to expand the company. As a consultant, he and a partner then built solar farms to supply rural electric co-ops in New Mexico. Standard Solar has become a leading U.S. solar-power project developer, now owned by Energir, Montreal.



Philip Wolfe

Country: United Kingdom

Year joined industry: Mid 1970's

Company first worked for: Lucas Industries

Technology area: PV

Still active in the industry: Yes

Philip Wolfe obtained his engineering degree from Cambridge University. He joined Lucas Industries and was requested to investigate the solar power market which resulted in the formation of Lucas Energy focussing on solar in the mid 1970's. He led Lucas Energy until he negotiated their joint venture with BP in 1979, becoming the first Chief Executive of what became BP Solar. He left BP Solar in 1981 and with a few others acquired Solapak from Solarex which morphed into the Intersolar Group. He was Chairman and Chief Executive while it expanded its business from industrial systems engineering into product marketing and thin film solar cell manufacturing. From 1993 to 2002, when its assets were sold, the Group was the sole UK manufacturer of photovoltaic cells. In 2003 he established WolfeWare a consultancy business that is still operating today. In 1985 he was one of the founders of EPIA serving as its third president. He was also one of the founders of UK PV Association. He was Director General of the Renewable Energy Association from 2003 to 2009, overseeing the successful campaign for Feed-in Tariffs and the Renewable Heat Obligation. He is an expert on utility scale PV systems (solar parks) and pioneered their introduction in the UK and also community power systems. He wrote the first book on utility-scale solar power, which was published by Routledge in 2012 and has many other publications on the application of renewable energy technologies. In 2018 he released the book: *The Solar Generation* published by Wiley-IEEE about the early years of terrestrial photovoltaics. [He has lectured at universities, presented at conferences worldwide and featured on television and radio.] He was appointed Member of the Order of the British Empire (MBE) in 2016 for services to renewable energy and the energy sector.

7.10 SWC50 Platinum Partner: NREL



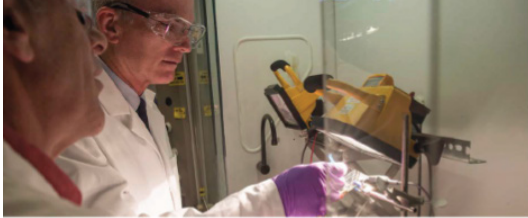
For more than 40 years, NREL's world-class research staff has devised solutions to transform the way we generate, consume, store, and distribute energy. And now, our work is more important than ever. As the population grows and new technologies and devices are added to the grid, we must examine the effects on the grid and enhance security within our most critical systems. As environmental threats expand and human demands on urban centers increase, we need more sustainable and efficient ways of generating energy that consider resource competition worldwide. NREL continues to anticipate these challenges, offering solutions through research, innovation, analysis, partners, and people. We are building the foundation of tomorrow's energy landscape and inspiring the economic growth of the future.

From the start, NREL's leadership in energy efficiency and renewable energy science and technology has set us apart. We are focused on creating the technical foundation that will support the continued evolution of an advanced energy ecosystem. Researching energy systems and technologies—and the science behind them—for a future powered by advanced integrated systems is what we are known for and what we do best. Our scientific excellence shines bright. We are proud that, during our 40-plus years, NREL scientists have been awarded more than 60 R&D 100 Awards, known as the "Oscars of Innovation." Our groundbreaking energy research has contributed to transformational scientific advancements, exponential decreases in costs, and more renewable installed capacity than ever before.

At NREL, we are transforming energy to create a better today...and tomorrow. NREL is home to the most powerful, high-performance computing system exclusively dedicated to advancing renewable energy and energy efficiency technologies. NREL also offers state-of-the-art immersive, high-resolution visualization capabilities at the Energy Systems Integration Facility's (ESIF's) Insight Center. The high-performance computing data center at NREL is highly energy efficient, thanks to a warm-water liquid cooling system. The system captures and reuses waste heat as the primary heating source throughout ESIF offices and laboratory space. Whether it is growing the scientific body of knowledge, developing analyses to help inform policymakers, engineering integrated energy infrastructure, or establishing valuable partnerships to bring the next generation of technologies to market, innovation for positive societal impact is at the core of our work. With programs to advance research and technologies in advanced manufacturing, bioenergy, buildings, computational science, energy analysis, energy security and resilience, energy storage, geothermal, grid modernization, government energy programs, hydrogen and fuel cells, solar, transportation, water, and wind, we stop at nothing to push the boundaries of what is possible.

At the National Renewable Energy Laboratory (NREL), we are transforming today's energy challenges into tomorrow's solutions.





We are transforming energy through **partnerships.**

Creating sustainable, transformational change is not an easy job—and we know we cannot do it alone. That is why NREL partners with a diverse range of businesses and organizations. Together, we accelerate the transition of renewable energy and energy efficiency solutions into practical applications. These collaborations are critical to creating a clean energy ecosystem that transforms science into impact.

Our researchers, facilities, tools, and analyses catalyze cutting-edge innovations that create affordable and abundant energy and new business opportunities and greatly reduce risk for new technology investment. By bridging the gap from concept to market, we link R&D with real-world applications.

-  871 active partnerships with industry, universities, foundations, and governments
-  573 patents for NREL technologies to date
-  65 R&D 100 Awards
-  Research investment exceeded \$491 million in business volume in Fiscal Year 2019

Our campuses boast world-class facilities and other unique laboratory environments that provide our partners with valuable research space and solutions to help speed new approaches to market.

During the past four decades, we have learned a lot about how to get the most out of every research dollar. To ensure our partners get what they need in the most efficient way possible, we have transformed the way we do business. We offer several types of partner agreements and mechanisms that enable us to provide flexible and efficient ways to get the job done.

"The best thing that NREL provides to us is their expertise. Whenever we're hiring someone to help us with a particular project, we want to have the best in the business. We view NREL as that and a phenomenal partner in helping us accomplish our energy goals."

Col. Brian K. Wortinger
U.S. Army Garrison Commander



-  2,700 full- and part-time employees
-  25% of staff are early-career researchers and visiting scientists

We are transforming energy through our **people.**

Our passionate people are 100% committed to changing the world every single day. NREL is a rich, cultural melting pot that enables many voices and levels of experience to collaboratively solve problems that come our way. And while passion is one thing, credentials are another. Our academic degrees outnumber our staff, and our researchers typically publish more than 1,700 publications a year. Our scientific innovation and excellence has resulted in more than 570 patents and counting.







We are transforming energy at **home.**

NREL is a living laboratory. We showcase the benefits of energy efficiency and renewable energy technologies by investing in site design and building development across our campus. Many of the high-performance buildings on NREL's main campus in Golden, Colorado, have achieved Leadership in Energy and Environmental Design (LEED) and/or net-zero energy status. NREL's Science and Technology Facility was the first federal laboratory building in the nation to achieve LEED Platinum certification.

Additionally, our Research Support Facility is one of the world's largest energy-efficient office buildings, and what we have learned here has been applied to more than 50 new buildings across the United States. Incorporating cost-effective design approaches that maximize the use of energy efficiency and renewable energy technologies has positioned these buildings as models for energy use and sustainability.



-  **Campus Size**
Two campuses totaling 632 acres in Golden and Boulder, Colorado
-  **World-Class Facilities**
Open to entrepreneurs, engineers, scientists, and universities
-  **Publications**
More than 1,700 scientific and technical materials published annually
-  **Nationwide economic impact**
exceeded \$1.4 billion in 2019

7.11 SWC50 Supporter: IEA SHC



IEA Solar Heating and Cooling Programme

In the wake of the 1973-74 oil crisis, industrialized countries established the autonomous International Energy Agency (IEA) within the OECD framework to help its members respond to major oil supply disruptions and create an international forum for energy cooperation. This belief that the future of energy security and sustainability starts with global collaboration led to the creation of Technology Collaboration Programmes (TCPs). Of these TCPs, the **Solar Heating and Cooling Programme (SHC TCP)** is one of the oldest, established in 1977.

For over 40 years, the SHC TCP's overarching objective has been co-operative research, development, demonstration, and stakeholder-oriented information exchange regarding solar heating and cooling systems. What has made our solar work unique over these past four decades is our international R&D collaborative work. The benefits of such an approach are numerous; namely, it accelerates the pace of technology development, promotes standardization, enhances national R&D programs, permits national specialization, and saves time and money.



Our vision has adapted over the years, but our core objective remains the same – to expand where and how solar heating and cooling technology is used by breaking down the technical and non-technical barriers through our collaborative research and knowledge exchange.

Who we are today is very different than in 1977. Our SHC family includes 19 countries, the European Commission, European Copper Institute, ISES, and five UNIDO GN-SECs. And 2020 will see the start of our 66th project. Our projects, referred to as Tasks, bring experts together to work on basic research, materials testing, reliability and durability, design tools, and demonstration projects. All with the primary objective to develop and improve technologies that use the energy of the sun to heat, cool, light, and power buildings.

What we do today is very different than in 1977. R&D is still the focal point of what we do, but so is increasing the visibility of solar thermal. To do this, we've taken a diverse approach – SHC Solar Academy (webinars and trainings), annual statistics (Solar Heat Worldwide), publications (reports, databases, factsheets, newsletters, etc.), conferences (our own and others), and our Solar Award.

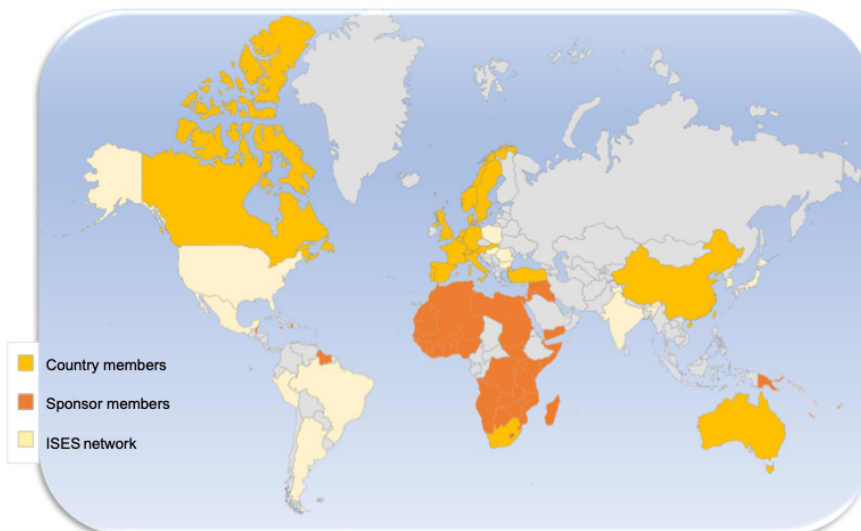


Looking forward, we will undoubtedly continue to adapt as we work toward our vision of solar heating and cooling technologies providing more than 50% of low temperature energy demand for buildings in 2050 and contributing a relevant share to the heat supply for the industrial and agricultural sectors.

We expect solar heating and cooling will contribute significantly to lowering CO2 emissions worldwide, and we will work hard to help make this happen.

To learn more about the SHC TCP and our work, please visit www.iea-shc.org.

SHC TCP Members



19 Countries + EC

9 Sponsors

European Copper Institute, ISES, and 7 GN-SECs representing 173 countries (2 in process of joining)

7.12 SWC50 Supporter: RENEW



About Renew

Renew is an Australian national, not-for-profit member-based organisation that inspires, enables and advocates for people to live sustainably in their homes and communities.

Founded in 1980 as the Alternative Technology Association, Renew provides expert, independent advice on sustainable solutions for the home to households, government and industry.

Renew has helped thousands of households and organisations save money and reduce their environmental footprint with information on energy efficiency, solar power and batteries, rainwater tanks, materials reuse and waste.

Renew provides advice and consultancy services based on its technical expertise in energy, water and communications.

Renew also advocates in government and industry arenas for policies that promote renewable energy and cut emissions, make our homes healthier, more affordable and climate resilient, and protect consumer rights in our rapidly changing energy markets.

Renew has around 11,000 members (mostly individuals) and a network of 14 active volunteer branches around Australia and beyond, but also engages with more than 250,000 people each year through its publications, events, services, and projects. Its community of influence and action includes:

- readers of its two market-leading sustainability magazines Renew and Sanctuary;
- attendees at its annual Sustainable House Day and EV (electric vehicle) Expo events;
- participants in its Speed Date a Sustainability Expert events and information sessions;
- users of its online information, calculators, and analysis tools such as the Sunulator solar assessment tool;
- people and businesses using our energy advice service; and
- people and organisations partnering and engaged with its research and advocacy work.

History

Renew's genesis was in a decision by Friends of the Earth in 1976 to form a group to be proactive on green energy and technology – the Alternative Technology Cooperative. In early 1980 it reconstituted itself as a fully-fledged organisation called the Alternative Technology Association (ATA) and started publishing a regular newsletter, which morphed into a magazine called Soft Technology by June.

In 1983 ATA members built the solar workshop at CERES environmental park in Melbourne's north, and in 1984 they published their first book, drawn from the best content in Soft Technology magazines. This was also the year they started establishing branches in different regions.

In 1986 ATA members first wrote a submission to a government inquiry – regarding electricity generation and insulation regulations. As became common, their recommendations were influential in the legislation and regulations that were implemented as an outcome of the inquiry. By 1989 they developed their first fully-fledged strategic policy platform, setting out a path to renewable energy for the State of Victoria. It was subsequently used as a basis for numerous submissions to state and federal government inquiries on the issue.

By the 2000s, the ATA was well established as a national organisation with a highly regarded alternative technology magazine (Renew, the renamed Soft Technology) and the new, increasingly popular Sanctuary magazine focusing on modern sustainable home design. It was becoming an increasing presence and influence in energy policy advocacy. It was also in this decade that the precursors to the Speed Date a Sustainability Expert and Sustainable House Day were first held. And in 2007, ATA launched its International Projects Group to develop and implement a solar lighting program for remote villages in Timor Leste.

During the 2010s all these activities increased in scope and significance, cementing ATA as a key organisation in inspiring and enabling people and communities to live more sustainably, informing households' decisions to increase their energy and water efficiency and invest in energy technology, and influencing state and national energy and climate policy development – winning Climate Change Leadership awards from the United Nations Association of Australia and the NSW Government in 2017. A key achievement was the development of Sunulator – a comprehensive solar and battery analysis tool that uses climate and weather data,

solar PV and battery performance specifications, household energy usage data and financial parameters to determine the financial viability, environmental impact and energy performance of a solar PV system, with or without a battery. Sunulator quickly became an integral part of ATA's energy advice and consultancy services, and a critical resource for research and advocacy projects. It was expanded in 2018 to include heating, cooling, and hot water appliance simulations in order to assess appliance options as well as solar and batteries. In 2018 – in recognition that what was once alternative technology was now mainstream, and that the organisation was about so much more than just the technology – the ATA changed its name to Renew. In 2019 it won the Victorian Premier's Sustainability Award, published the 150th issue of Renew magazine, and ran the largest ever Sustainable House Day with 44,560 visits to 252 open homes across Australia. In 2020 the work of Renew continues to grow, publishing the 50th issue of Sanctuary magazine, successfully pivoting Sustainable House Day to an online format due to Covid-19 requirements and stay-at-home orders in key states, continuing to host a wide variety of information events around the country, and playing a key role in energy and climate policy development process with wide recognition as an expert consumer advocate.

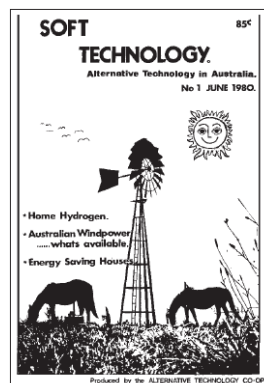
The Future

As it heads into its fifth decade, Renew is as determined as ever to inspire, enable and advocate for people to live sustainably in their homes and communities, and help make a world in which communities thrive in a way that does not cost the earth. More practically, its 2025 goal is that sustainable living in Australia will:

- Be a common expectation for Australian households.
- Be increasingly affordable and accessible.
- Have broad-based political support.
- Occur at a scale where it creates its own momentum.



1992 Energy Demonstration Mobile Demonstration



First Edition of Magazine

7.13 SWC50 Supporter: Solar Energy Industries Association



The Solar Energy Industries Association (SEIA) is the national trade association for the U.S. solar industry, leading the transformation to a clean energy economy and creating the framework for solar to achieve 20% of U.S. electricity generation by 2030. SEIA works with its 1,000 member companies and other strategic partners to fight for policies that create jobs in every community and shape fair market rules that promote competition and the growth of reliable, low-cost solar power.

In 1974, a group of five industry members met in the noisy basement of the Washington Hilton to discuss the possibility of establishing an association for the solar industry. They agreed to create “a broad-based trade association supporting prompt, orderly, widespread and open growth of solar energy resources now.” This was the beginning of SEIA’s four decades of solar energy advocacy.

SEIA faced a host of formidable challenges early on, chief among them, building a profitable solar energy industry. Sheldon Butt, SEIA’s first president, was famously quoted as saying “shouldn’t we have an industry before we can have an industry association?” But SEIA had emerged just as the effects of the first oil embargo were becoming painfully clear. SEIA would play a central role in integrating solar energy into the energy saving policies of the Carter Administration.

In the 1980s the solar industry faced one of its biggest challenges when President Reagan signed a tax bill that severely cut federal research funding and residential tax credits. Despite the political climate, SEIA, through its strength in numbers, was able to promote ongoing research and development funding, which kept solar energy a priority for the Department of Energy.

SEIA has grown tremendously from its early days. By the 1990s, SEIA had built the association to encompass 150 national members. In 2006, SEIA and its members successfully advocated for the establishment (and subsequent extensions) of the solar Investment Tax Credit, a critical federal policy that has spurred billions in economic investment nationwide. As the solar industry’s growth has skyrocketed and prices continue to fall, SEIA has been advocating at the federal and state level for policies that continue this story of American innovation.

Today, SEIA represents nearly 1,000 companies from across the solar supply-chain, from all technology and market segments. Installers, project developers, manufacturers, contractors, financiers, law firms, and non-profits have all seen the value of joining SEIA and participating in the collective growth of solar energy in the U.S. Through the work of SEIA and its members, the solar industry has become one of the fastest growing industries in America.

SEIA, along with its members and allies across the energy system, have set an ambitious goal for solar to reach 20% of all U.S. electricity generation by 2030. To meet this target, SEIA is working collaboratively across technologies and industries to build a comprehensive clean energy economy. The COVID-19 crisis has heightened the need for long-term thinking on workforce development, infrastructure, resilience, equity and economic recovery. We can address all of these needs by investing in a clean, affordable electricity system, and one that puts diversity, equity, inclusion and justice at the forefront.

SEIA looks forward to working with anyone who shares our vision for job creation, equity, climate action, and a strong clean energy economy.

7.14 ISES Section: Brazil



The Brazilian Section of ISES

The Brazilian Solar Energy Society (ABENS, Associação Brasileira de Energia Solar in Portuguese - www.abens.org.br) is the official Brazilian Section of ISES, and was created on February 17, 1978 with the aim of promoting the dissemination of and carry out studies on the many areas of solar energy in Brazil.

The years of growth in solar energy research in Brazil coincide with the international oil crisis, a situation that, at the time, encouraged researchers and authorities responsible for the energy area to look for alternatives to this crisis. However, having gone through its worst phase in the second half of the 1980's, the resources available for carrying out research in the field of solar energy began to suffer a retraction, which decisively contributed to a reduction in the scientific production of researchers active in this area.

ABENS held several Annual Work Meetings throughout the 1980's, but never a scientific congress, and the association remained dormant throughout the 1990's and early 2000's. The first ABENS scientific conference CBENS (Congresso Brasileiro de Energia Solar in Portuguese) took place only in 2007, and has been held regularly ever since, as listed below:

- I CBENS (Fortaleza, 8 - 11 April 2007)
- II CBENS (Florianópolis, 18 - 21 November 2008)
- III CBENS (Belém, 21 - 24 September 2010)
- IV CBENS (São Paulo, 18 - 21 September 2012)
- V CBENS (Recife, 31 March - 3 April 2014)
- VI CBENS (Belo Horizonte, 4 - 7 April 2016)
- VII CBENS (Gramado, 17 - 20 April 2018)
- VIII CBENS (Fortaleza, 26 - 20 October 2020)
- IV CBENS (Florianópolis, scheduled to take place between April and June 2022)

CBENS is now an established event, and usually attracts from 400 to 600 participants, mostly from Brazilian universities and research centers, as well as participants from neighbouring countries in South America, with guest speakers invited from all over the globe.

ABENS' bylaws are based on ISES' bylaws, and ABENS' governance body is composed of a President and a Vice-President, together with the 1st and 2nd Secretary and the 1st and 2nd Treasurer, which are elected by simple ballot every two years.

ABENS actively promotes gender equality, and has created a Women in Solar Energy Network to discuss gender equality issues and attract women to the field of solar energy.

Information provided by Prof. Ricardo Rütther – ABENS President Elect 2019-2021
ricardo.ruther@ufsc.br




ABENS

ASSOCIAÇÃO BRASILEIRA DE ENERGIA SOLAR

[f](#) [@](#)
[CONGRESS AREA](#)
[JOIN ABENS](#)
[PORTUGUÊS](#)
[ESPAÑOL](#)

[PRESENTATION](#)
[REGISTRATION](#)
[SUBMISSION OF PAPERS](#)
[PROGRAM](#)
[COMMITTEES](#)
[VENUE](#)
[TECHNOLOGICAL FAIR](#)
[TOURISM AND ACCOMMODATIONS](#)
[CONTACT](#)



VIII BRAZILIAN SOLAR ENERGY CONGRESS • 2020

A MESSAGE FROM THE ABENS PRESIDENTS
 (PRESIDENT IN OFFICE AND THE PRESIDENT-ELECT)

A MESSAGE FROM THE LOCAL ORGANIZING COMMITTEE

CBENS2020 HÍBRIDO

7.15 ISES Institute Members: ZAE Bayern



History of ZAE Bayern

In 1973, the Middle East crisis led to a steep rise in the price of oil. The Federal Government reacted by establishing a “Non-nuclear Energy Research” unit within the BMFT. Prof. R. Sizmann was an advisory member of a committee of the Federal Ministry for Research and Technology (BMFT). This gave him the impetus to also experiment with alternative energies. As one of the first concrete activities, a workshop with the professors G. Lehner, W. Bloss, E. Hahne and N. Meier from Bamberg took place in Stuttgart in April. The lectures dealt with the use of hydrogen and renewable energies.

In 1976, a first European test of thermal collectors was carried out at the Ludwig-Maximilians-University for the public magazine “Schöner Wohnen”. Ultimately, it was this project that gave rise to the idea of founding a Bavarian Solar Energy Research Institute. However, it was only after the Chernobyl accident, 10 years later, that actual activities took place. Prof. R. Sizmann went to the Bavarian Ministry of Economics and presented the idea of founding a Bavarian Institute for Renewable Energies. In the following years until 1991, various concepts for the institute were discussed and comrades-in-arms from other universities were found. In the end, a structure for the association was agreed upon. Industrial companies, municipal utilities and also private individuals could be won as members of the association. Five university professors with relevant fields of work formed the executive board. They were also scientific department heads. Five divisions were constituted:

- Division of Prof. Dr. Georg Alefeld „Energy Conversion and Energy Storage“
- Division of Prof. Dr. Jochen Fricke „Thermal Insulation and Heat Transfer “
- Division of Prof. Dr. Rudolf Hezel „Photovoltaics“
- Division of Prof. Dr. Rudolf Sizmann „Solar Thermal“
- Division of Prof. Dr. Helmut Schaefer „Efficient Use of Energy “.

So the Bavarian Centre for Applied Energy Research, ZAE Bayern, was founded in December 1991 as a non-university, non-profit research institute and began working at three locations under the direction of Prof. Jochen Fricke in January 1992.

Current structures of ZAE Bayern

From an initial staff of 24 in 1992, ZAE Bayern expanded its workforce to a total of 220 employees in 2017. The employees were scientists, technicians and student assistants from the departments of physics, mechanical engineering and energy technology. The five departments of the foundation were gradually merged to 3 departments. In the year 2018 another break occurred. The Erlangen department with almost all its staff was transferred to the Helmholtz Association. The now two departments in Würzburg and Garching near Munich currently have 120 employees.

ZAE Bayern is a member of the National Renewable Energy Research Association (FVEE) and the German Industrial Research Foundation Konrad Zuse e. V. ZAE Bayern is also a founding member of Energy Campus Nürnberg (EnCN). And ever since its founding ZAE Bayern was member of the International Solar Energy Society ISES!



ZAE Bayern's project work

In the years from 1992 to 2020, ZAE Bayern developed into a major factor in the Bavarian energy research landscape for renewable energies. It works closely with its associated universities in Würzburg (Julius-Maximilians-University Würzburg, Friedrich-Alexander-University Erlangen, Technical University Munich) and the Bavarian and German industry together in projects. The financial basis is a basic funding by the Bavarian Ministry of Economic Affairs. The projects concern in particular the use of renewable energies and the rational use of energy. The focus is on the transfer of scientific development from university research to industrial application. Over the years, the transfer of technology to industry has also been largely carried out by ZAE staff who have moved from temporary positions at ZAE Bayern to the relevant industrial companies.

The contents of the interdisciplinary research projects in the past 3 decades were:

- Use of renewable energies such as solar energy (photovoltaics, solar thermal energy, near-surface geothermal energy) and deep geothermal energy.
- Development of materials in the above mentioned areas. - Efficient use of energy in buildings for both heating and cooling.
- Development of solar cells, thermal and chemical storage systems and fuel cells.
- Efficient use of energy in industrial processes. There is considerable potential for savings, especially in the sector coupling and storage of thermal energy.

Today, ZAE Bayern has developed into a nationally and internationally recognized research institute where young people are trained in relevant fields for industry and research.

8. 1980-1989

8.1 ISES 1980-1989

1980

- The Board decided that ISES Solar World Congresses would be held every two years oscillating between three areas: North, Central and South America; Europe and Africa; and the East and Oceania.
- ISES Sections were established in Spain and Austria.

1981

- ISES Section was established in France.
- The Löf/Duffie Best Paper Award was established to honour authors of papers considered to be outstanding contributions published in the ISES scientific journal, "Solar Energy".

1982

- The Mexican and Portuguese Sections were formed.

1983

- The Christopher A. Weeks Achievements through Action Award was established to encourage young professionals in solar.



Figure 26: Past Presidents sitting with the newly elected President in Perth. In the front row, left to right, are Wal Read, Harry Tabor, and Bill Charters and in the back row, Jack Duffie, Roger Morse, George Löf and Bill Klein.

1984

- The Egyptian Section was formed.
- An editorial Board was created to assist Everett Howe with SunWorld.
- Solar Energy Journal expanded its pages to 1,400 per year from 1200, with papers limited to 10 pages.

1985

- The 1985 Solar World Congress, Montreal, had a new format which included posters.
- Jack Duffie became Editor of Solar Energy Journal.



Figure 27: Wal Read and newly-elected President Bill Beckman with Horst Hörste (President of the German Section of ISES) pointing the way to the 1987 Hamburg Congress

1986

- A members' survey indicated the following distribution: engineers (57%), physicists (17%), architects (8%) and chemists (4%) with most in education and research.

1987

- First ISES working groups were chartered.
- Passive and Low Energy Architecture (PLEA) Working Group created the first PLEA Newsletter.
- The Swiss Section was accepted.
- The first *Solar World Challenge* car race was held in Australia.
- The Brundtland Commission published *Our Common Future* which strongly influenced the Earth Summit (1992) and UNCED 3 in Johannesburg (2002).

1988

- In June 1988, ISES headquarters moved from CSIRO laboratories in Melbourne to Chisholm Institute of Technology in Melbourne.
- The Italian Section instituted the first ISES journalism prize for outstanding contributions to the promotion of renewable sources and energy saving.
- ISES Section members were using climate change as a rationale for local support of solar energy.

1989

- *ISES News* produced an editorial called *The Greenhouse Effect and Society*.
- South Pacific and the Republic of South Korea Sections were created.



Figure 28: A traditional ISES presentation: newly-elected President Lorriman with assembled Past Presidents Löf, Tabor, Datta, Beckman, Read and Corvi. 1989

- ISES outreach program includes creation of new national Sections, development of student membership, establishment of connections between ISES and other organizations like the United Nations with compatible goals, and expansion of the working group structure.
- International Association for Solar Energy Education (IASSEE), ISES working group, was started.

Table 10: Officers of ISES 1981-1991

Years	President	Vice President	Secretary or Secretary / Treasurer	Asst Treasurer
1981-83	Harry Tabor	Wal R Read S. Karaki	Frank. G. Hogg	William. H. Klein
1983-85	Wal R Read	William A. Beckman Horst Hörster	Frank. G. Hogg	William. H. Klein
1985-87	William A Beckman	Corrado Corvi Vagn Korsgaard	Wal R Read	William. H. Klein
1987-89	Corrado Corvi	Doug Lorriman Georges Peri	Wal R Read	William. H. Klein
1989-91	Doug Lorriman	Adolf Lorriman Leslie Jesch	Wal R Read	William. H. Klein

Table 11: Conferences and Meetings 1981-1989

Year	Location	Overview
1981	Brighton UK	Theme: <i>Solar Technology in the Eighties</i> 1,700 participants, and 100 displays Organiser: David Hall. First use of poster papers at a technical conference. Farrington Daniels Award: Dr Harry Tabor (Israel)
1983	Perth Australia	1,000 participants (60 countries), 560 papers and 87 industry exhibitors from 15 countries Conference Chair: Wal Read Farrington Daniels Award: Dr Peter E. Glaser (USA) The first Christopher Weeks Achievement Award went to the Solar Energy Lab University of Madison, USA (Jack Duffie and Bill Beckman)
1985	Montreal Canada	Intersol 85 1,100 participants Chair of Organising Committee: Gilles Gloutier Farrington Daniels Award: Prof. Georg O. Löff (USA) Christopher Weeks Achievement Award: Solar Energy Unit, Cardiff, Wales, UK (Brian Brinkworth)
1987	Hamburg Germany	Theme: <i>Advances in Solar Energy Technology</i> 1,700 participants (54 countries), 900 accepted papers, large exhibition Farrington Daniels Award: Professor Jack Duffie (USA) Christopher Weeks Achievement Award: Solar Energy Applications, Colorado University) Bill Duffy and Terry Lenz)
1989	Kobe Japan	Theme: <i>Clean and Safe Energy Forever</i> 700 participants (54 countries), 450 Verbal presentations and 150 Posters. Solar car and solar boat display with first Japanese Solar Boat Race being held. Conference Chair: Dr T Noguchi Farrington Daniels Award: Professor John Page (UK) Christopher Weeks Achievement Award: The Solar Thermal Engineering Centre, University of Waterloo (Canada) and LUZ Industries (Jerusalem)

8.2 ISES Presidents 1980-1989



Figure 29: Harry Tabor, President 1981-1983

Harry Tabor

Harry Tabor (UK, Israel) was born in London, the UK in 1917. He received a BSc in Applied Physics from the University of London in 1939. In 1949, David Ben-Gurion, Israel's first Prime Minister, invited Harry to move to Israel to create the National Physical Laboratory (NPLI). While there, he invented the 'selective solar surface' and was the 'father' of the solar collector industry in Israel. In 1961, together with Lucien Yehuda Bronicki, he developed the low-temperature Organic Rankine Cycle turbine (the Ormat turbine). In 1981, he was awarded the Farrington Daniels Award and on his 80th birthday, ISES published a selection of his scientific papers. In 2014 at age 96, he received the President's Prize for Life Accomplishment, one of Israel's most prestigious awards.



Figure 30: Wal Read, President 1981-1983

Wal Read

Wal Read (Australia) was a mechanical engineer who joined the Commonwealth Scientific and Industrial Research Organization (CSIRO) in 1952. In 1956, he became a principal research scientist working in the areas of solar domestic hot water and desalination and for many years he led the Solar Energy Utilization Group, which later became the Solar Energy Unit. He became very active in the development of solar water heating systems, swimming pool heating, solar air heating with rock bed storage, solar kiln timber drying, and, in particular, large solar distillation projects. For several years he was the engineer responsible for developments in industrial process heating in areas such as pasteurization and bottle washing.

He became Secretary of the Australia-New Zealand Section of ISES in 1969 and Chairman in 1976–78. He submitted the proposal to the section to consider holding the ISES SWC 1983 in Perth. He was also elected to the ISES Board in 1976 and later joined the ISES Committee for Programs and International Activities, becoming the Vice President of ISES in 1981. In 1986, he was awarded an Order of Australia for service to science and solar energy. He was asked to take over the position of ISES Secretary/Treasurer and was subsequently to carry out this important task for many years, along with maintaining the ISES News

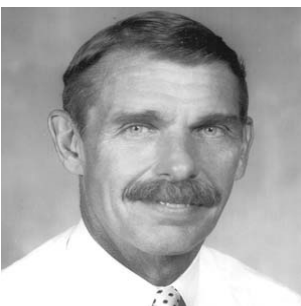


Figure 31: William Beckman, President 1985-1987

William A. Beckman

Bill Beckman (USA) was very well known to ISES scientists and engineers as the co-author (along with Jack Duffie) of *Solar Energy Thermal Processes*, probably the most used solar basic engineering text of the period. Beckman joined the University of Wisconsin-Madison as an Assistant Professor in 1963 and remained there for the rest of his career. Prior to coming to the UW, he gained his BS, MS, and PhD from the University of Michigan and worked for an automotive manufacturer. He spent several summers at the Jet Propulsion Laboratory and was a visiting scientist at CSIRO in Australia and Valbonne, France. He then served as Chair of the Mechanical Engineering Department at UW from 1987 to 1991. Bill earned numerous other honours over the years, including being named a Fulbright Scholar in 1977. He held an Ouweneel-Bascom Professor Emeritus position continuously from 1981 to his retirement and retired in 2000.



Figure 32: Corrado Corvi, President 1987-1989

Corrado Corvi

Corrado Corvi (Italy) obtained his doctorate in Electrical Engineering at Torino University and started to work in Milan in the field of electric batteries and electric power. When electricity was nationalized and ENEL was formed, he became a member of its management in Rome, where he managed the field of renewable energy. He became a member of different committees of the European Community in Brussels and of the International Energy Agency in Paris. Corrado chaired the European Community committee in charge of the construction of "Eurelios," the solar energy power station built in Adrano (Sicily). In the speech he gave at the beginning of his term, he emphasized the importance of involving energy industry operators in the activities of all of the ISES Sections, side by side with the academic institutions and research centres. As president of ISES, Corvi described the Society's role at the United Nations (1988).



Figure 33: Doug Lorriman, President 1989-1991

Doug Lorriman

Doug Lorriman (Canada) received a Bachelor of Environmental Studies in 1972 and a Bachelor of Architecture in 1974, both from the University of Waterloo. After completing his university studies, he was employed at Moriyama and Teshima Architects of Toronto, and he became an Associate of the firm in 1978. In 1985, he left Moriyama and Teshima to help found Solarchem Environmental Systems. At Solarchem, Doug served as Vice President, and then Chairman of the Board of Directors. Solarchem developed a UV/oxidation system for the destruction of dissolved organic contaminants in groundwater and industrial wastewater. Lorriman was a Director of the Solar Energy Society of Canada from 1975 to 2000 and was a Board Member of the International Solar Energy Society from 1986 to 1993. He also was the Operating Agent for Task 14, Advanced Solar Domestic Hot Water Systems of the International Energy Agency as well as the Operating Agent for Task 29, Solar Crop Drying.

8.3 PV 1980-1989

The price of PV modules continued to drop, and the applications of PV continued to grow through the 1980's with the first large scale grid connected systems being installed and the installation of the first system over 1MW. Solar powered aircraft are demonstrated, and Solar car racers started in countries like Australia, Switzerland and Austria. Manufacturers' merge or are bought out and some early ones disappear.

1980

- **ARCO Solar** became the first solar company to produce more than 1 megawatt of photovoltaic modules in one year.
- **IEC at University of Delaware**, achieved 10% efficiency for the thin-film solar cell using copper sulphide/cadmium sulphide.
- On behalf of Ford, Bacon & Davis, Utah, **Wasatch Electric** built a 105.6 kW PV system in the State of Utah. The modules integrated into the system were produced by **Motorola**, **ARCO Solar** and **Spectrolab**.
- **Heliodinamica** was founded near Sao Paulo, Brazil by private investors led by Bruno Topel.
- **Newcastle Photovoltaics Applications Centre (NPAC) (Northumbria University)** was established by Professor Bob Hill and managed by Dr Nicola Pearsall.

1981

- Dr. Paul MacCready (founder of AeroVironment in 1971) along with support from other engineers at AeroVironment designed the solar-powered aircraft—the “Solar Challenger”. On July 7th the “SolarChallenger” flew from France to England across the English Channel. The aircraft had over 16,000 solar cells mounted on its wings, which produced 3,000 watts of power.
- Antonio Luque started **Isofoton** and it is the first company to mass-produce bifacial solar cells based on the work undertaken by Antonio Luque et al. at the **Institute of Solar Energy** in Madrid.
- **Photowatt** (France) was formed by **SAFT** (Battery division of Compagnie Generale d’Electricite (CGE) and oil company **ELF** (Societe Nationale Elf Aquitaine).
- **Philips** merged its PV activities with **Photowatt**.
- **NASA LeRC** built PV systems for vaccine refrigerator power and by 1984 had supplied systems to 30 locations around the globe.
- A system with peak power of 90.4 kW, with modules produced by **Solar Power Corporation**, was built in Square Shopping Centre in Lovington, New Mexico and a similar system was built for Beverly High School in Beverly, Massachusetts.
- A seawater desalination system with 10.8 kW peak power was built in Jeddah, Saudi Arabia the same year.
- **Helios Technology** was established in Italy.
- **BP** acquires 50% of **Lucas Energy Systems** and **Lucas BP Solar** is formed.
- **Fraunhofer Institute for Solar Energy Systems (F-ISE)** was founded by Adolf Goetzberger as part of Fraunhofer Society.

1982

- The first, photovoltaic megawatt-scale power station went on-line in Hisperia, California. It had a 1-megawatt capacity system, developed by ARCO Solar, with modules on 108 dual-axis trackers.
- Australian Hans Tholstrup (and support driver Larry Perkins) drove a solar-powered car - the QuietAchiever – 4000 Kms between Perth and Sydney in 20 days. Tholstrup was the founder of the “World Solar Challenge” in Australia, considered the world championship of solar car racing.
- Volkswagen in Germany began testing photovoltaic arrays mounted on the roofs of Dasher station wagons, generating 160 watts for the ignition system.
- **Kyocera Corp** was the first manufacturer in the world to mass-produce Polysilicon solar cells using the casting method, today’s industry standard.
- Worldwide photovoltaic production exceeded 9.3 megawatts.
- A 200 kW_p PV array was installed on **Solarex’s** production premises rooftops in Frederick, Maryland.
- **Pragma** founded by AGIP (Petroleum business of Italian oil company ENI) in Nettuno (south of Rome) under the leadership of Giovanni Simoni.
- **Crystalox** was established in Oxforshire UK and focussed on the development of equipment for manufacturing multicrystalline silicon technology.
- **PV Energy systems Inc** (USA) was established by Paul Maycock and his newsletter **PV News** was produced until 2002.

Exact Years Not Known

- **Solarvolt** was formed in early 1980’s as a joint venture between **Motorola** and **Shell**.
- **Siemens** involvement with PV started in the early 1980’s through its nuclear energy subsidiary **Interatom**.
- **Grundfos**, a Danish company who manufacturer quality pumping systems commenced the manufacturing of solar water pumping systems in the early 1980’s.

1983

- **Amoco** bought out **Solarex** for \$25 million.
- **BP** acquired final 50% of **Lucas** and **BP Solar** was formed.
- **Astropower Corporation** formed as Astropower Division of **Astrosystems Inc.**
- **ARCO Solar** dedicated a 6-megawatt photovoltaic substation in central California. The 120-acre, unmanned facility supplied the **Pacific Gas & Electric Company's** utility grid with enough power for 2,000-2,500 homes.
- Worldwide photovoltaic production exceeds 21.3 megawatts, with sales of more than US\$250 million.
- A Solar Trek vehicle with a 1 kW photovoltaic system drove 4,000 km in the twenty days of the Australia Race. The maximum speed was 72 km/h and the average speed was 24 km/h. Later in the year, the vehicle surpassed the distance of 4,000 km between Long Beach, California, and Daytona Beach, Florida, in 18 days.
- **Solarex Corporation** bought amorphous cells production technology from **RCA** and built its own trial power plant in Newtown, Pennsylvania.
- **Solar Power Corporation** closes.
- Roland Barthez convinced the oil company **Total** to enter the market and the company's work is managed by Total **Energie Development**.
- **Tenesol** is established by Total.

1984

- The **Sacramento Municipal Utility District (SMUD)** commissions its first 1-megawatt photovoltaic electricity generating facility.
- A 337kW Building-Integrated Photovoltaic [BI-PV] Roof was installed on Intercultural Centre of Georgetown University using 4464 **Solarex** Modules.
- **BP Solar Systems**, with EGS donations, built a 30kW photovoltaic system connected to public electric grid near Southampton, Great Britain.
- **R & S Solar**, wholly owned subsidiary of **Shell** based in Helmond Netherlands bought the systems business known as **Holecol** (The date **R & S Solar** started is unknown).
- **HCT Shaping Systems** was established in Lausanne Switzerland by Charles Hauser and developed innovative saw for cutting wafers.

1985

- The **University of South Wales** breaks the 20% efficiency barrier for silicon solar cells under 1-sun conditions.
- **SunPower Corporation** was established by Dick Swanson and Dick Crane. After focussing on high efficient concentrating cells the company went onto to develop and commercialized cost-effective, high-efficiency photovoltaic modules based on the "all-back contact" cell design.
- **BP Solar** bought Tideline's manufacturing plant in Sydney, Australia and launched **BP Solar Australia**.
- **Daimler Benz** acquired **AEG Telefunken** and incorporated the solar business into its Deutsche Aerospace division.
- **Photowatt** absorbed **France Photon**.
- **Showa Shell Sekiyu** formed through the merger of two oil companies **Showa Oil** and **Shell Sekiyu** and signed joint venture with **Arco Solar** to collaborate on thin fil research.

1986

- **Siemens Solar** was formed, though **Siemens** involvement with PV had started early 1980's through its nuclear energy subsidiary **Interatom**.
- **Neste Advanced Power systems (NAPS)** was established by Finnish oil company **Neste**.

1987

- In the Pentax World Solar Challenge 1987 race through Australia, a General Motors Sunracer vehicle won with an average speed of 71 km/h.
- **Chronar France** acquired the majority share of **Photowatt**.
- **Solarvolt** was closed.

1988

- Dr. Alvin Marks received patents for two solar power technologies that he had developed: Lepcon and Lumeloid. Lepcon consists of glass panels covered with a vast array of millions of aluminium or copper strips, each less than a micron or thousandth of a millimeter wide. As sunlight hits the metal strips, the energy in the light is transferred to electrons in the metal, which escape at one end in the form of electricity. Lumeloid uses a similar approach but substitutes cheaper, film-like sheets of plastic for the glass panels and covers the plastic with conductive polymers, long chains of molecular plastic units.
- The Dye-sensitized solar cell was created by Michael Grätzel with support from Brian O'Regan (chemist). These photoelectrochemical cells work from an organic dye compound inside the cell.
- Management of **Photowatt** bought back major share from **Chronar France**.

1989

- Reflective solar concentrators were first used with solar cells.
- **ARCO Solar** increased the thin film system production capacities in Camarillo, California to 7 MW per year. **ARCO Solar** opened production in Japan and German.
- **Astropower Corporation** became an independent company under Allen Barnett.

8.4 Solar Thermal 1980-1989

Key points from the IEA SHC data:

- For the 1980's the IEA SHC has data from Australia, Austria, Canada and the USA.
- Austria was installing a few evacuated tube collectors however this represented less than 0.06% of the total installations in 1980 with the highest contribution in the decade being 0.22% in 1988.
- Figure 34 shows the combined annual installed capacity for the four countries.

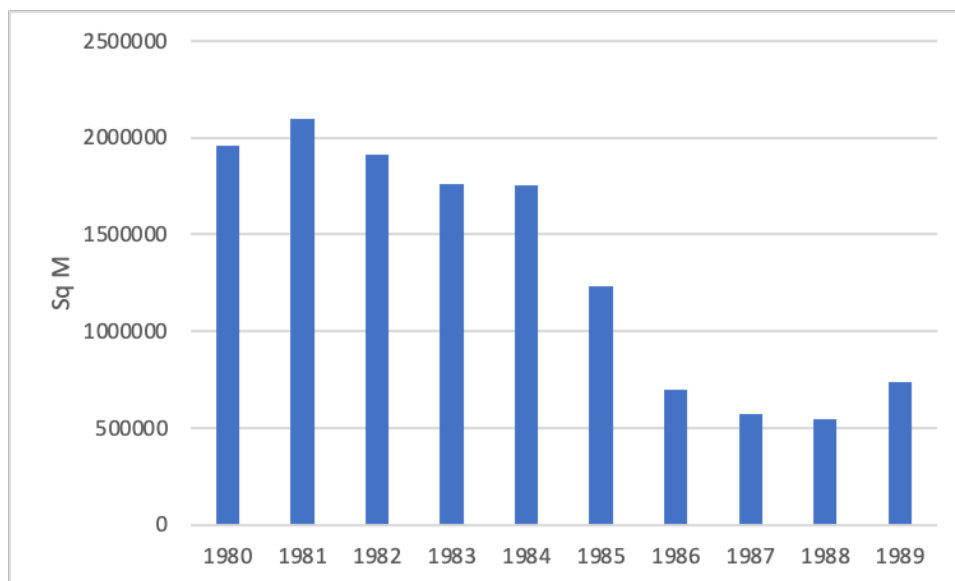


Figure 34: Annual recorded installed solar water panels capacity 1980-1989

Source: IEA SHC

1980

- The USA Solar Rating & Certification Corporation (SRCC) founded as a non-profit by industry associations and a national consortium of U.S. state energy offices and regulatory bodies <https://solar-rating.org/company/about-us/>
- First meeting of Standards Australia Technical committee CS028 *Solar Heating and Cooling* chaired by Wal Read. Ken Guthrie became the second Chair in early 1990s. Many standards published in Australia and New Zealand, some of which became the basis for ISO Standards.
- ISO TC180 Solar Energy first met. Standards Australia has maintained the secretariat since that time. 19 standards have been published by ISO TC180 and its subcommittees. <https://www.iso.org/committee/54018.html>

1982

- **Torvalla - First large-scale solar district heating in Sweden (Europe).** The first-ever ground-mounted SDH system was a 2,000 m² collector field operated by Östersund Energi in Torvalla between 1982 and 1992. The second was a 4,320 m² collector plant run by Uppsala Energi in Lyckebo from 1983 to 2001 and the third a 7,500 m² collector field operated by Telge Energi in Nykvarn between 1984 and 2008. For more information please see: <https://www.sunwindenergy.com/bioenergy/sweden-pioneer-solar-district-heating>
- **50,000 solar thermal systems built in self-assembly groups in Austria** From 1982 onwards, around 50,000 solar thermal systems for domestic hot water but also for space heating with a total collector area of 400,000 m² were assembled by organised self-assembly groups in Austria. The AEE INTEC research institute in Austria emerged from this in 1988.
- From 1982 to 1984, Geoffrey Harding of University of Sydney and Prof Zhiqiang Yin from Tsinghua University Beijing worked on the development of selective surfaces for evacuated tubes. Prof Yin also worked with Morrison at the outdoor test facility at UNSW.

1983

- 800 m² Solar water heating system installed in the ZAZ tannery in Nový Bydžov, about 80 km from Prague.

1984

- Al N/Al solar selective absorbing coating making by single-target magnetron sputtering was completed by Prof. Zhiqiang YIN from Tsinghua University, which created the industrialization of all-glass vacuum tube solar collectors in China.
- Beasley industries installed a 3855m² solar water heating system installed at Yulara resort near Uluru in Central Australia.

1987

- **First application of Guaranteed Solar Results (GSR) in France.** The first-ever solar collective domestic hot water system using the mechanism of Guarantee of Solar Results. Hospital of Castres (South of France) installed a 92m² flat plate collector system using 5000 liters of storage. Collectors were from SOLEFIL, French solar collector manufacturer. Installation cost was 70 000 EUR. The plant operated successfully for more than 20 years.

1988

- An agreement between Greece and Germany leads to the Solar Village in Lykovryssi. Intended for 435 families. Its main goal was to demonstrate the feasibility of energy conservation as well as the utilisation of low temperature solar systems for space heating and heating of domestic hot water.
- **Integrated storage collector with Transparent insulation materials** Fraunhofer ISE in Germany developed an integrated storage collector with transparent insulation material.

1989

- Australian Standard 3634- 1989 "Solar Heating Systems for Swimming pools" Published.
- **Solar house in Switzerland.** The Oberburger Sonnenhaus was built in 1989, it supplies a house with 100% solar energy for heating, hot water and electricity all year round. The system consists of 84 m² solar thermal collectors, PV 48 kW and Heat storage 118 m³. For more information please see: <https://jenni.ch>
- David Mills and Qi Chu Zhang Mills modelled and created examples of Ge surfaces in the Dept. of Applied Physics at Sydney University Australia and also performed a more general simulation showing that surfaces using two uniform cermet layers of different refractive index could perform as well as Ge. These would be thinner and able to use cheaper materials such as stainless-steel carbide.

8.5 CSP 1980-1989

1980

- The first Australian Solar Thermal Power Station was built at White Cliffs. The fourteen large dishes made superheated steam to drive a single phase 37KVA alternator to produce power for the town.

1981

- The two IEA CSP projects at PSA in Spain began operation.

1982

- CSP demonstration plants – CESA 1 in Spain, Eurelios in Italy and Themis in France, began operation.
- Solar One, a 10 MW power tower with thermal energy storage using oil and rocks, supported by DOE and an industry consortium, began operation.

1984

- California's policies combined with a Federal tax incentive enabled the building of the first of nine Solar Electric Generating Stations (SEGS) by Luz, a US/Israeli entity. SEGS 1, a 14 MW trough plant, began commercial operation under a Standard Offer 4 contract in California.

1985

- SEGS 2, a 30 MW trough plant, began operation.

1986 – 1988

- SEGS 3, 4, 5, 6 and 7, each a 30 MW trough plant, began operation in those years, facilitated by California's Standard Offer 4 contracts and continued State and Federal incentives.

1989 – 1990

- SEGS 8 and 9, each 80 MW, began operation.

8.6 Solar Architecture Buildings 1980-1989

1989

- Jenni Energietechnik of Switzerland builds a 100% solar heated home and for first 10 years, 100% of the electricity demand was also covered by the PV panels in combination with lead batteries making the house energetically fully independent. (Refer Section 8.3 Solar Thermal 1980-1989 for photo)
- IEA SHS Cooling Task 13 Advanced Solar Low Energy Buildings Started in 1989 and finished in 1996 with a final symposium at Eurosun 96. The objective was to advance solar building technologies through the identification, development, and testing of new and innovative concepts which have the potential for eliminating or minimizing the use of purchased energy in residential buildings while maintaining acceptable comfort levels. In the end, eleven of the member countries constructed a total of fourteen experimental buildings. These buildings, which range in size from single family houses to a large apartment building, have all been designed in part as a team effort. The building projects were:
 - Belgium/E. C. : The PLEIADE rowhouse unit in Louvain-la-Neuve
 - Canada: The Advanced House in Brampton, Ontario
 - The Green Home in Waterloo, Ontario
 - Denmark: The Solsikkeparken rowhouses in Vonsild, Jutland
 - Finland: The IEA5 Solar House in Pietarsaari
 - Germany: The Zero Heating Energy House in Berlin
 - The Ultra House in Rottweil
 - Japan: The WISH House 3 in Iwaki
 - Netherlands: The Urban Villa in Amstelveen
 - Norway: The IEA rowhouse unit in Hamar
 - Sweden: The low cost prototype at Rörskär
 - Switzerland: The duplex in Gelterkinden
 - USA: The Exemplary House at Grand Canyon

8.7 PV in Developing Countries 1980-1989

The PV industry is slowly growing along with the interest in providing solar power to unelectrified people around the world. However, individuals begin to investigate how to overcome the need for upfront capital. During this decade Kenya's reputation becomes known globally as one of the active commercial markets for sales of solar home systems and for this reason these highlights show its growth. Many studies were undertaken about Kenya particularly during the 90s. Multi-lateral and bi-lateral donors' interest in solar projects started to grow.

- Between 1980 and 1990 **G.I.E. Solar** installed 3300 SHS such that by 1987 50% of electrified houses in French Polynesia ran on solar power.

1981

- **IT Power Ltd**, one of the first solar energy consulting firms, founded in UK by Bernard McNelis, Peter Fraenkel and Anthony Derrick. This company's main focus was renewable energy for the developing countries and the company has since undertaken hundreds of projects around the world.
- **NASA LeRC** built PV systems for vaccine refrigerator power and by 1984 had supplied systems to 30 locations around the globe.
- **Wirtschaft and Infrastruktur Planungs (WIP)** had been established in 1968 to advise on developing countries infrastructure projects and moved into renewable energy in 1981.

1982

- Ex USA Peace Corps worker Harold Burris establishes **Kidogo Systems**, a solar retail business, in Machakos, Kenya.

1983

- BP Solar sets up **BP Solar East Africa** office in Kenya.
- Mark Hankins was a USA Peace Corps teacher at a high school without power and he met with Harold Burris to discuss solar for the school. The system went in and other teachers then wanted solar for their houses. This convinced Hankins on solar and to this day he is still promoting solar in Kenya.

1984

- On January 21, 1984, Richard Hansen boarded a plane from Boston headed for the Dominican Republic with a solar photovoltaic panel under his arm. He demonstrated the technology to rural families. This resulted in the first installation of an appropriate solar PV system combined with a micro-credit payment plan, sold to Sr. Felipe Martinez in April 1984 for his country store/home in the community of Bella Vista. Soon, as word spread, many other families and businesses in Bella Vista and other communities expressed interest. In September 1984 Richard incorporated **Enersol Associates**, Inc. a Boston based non-profit organization to introduce solar technology in developing countries through technical assistance for local solar technicians and NGO credit programs.
- Harold Burris renames his business **Solar Shamba** and moves to Embu, in the coffee-growing belt around Mt. Kenya
- The **Solar Energy Company (SEC)** was established by the Foundation of the Peoples of the South Pacific (FSP) in Kiribati with USAID funding. SEC was formed as a private company and carried out the sales of PV systems or components and their installations. In 1989 the Kiribati Government took over SEC and it still operates today.

1985

- Kenya becomes one of the fastest growing market for providing solar to the rural people with four more companies entering the market in 1985: **Television Sales and Rentals – Telesales; Alpa Nguvu; Associated Battery Manufacturers; Solar World.**
- In 1985 Richard Hansen established a local model PV supply enterprise in Dominican Republic that served as a training vehicle, an enterprise which evolved to become SOLUZ. SOLUZ is still operating in 2020.

1986

- Pradip Jayewardene, Viren Perera and Lalith Gunaratne started **Power & Sun (Pvt) Limited** in Sri Lanka. At one stage they were assembling solar modules with imported cells. The company changed to Solar Power and Light company which was purchased by Shell Solar in 1999.
- Finnish government owned **Neste** starts the research & development project called **NAPS** (Neste Advanced Power Systems) aiming for launching a photovoltaic business. In 1981 Neste had acquired a solar photovoltaic unit set up by Ericsson in Sweden which was focused on supplying solar power to telecommunications. NAPS focused on off grid solutions and products, and marketed and sold globally, particularly in developing countries. NAPS still operates today and it became an independent company in 2001.
- EU commission started the Regional Solar Programme in West Africa. This program installed:
 - 626 PV water pumping systems in nine West African countries
 - 660 community systems installed for lighting and cold storage.
 - Total of 1,257kW of PV was installed by 1996.

1987

- Three more companies commence operation in Kenya: **NAPS; Chintu Engineering; Total Solar.**

1988

- Daniel Kithoki, who had been working closely with Harold Burris in Kenya, starts **Solar Energy Installations.**

1989

- Two more companies commence operation in Kenya: Animatic and Botto Solar.
- Richard Hansen introduced PV for rural electrification in Honduras and formed **SOLUZ Honduras** which still operates in 2020.

8.8 Research Pioneers 1980-1989



Ahmed Hamza Ali

Country: Egypt

Year Started Research: 1988

Title of Research: Cooling of water flowing through a night sky radiator

University: Assiut University

Still Active in Research: Yes

Dr Ahmed Hamza Ali joined the research team of Professor Ibrahim M. S. Taha in 1988 2 years after graduating with his BSc. The team investigated experimentally and analytically the utilization of the cold deep sky temperature to have nocturnal cooling of water by infrared radiation to the sky. The experiments were carried in the hot arid climate of upper Egypt and the study finding was published in Solar Energy in 1995. The paper was titled: cooling of water flowing through night sky radiator.



Abdo Almakaleh

Country: Yemen

Year Started Research: 1982

Title of Research: Models of the Incoming Solar Radiation at the Earth Surface

University: University of Reading, UK

Still Active in Research: Yes

Dr. Almakaleh was looking for an inspiring career in the energy sector after his graduation. He was employed by The Civil Aviation and Meteorological Authority and served in various capacities including the Assistant Deputy Minister since January 1993. He holds a BSc degree (1979) in Physics from University of Mosul, Iraq; an MSc degree (1982) in Meteorology from University of Reading, United Kingdom. He also holds an MSc Degree (1990) and a PhD. Degree (1992) in Civil Engineering, both from the University of Colorado at Boulder, USA. In 1994, he was involved in establishing the University of Science and Technology and the first Solar Energy Center (SEC) in Yemen. He has also published over a dozen scientific papers. As a co-founder of the center, he was responsible for future vision of solar energy in the country. The vision objective was to have joint efforts between government agencies and universities to address; education, training, capacity building, and information dissemination of solar energy utilization. National Renewable Energy Society (NRES) was established to provide professional training programs in solar energy. This program conducted by SEC and NRES has trained more than one hundred engineers from Government agencies and universities until the end of 2010. In 2011, due to civil unrest and subsequent regional war, the whole country went under complete siege (Land, Air and Sea) with no fuel or electricity. Photovoltaic solar systems became the reliable source of electricity for all population of Yemen. Thanks to the early training programs that prepared selected engineers to take up such unprecedented task to fulfill the huge demand for solar applications in such time of war. Photovoltaic solar energy systems now are the major source of electricity in the country.



Fernando Artigas

Country: Spain

Year Started Research: 1983

Title of Research: Sener Heliostats For CESA-I Testing Facility

University: Plataforma Solar de Almeria

Still Active in Research: No

As a young engineer at SENER, Fernando Artigas was the Technical Lead of the team that was responsible for the delivery of 150 heliostats to CESA-I solar field, including design, manufacturing and testing of the units. These 150 heliostats were exactly half of the total number of heliostats in this pioneer testing facility at Plataforma Solar de Almería, conceived to demonstrate the viability of central tower systems and to ease the development of such plants in Spain. The 150 heliostats provided by SENER are still standing today at CESA-I facility.



Lars Broman

Country: Sweden

Year Started Research: 1983

Title of Research: Nonimaging solar concentrators with flat mirrors;
Thermophotovoltaics, Public Understanding of Renewable Energy

University: Solar Energy Research Center, Dalarna University, Sweden
Strömstad Academy, Strömstad, Sweden

Still Active in Research : Yes

Lars Broman was born 1940, received his degrees at the University of Göteborg, PhD in 1965, DrSc in Physics 1967, and is Professor Emeritus from Dalarna University and Professor of Physics at Strömstad Academy since 2008. In 1980, Lars Broman initiated an undergraduate program in solar energy at Dalarna University—the first such in Sweden. In 1984, he founded the Solar Energy Research Center (SERC) and in 1999 European Solar Engineering School (ESES). Both are still active; SERC has fostered over 10-doctorate degrees and the professional development of several professors. ESES has graduated over 200 MS students. At SERC, Broman first studied non-imaging concentrators for both thermal and photovoltaic applications. He then governed a group of researchers in developing the program PRESIM, with which computer non-specialists could use TRNSYS for simulating solar energy systems. He continued research in solar energy optics and was engaged in thermophotovoltaics (TPV); he invented the egg-shaped “Fabergé” optics for enhancing selective filters. In 1979, Broman and colleagues started the International Association for Solar Energy Education (IASEE) and was for several years, its first President. IASEE grew to over 400 members from countries in all continents. In 1990, IASEE was made ISES Working Group on Education. Broman then initiated the International Symposium of Renewable Energy Education (ISREE), chairing the first ISREE (1991) and ISREE-3 in Borlänge (1993), ISREE-9 in Göteborg (2003), and ISREE-12 in Strömstad (2017) (revising this important ISES activity). IASEE symposia have taken place in 7-different countries worldwide. Broman has published over 120 solar-energy papers. He has actively participated in numerous international conferences including ISES Solar World, WREC, and EuroSun Congresses; frequently as a keynote speaker. Lars' present R&D activities are in the field of Public Understanding of Renewable Energy (PURE). His most downloaded recent publication is Kandpal and Broman, Renewable Energy Education: A Global Status Review in RSER 34(2014) pp.300-324.



Reiner Buck

Country: Germany

Year Started Research: 1986

Title of Research: Concentrating Solar Power Systems

University: German Aerospace Center (DLR), Institute of Technical Thermodynamics, Institute of Solar Research

Still Active in Research: Yes

The research on Concentration Solar Power (CSP) systems over the last 2 decades has been immensely influenced and shaped by Dr. Reiner Buck, currently Head of Department “Solar Tower Systems” at the DLR Institute of Solar Research. With over 160 publications, almost 2000 citations and a current h-index of 27 he is an outstanding researcher and a pioneer in his field. His contribution to all topics within the CSP research – from the development of heliostats and solar receivers, simulation of optical performance and concentrator systems to the layout design and optimization of steam cycles or gas turbine systems – were essential to the overall development and advancement of CSP technologies. Reiner’s long-lasting experience and especially his personal dedication and engagement in improving these highly complex systems led to a numerous number of patents and patent applications which are partly licensed for commercial use. His exceptional and pioneering work culminated in co-founding the startup company HelioHeat in 2017. HelioHeat’s objective is to commercialize Reiner’s latest development on solar receivers, a special particle receiver. The solid particle technology is considered to be the most promising option for future CSP plants and thanks to his fundamental work on the particle technology it is now possible to build the world’s first pre-commercial solid particle CSP plant in order to demonstrate its techno-economic feasibility. Reiner dedicated his entire professional life to the research and development of CSP systems. Without his substantial work the CSP technology would not have come as far as we know it today.



Jan-Olof Dalenbäck

Country: Sweden

Year Started Research: 1987

Title of Research: Large-scale solar heating technology in Sweden: system construction and dimensioning

University: Chalmers University of Technology

Still Active in Research: Yes

Jan-Olof Dalenbäck is a professor in Building Services Engineering, Dept. of Energy and Environment at CHALMERS University of Technology. Jan-Olof has a rich academic background, with a MSc in Electrical Engineering from 1980, and a Ph.D. in Building Services Engineering from 1993. He is the author or first author of 30 printed reports or books (14 in English) and >30 international articles (>20 in English, 8 in German), out of which 12 are reviewed, >50 international conference papers and >25 national articles. Jan-Olof has extensive experience as tutor and teacher in Building Services Engineering, i.e. planning and design of heating, ventilation and air conditioning (HVAC) systems. He is a specialist with a knowledge in planning and design of solar heating systems, and a good overarching knowledge of global and national energy supply and energy end use. He was tutor for >10 PhD students and >100 Master thesis on various subjects within his field. Throughout his vast experience in the field, Jan-Olof had taken upon a significant number of national assignments, such as being the Swedish representative of different tasks under the IEA SHC Programme, or Secretary, Solar energy R&D program 1997-1999, on behalf of the Swedish Council for Building Research (BFR)². Between 2000-2011 he held different positions with international impact, such as being a Board member representative at ISES, Scientific/Program committee member at ISES SWC and part of ISES Europe Governing Board. In 2002 he was Vice President ESIF, as responsible for the reformation to ESTIF. More on his research: <https://www.chalmers.se/en/staff/Pages/jan-olof-dalenback.aspx>



Gouri Datta

Country: India

Year Started Research: 1984

Title of Research: Solar Thermal Technologies, Buildings energy efficiency

University: University of Delhi

Still Active in Research: Yes

Dr Datta served as Associate Professor of Physics, Deshbandhu College, University of Delhi India, retiring in 2017. Prior to this position, Gouri Datta was Visiting Scientist at Centre for Energy Studies, IIT Delhi, 1996-1998. Her research work has mainly been on solar air and water heaters, drying, solar radiation, storage, collector testing and passive-solar architecture. She has more than sixty publications in international journals and conferences in these fields and has completed several research projects including an international project on solar energy between Italy & India. Dr Datta has been an invited/keynote speaker for more than 40-International conferences. Dr. Datta has participated in several ISES SWC and ISREE events. She held the SERC Fellowship to work in SERC, Borlange Sweden (1990) on solar collector geometries at high latitudes. Dr Datta was awarded the prestigious TRIL Fellowship (ICTP Trieste Italy, 1998) to work with ENEA Rome on solar-passive architecture, and DST fellowship (1996) to work MNRE in Gurgaon on solar-collector testing. She is also a member of 8 professional societies and is on the executive of Indian chapter of ICTP. Dr Datta is also interested in physics and philosophy and has presented papers on correlation between ancient Hindu religion and solar science in ancient times in India- particularly on astronomy and cosmology. She has been on the gender sensitization committee at her institute, which has initiated her to study the plight of women in India's rural areas. She is making efforts to reduce vulnerability of these rural women and empower them by sustainable-energy use. Gouri was recognized with the International Solar Energy Pioneer Award by UNESCO and the WREN in 2010. Gouri Datta remains active in research through her appointment and recognition as Fellow of Stromstad Academy, Stromstad Sweden since 2011.



Antonia Sônia Alves Cardoso Diniz

Country: Brazil

Year Started Research: 1988

Title of Research: Solar Thermal and PV Systems, PV Reliability

University: Pontifical Catholic University of Minas Gerais (PUC Minas)

Still Active in Research: Yes

Antonia Sônia Alves Cardoso Diniz is currently Coordinator of the Grupo de Estudos em Energia (GREEN Solar Laboratory) at the Pontifical Catholic University of Minas Gerais (PUC Minas) in Belo Horizonte, Brazil. She is an Associate Professor in the Graduate Mechanical Engineering Program at PUC Minas. She received her Bachelor of Physics from the Federal University of Minas Gerais in 1980, her Electrical Engineering degree from PUC Minas in 1981, and Ph.D. from the University of Liverpool in Material Science and Engineering in 1995. Before coming to PUC Minas, Dr. Diniz was a Specialist Engineer at the Energetic Company of Minas Gerais (CEMIG) in Belo Horizonte for 28 years, including initiating their projects in PV rural electrification. Dr. Diniz was a visiting research professor at the Arizona State University Photovoltaic Reliability Laboratory in 2013. Dr. Diniz' current research is focused on solar thermal systems, PV module and system reliability, energy efficiency, and distributed energy resources. Particular mention is her leadership in gaining ISO 17025 accreditation for GREEN, leading activities in Brazil for certification of solar thermal systems, and R&D on soiling of PV modules and systems in the Brazil climate conditions. She has been active in, IEEE, ISES, WREN, and ABSOLAR. Dr. Diniz is a consultant for CAPES (Brazil's science and education agency), past Associate Editor of Renewable and Sustainable Energy Reviews (Elsevier), served as a member of the International Committee of the IEEE Photovoltaic Specialist Conference (IEEE PVSC). Currently, Dr. Diniz is a member of the International Advisory Committee for the World Conferences on Solar Energy Conversion (WCPEC)—with the next conference in Rome, 2022. She has some 100 publications in journal and conference proceedings, has had many invited and contributed presentations at technical meetings, including participation in ISES SWCs.



Hans-Martin Henning

Country: Germany

Year Started Research: 1987

Title of Research: Regeneration of Absorption Materials Using Solar Process Heat

University: Oldenburg University

Still Active in Research: Yes

Prof. Dr. Hans-Martin Henning is Director of the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany and Professor of "Solar Energy Systems" at the Institute of Sustainable Systems Engineering in the Faculty of Engineering, University of Freiburg. He is member of the Expert Council on Climate Issues of the German Government, member of ACATECH (German National Academy of Science and Engineering) and spokesperson of the Fraunhofer Energy Alliance and member of the board of directors of the academy project "Energy Systems of the Future". Prof. Dr. Henning obtained his PhD in physics at Oldenburg University in 1993. Since 1994, he has been working at Fraunhofer ISE in Freiburg, holding several different positions of responsibility over the years. In 2014 he was appointed Professor of Technical Energy Systems at the Karlsruhe Institute of Technology KIT and in 2017 Director of Fraunhofer ISE. From 2011 to 2016 an Associate Editor of "Solar Energy", the official journal of the International Solar Energy Society. Prof Henning has been an active member of many committees including the IEA SHC where he was Operating Agent of Task 25 "Solar Assisted Air Assisted Conditioning of Buildings" from 1999 to 2004 and Operating Agent of Task 38 "Solar Refrigeration and Air Conditioning" from 2006 to 2010. He has also been member of the scientific committee for a number of ISES SWC. He has had 97 papers published in periodicals and journals, authored 17 books, been the editor of two handbooks on solar energy and had papers in 173 conference proceedings



Arnulf Jäger-Waldau

Country: Italy

Year Started Research: 1987

Title of Research: Preparation and Solar Cell Performance of n-ZnO/p-WSe₂ Heterojunctions

University: Universität Konstanz

Still Active in Research: Yes

Dr. Arnulf Jäger-Waldau is a Scientific Officer and Senior Scientist at the European Commission's Joint Research Centre since 2001. His current research portfolio ranges from the assessment of renewable energy technologies, the effectiveness of deployment policies and how to integrate them into energy infrastructures to the role of renewable and solar energy for the energy transition and climate change mitigation. Since 1987 he works in the field of material research for solar cells and holds patents on semiconductor material deposition for thin film solar cells and solar module design. His material research work spans from the investigation of fundamental material properties of transition metal dichalcogenides for solar cell applications to the development of novel deposition methods for compound thin film solar cells. He has more than 250 publications in peer reviewed journals and conference proceedings ranging from materials research for PV and solar cell development to market studies and policy evaluations for Renewable Energies. He is the author of the European Commission's annual "Photovoltaic Status Report", which is published annually since 2002. From 2011 to 2014 he was the Technical Chairman of the European Photovoltaic Solar Energy Conference (EUPVSEC) and served as European Co-Chair of the 6th World Conference on Photovoltaic Power Conversion in Kyoto, November 2014 as well as Conference Chairperson of the E-MRS Spring Meetings in 2009 and 2013. Dr. Jäger-Waldau was a Lead Author for Solar Energy of the Special Report of the IPCC on Renewable Energy and Climate Change Mitigation. He served as a reviewer of the Global Energy Assessment Report (GEA) published in 2012 and as a reviewer of various IPCC Assessment and Special Reports. He is a reviewer of the annual Renewable Energy Market Report of the International Energy Agency as well as the Renewable Global Status Report published by REN21.



Kamil Kaygusuz

Country: Turkey

Year Started Research: 1986

Title of Research: Experimental Performance of the Solar Assisted Heat Pumps

University: Karadeniz Technical University, Department of Chemistry and Mechanical Engineering laboratuars

Still Active in Research: Yes

Professor Kamil Kaygusuz was born in 1963 Trabzon, Turkey. He started renewable energy research in April 1986 at the Karadeniz Technical University as MS student. He studied solar energy, solar assisted heat pump with PCM energy storage for building heating at the Department of Mechanical Engineering in Karadeniz Technical University, Trabzon, Turkey. He obtained his PhD degree in April 1993. The subject of the PhD thesis is "Experimental Performance of the Solar Assisted Heat Pumps with PCM Energy Storage for Building heating in Black Sea Region of Turkey". He published 240 scientific papers and five book chapters. He is currently researching about renewable energy sources such as solar energy, biomass, hydropower, wind energy and geothermal power, heat pumps, energy storage and energy policies. He was supervisor for 15 master and doctorate students in research area of renewable energy. He has h-42 for Web of Science; h-46 for Scopus and h-53 for Google Scholar.



Ulrich Leibfried

Country: Germany

Year Started Research: 1980

Title of Research: Solar Collector with direct evaporation for a Rancine cycle

University: University Karlsruhe (Germany) and INSA Lyon (France)

Still Active in Research: Yes

Ulrich Leibfried first activities in RE had been as student: internship in 1980 in a heat pump company who used solar absorbers, courses in RE at University Karlsruhe (Germany) and INSA Lyon (France) and a study project in Lyon on a solar collector with direct evaporation for a Rancine cycle. From 1986 to 1988, he worked in an institute for appropriate technology for African and other southern countries with wind driven water pumps and others. In 1989 he started in the solar research company Bomin Solar in Lörrach, southern Germany as a project leader in the development of a system with solar concentrator (Fix Focus), Stirling motor and thermochemical storage (Mg/MgH₂). During this time he graduated from University Karlsruhe (Optimization of a fixed focus solar concentrator and a cavity receiver). In 1994 he co-founded the solar company Consolar GmbH in Lörrach and Frankfurt, Germany, together with 3 other engineers. His main concern is the transition of technologies, economies and society to a system respecting planetary boundaries and life. Currently he is engaged in a network which was initiated in autumn 2019, working for climate neutral communities.



Joachim Luther

Country: Germany

Year Started Research: Early 1980's

Research Topic:

Institute: University of Oldenburg, Germany

Still Active in Research : Yes

From 1974 to 1993, Joachim Luther was a full professor for applied physics at the University of Oldenburg, Germany. In the beginning of the 1980s, his scientific interest shifted towards renewable energy sources, in particular solar power. At the University of Oldenburg under Joachim Luther, the energy autonomous laboratory "Energielabor" was realized in 1982. Since 1993, he held the position as full professor for solid state physics and solar energy at the University of Freiburg, Germany and served, in parallel, as institute director of the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany until 2006. Joachim Luther is Professor Emeritus at the University of Freiburg and Director Emeritus of the Fraunhofer Institute for Solar Energy Systems ISE, Freiburg. In 2008, Prof. Luther became Founding Director and Chief Executive Officer of the newly founded Solar Energy Research Institute of Singapore (SERIS). Prof Luther has been a leading member of numerous important national and international organisations. In 2005, Joachim Luther won the German Environmental Award of the Deutsche Bundesstiftung Umwelt and the International Rheinland Prize for Environmental Protection. In 2005 he was awarded the Becquerel Award from European Commission. In 2006, he received the Fraunhofer Coin "for outstanding merits within the Fraunhofer society". In 2008 he was recognized by TIME magazine as Hero of the Environment, and in 2009, he won the Achievement through Action Award of the International Solar Energy Society (ISES). Joachim Luther was an ISES board member from 1992 to 2001 and President of the EUREC Agency (the European Association of Renewable Energy Research Centers) from 1997 to 2002. He was Editor in Chief of Solar Energy Journal from 1999 to 2002 and Chairman of the International Science Panel on Renewable Energies (ISPRE) from 2007 to 2010. Since 2010 he has been the Chairman of the European PV Conference Becquerel Prize Committee.



Douglas Mahone

Country: United States

Year Started Research: 1980

Title of Research: Study of Photovoltaic Residential Retrofits

University: USDOE/Sandia National Laboratories Photovoltaic Program

Still Active in Research: No

Mr. Mahone was active in research and consulting during the early years of passive solar buildings and photovoltaics, as an original member of the pioneering solar energy firm of Total Environmental Action (TEA), beginning in 1974. One major study was focused on the problem of integrating photovoltaic systems onto residential rooftops at scale. The study had three parts: 1) a field and satellite survey to estimate the quantity of solar roof areas, and the potential power they could generate nationwide; 2) development prototype mounting systems for PV panels on residential roofs, including simple stand-offs as well as solar shingles; 3) design, build and test a functioning photovoltaic system for a residential rooftop. The study was funded by USDOE through Sandia National Labs, as part of a large-scale research program in photovoltaics. The study was the most applied of the program; other program areas were focused on more fundamental science and engineering. The study concluded that the technical problems were all solvable. The primary barrier to widespread adoption of PVs was that the cost of PV panels had to be reduced by 70% to be cost effective. The study was published in 1982. Thirty years later, the cost problem has been solved and residential PV systems are being widely adopted. In addition to this research, Mr. Mahone also did substantial work on developing design strategies for passive solar systems and estimating their performance and cost-effectiveness. Since the 80's, he shifted his focus to the broader field of energy efficiency in buildings, working on utility energy programs and on codes and standards development. He retired in 2015.



Arturo Morales-Acevedo

Country: Mexico

Year Started Research: 1985

Title of Research: "Optimum concentration factor for silicon solar cells" published in Solar Cells

University: Centro de Investigación y de Estudios Avanzados del IPN

Still Active in Research: Yes

Dr. Morales-Acevedo pioneering work contributed to establishing a strong solar cell and photovoltaic research community in Mexico with international academic recognition. He has done research on different kinds of solar cells such as Silicon and CdTe and CuInGaSe₂ thin film solar cells. Recently he has focused his work on Metal Organic Perovskite thin film cells. Much of his investigation has been devoted to understanding the physical limits and optimizing cell designs by simulating their behavior, but he also has done experimental work collaborating with other groups in Mexico for making and characterizing solar cell devices. He participated in the first pilot line for silicon solar cells production established in Mexico (at his institute) at the beginning of the 80's. His first paper (of more than 180) on silicon solar cells was published in 1985 and his most recent one on perovskite materials for solar cells was published this year (2020). He is currently an active professor at Centro de Investigación y de Estudios Avanzados del IPN (CINVESTAV, in Mexico), and associate editor for Solar Energy Journal and Journal of Electronic Materials in the solar cell and photovoltaic fields. He has edited one book on Solar Cell and Photovoltaic Research Perspectives (2013) and is the author of another Solar Cell popularization book in Spanish (1996). In addition, he has directed at least 28 M. Sc, and Ph. D. Thesis. At present, most of his former students are doing research at different universities in Mexico and Colombia where he has sustained collaboration with different investigation groups. In summary, Dr. Morales-Acevedo successfully has dedicated his whole professional life to the research, teaching, dissemination and formation of groups on photovoltaics in Mexico.



Brian Norton

Country: Ireland

Year Started Research/Industry: 1980

Title of Research: Optimization of Thermosyphon Solar Water Heaters

University: Solar Energy Technology Centre, Cranfield University, UK

Still Active in Research/Industry: Yes

Professor Norton's research ranges from fundamental work on solar energy devices and systems to full-scale extensively-monitored demonstrations of novel energy systems and design approaches on domestic, educational and library buildings and in agricultural applications. In particular, he has led development of new techniques for lower temperature evacuated glazing fabrication, ground-breaking work on photovoltaic antenna devices adopted in commercial systems and conceived and developed now widely adopted application of phase-change materials to thermal management of photovoltaics. He has received numerous awards for research, including CIBSE Napier Shaw Medal for original development of "Degree-hour" building energy-use correlation, Energy Institute's Roscoe Award for research comparing embodied environmental impact of all renewable and non-renewable energy sources, "Solar Energy" Journal Best Paper Award in Photovoltaics, and, an Honorary Fellow, Chartered Institute of Building Services Engineers (CIBSE). His honours include Member, Royal Irish Academy; Fellow, Irish Academy of Engineering; and in September 2021 will receive an Honorary Doctorate from Université de Technologie de Troyes. Professor Norton established and led major university research centres at Cranfield, Ulster and TU Dublin. He is a Principal Investigator in MaREI, the SFI research centre for Energy, Climate and Marine and leads its Energy Efficiency research and has led international collaborative research programmes, IEA and COST activities. He has written over 220 peer-reviewed journal research papers and over 300 conference papers; supervised over fifty doctorates. Over 10,000 citations; h-index 51. He is currently and jointly Head of Energy Research, Tyndall National Institute, Research Professor, University College Cork and Professor of Solar Energy Applications, Dublin Energy Lab, Technological University Dublin.



Dr Heinz Ossenbrink

Country: Germany

Year Started Research/Industry: 1982

Institute: Europeans Commission Joint Research Centre

Still Active in Research/Industry: No

Dr Heinz Ossenbrink has a PhD in Nuclear Physics from Hahn Meitner Institute, Berlin and joined the European Commission's Joint Research Centre in 1982. He built up the JRC's activity on Photovoltaics when Europe started its research and pilot programme for Photovoltaic systems. In 1995 he became Head of the Unit for Renewable Energy, and expanded research and support activities to Energy Efficiency and Bio-Energy, notably Biofuels. His work is dedicated to the scientific support of EU legislation for Renewable Energies and Energy Efficiency. More recently, he was developing the Unit's portfolio to support Africa's efforts for a renewable energy supply, as well as projects around "Energy and Location", which comprise the science support to the "Covenant of Mayors", research into the "Decarbonisation of Urban Areas". His multidisciplinary team comprises about 50 scientists, covering fields like materials science, physics, electrical and building engineering, energy economy, agriculture and geographical information systems. His publications cover measurement and testing methods for photovoltaic generators, economic assessment of renewable energy, global environmental impacts of extended bio-fuel and bio-energy use and the economic assessment of Energy Efficiency policy as a means for Climate Change mitigation. He served since 1995 as Programme Chair for the series of European Photovoltaic Solar Energy Conferences, and since 2005 also for the European Biomass Conferences. In 2002 he became chair of the International Electrotechnical Commission Technical Committee 82 (TC82) a role he kept unto 2016 when he retired.



Nicola Pearsall

Country: United Kingdom

Year Started Research: 1985

Title of Research: Photovoltaic solar cells and system optimisation

University: University of Northumbria

Still Active in Research: Yes

Emeritus Professor of Renewable Energy in the Faculty of Engineering and Environment of Northumbria University, Newcastle, UK. 2020 General Chair, EU PVSEC 2020 conference. Nicola is also director of the Northumbria Photovoltaics Applications Centre and leader of the Energy Systems Research Group. Nicola undertakes research and teaching in the field of renewable energy, specialising in photovoltaics. Nicola graduated from the University of Manchester Institute of Science and Technology with an honours degree in Physics, before gaining her PhD in indium phosphide solar cells for space applications from Cranfield Institute of Technology. She joined Northumbria University in 1989 whilst completing her PhD and has held a variety of research and teaching positions, before being awarded the title of Professor in 2004. Nicola's research interests are in optimisation of PV systems performance for a wide range of applications, and the assessment of the environmental impacts during manufacture of solar cells. With over 25 years of experience in PV research, Nicola has also worked in solar cell device development, techno-economic assessments of PV technology and environmental impact assessment of energy technologies. Main research areas:

- Performance assessment of PV system operation and comparison with system design aspects, leading the EC FP6 Integrated Project PERFORMANCE, which included development of updated European guidelines on PV system monitoring.
- Several projects involving performance analysis for building-integrated PV systems. Current EPSRC-funded project mapping PV system performance as part of a UK-India consortium (STAPP – Stability and Performance of Photovoltaics).
- Environmental impact assessment of PV technology – PEPPER project, funded by the European Commission, led by Oerlikon Solar and involving a range of European industrial and research partners.
- In collaboration with colleagues in the University, Nicola is also involved with studies on integration of renewable energy systems into the UK electrical supply network and the built environment.



Deo Prasad

Country: Australia

Year Started Research: 1985

Title of Research: Building integrated PV and zero carbon buildings

University: University of New South Wales, Sydney

Still Active in Research: Yes

Scientia Professor Deo Prasad AO is a veteran of the solar field having started his research career under Professors John Ballinger and Graham Morrison in 1985. He came in as an architect interested in low energy buildings and finished a PhD in heat transfer engineering at UNSW. Deo became a member of ANZSES in 1987 and in 1994 became its President. He also was Director ISES for 9 years and looked after the ISES Asia Pacific Chapter for another 9 years. In fact, when the ISES Office in Melbourne closed he was ANZSES President and rescued the HQ by hosting it at UNSW in Sydney for a few years prior to it moving to Freiburg. Deo has been a prolific researcher and headed the SOLARCH Group at UNSW for 15 years after Prof John Ballinger. He was part of the pioneering team which published many of the Australian data and guidance on passive solar and energy efficient buildings. Deo represented Australia at many International Energy Agency Tasks and meetings. He was a sub task leader of the PV in Built Environment Task 7 of the PVPS agreement and led the Task Book on Designing with Solar Power (EarthScan). He supervised more than 40 doctoral students and more than 80 masters students in this field. In 2012 he was the Chief Investigator and CEO of a seven-year Co-operative Research Centre for Low Carbon Living which became a national innovation hub in the field delivering more than 111 Mt of carbon reductions by 2027. Deo continues his research in this integration field of energy efficiency, BiPV and zero carbon buildings.



Eduardo Armando Rincón-Mejía

Country: Mexico

Year Started Research: 1987

Title of Research: Tolokatsin Solar Cookers

University: Engineering Faculty-UAEM / Energy Program-UACM

Still Active in Research: Yes

Eduardo Rincón-Mejía works primarily in the area of Renewable Energy Technologies, with a strong emphasis on affordable solar technologies while being an astute critic of nuclear power. Rincón-Mejía's current research focus is the development of efficient and low-cost solar concentrators denominated "Tolokatsin", primarily using non-imaging optics for a wide range of applications, such as solar cooking and food processing, water distillation, space heating, steam generation for industrial and residential uses, sterilization, and high-flux research; resulting in more than 60 peer-reviewed publications; of which more than 40 are articles in scientific research journals and conference proceedings, both national and international, such as the "Journal of Solar Energy Engineering", "Renewable Energy" and "Applied Energy"; and he was in charge, together with Dr. Alejandro de las Heras, of editing the book "Sustainable Energy Technologies" published by CRC-Press in 2018. Since 1986, he is an active member of the ASME (American Society of Mechanical Engineers), where he was President of the Solar Energy Division (2013-2014); he is also a life member of the ISES (International Solar Energy Society) within which he has been part of the Board of Directors (2005-2009) and Secretary (2008-2009); while since 1987 he is a member of the ANES (Asociación Nacional de Energía Solar A.C.) where he was President (2002-2004). Devoted professor at the Engineering Faculty in the Universidad Autónoma del Estado de México since 1975, and at Energy Program in the Universidad Autónoma de la Ciudad de México since 2004, where he has directed more than 60 theses and taught classes as a devoted professor of thermal-sciences and renewable energies. In 2018-2019, he was the General Director of Energy Efficiency and Sustainability at the Secretary of Energy of the Federal Government of Mexico (SENER).



Manuel Romero

Country: Spain

Year Started Research: 1982

Title of Research: Concentrating Solar for Power, Fuels and Chemicals

University: IMDEA Energy

Still Active in Research: Yes

Dr. Manuel Romero started solar research with a grant in the University of Valladolid, in 1982. In June 1985 he joined CIEMAT (www.ciemat.es), working as researcher for the Plataforma Solar de Almería (www.psa.es). In 1990 he received his PhD for his work on solar steam reforming of methane in a central receiver system and from that year started as Project Manager till 2002 with responsibilities on R&D for solar thermal power plants, solar hydrogen and solar detoxification. In 2002 he became Director of PSA and afterwards Director of the Renewable Energy Division of CIEMAT since June 2004 till August 2008. He has been Guest Professor at the ETH Zurich during summer 2007 and 2014. Since 2008 he is Deputy Director of the Madrid's Institute for Advanced Studies on Energy (IMDEA Energy) and Research Professor at its High Temperature Processes R&D Unit with activities in high-flux modular concentrating solar power technologies and sustainable fuels production (www.energy.imdea.org). Manuel received the "Farrington Daniels Award" in 2009, conferred for R&D contributions to the development of high temperature solar concentrating systems. He has 209 publications (<https://scholar.google.com/citations?user=9nZRJDsAAAAJ&hl=en>) receiving 4566 citations so far, $h=34$ and $i10=71$ (71 publications with at least 10 citations). His manuscript on solar thermochemical fuels (*Energy & Environmental Science* 5 (11), 9234-9245) has received 423 citations; on CSP central receiver technology (*J. Sol. Energy Eng.* 124 (2), 98-108) 414 citations, on solar detoxification (*Solar energy* 66 (2), 169-182) 199 citations and the recent review on solar thermochemical storage (*Chemical reviews* 119 (7), 4777-4816) received 35 citations in only one year and was ranked number 6 in the The top 10 Chemical Reviews from 2019 Your Favorite Review contest. During his career he has participated in 62 collaborative R&D projects in solar energy research, 21 of them financed by the European Commission.



Wasim Saman

Country: Australia

Year Started Research: 1987

Title of Research: Zero energy buildings, Energy storage

University: University of South Australia

Still Active in Research: Yes

Wasim Saman started solar research in Iraq, where he helped establish the Solar Energy Research Centre in Baghdad in 1987 and pioneered research and demonstrations including the first passive solar building and 3 solar air conditioning projects in the region. He joined the University of South Australia (in Adelaide) in 1993 where he has been providing leadership in teaching and research while serving the national and international communities. He has implemented collaborative research projects with institutions from the European Union, Germany, USA, Greece, India and Mauritius. He has been involved in reviewing research funding applications and acted as consultant for bodies in the G20, UK, UAE, Chile, Ireland, Qatar, Canada, New Zealand as well as Australia. He has published over 300 reviewed articles in leading international journals. Impacts of Professor Saman's research which have found their way to commercialisation include: Developing phase change energy storage systems. The low temperature applications are in use in refrigeration and air conditioning as a cheap alternative to batteries. The high temperature systems offer a low-cost energy storage option in solar generation plants. Partnering with the housing industry/governments in developing residential developments designed for a changing climate. A good example is the near zero emissions Lochiel Park Green Village in Adelaide. Professor Saman has contributed to scores of technical conferences as a keynote speaker or a member of organising/technical committees. This started in Baghdad in the 1980's and continued throughout his career in Australia with the highlights being technical program chair of the 2001 ISES Solar World Congress and the International Solar Cities Conference in 2011. In 2020 he was awarded the title of Emeritus Professor by the University of South Australia where he continues to supervise students and work with industry on applications of phase change materials and innovative solar water heating systems.



Manuel Silva- Perez

Country: Spain

Year Started Research: 1985

Title of Research: Concentrated Solar Power

University: Plataforma Solar de Almería and Universidad de Sevilla

Still Active in Research: Yes

Manuel Silva is professor at the Department of Energy Engineering at the University of Seville, where he teaches Thermodynamics and Solar Energy related topics, and develops its R&D activity in the Group of Thermodynamics and Renewable Energy (GTER). He has also lectured solar energy courses or seminars at the University of Colorado in Boulder (USA), American University of Cairo (Egypt), ESPE of Quito (Ecuador), Euro Mediterranean University at Fez (Morocco) and other universities and institutions. He is author of a good number of journal papers and other scientific and technical publications. His research work has focused primarily on the use of solar energy at medium and high temperatures by means of Solar Thermal Concentrating Systems and on the measurement and assessment of the solar resource for concentrating solar plants. He started his research activity the Plataforma Solar de Almeria (PSA) in 1985 as a member of the International Test and Evaluation Team (ITET), participating in different projects and assuming different responsibilities, like the direction of the volumetric receiver tests or the reconstruction and improvement of the control system of the CRS (Central Receiver System) heliostat field. He has coordinated or participated in many R&D projects and technical assistances for CSP projects in Spain and other countries, in close collaboration with the industry and national and international institutions. He has been Secretary General of the Spanish Association of the CSP Industry (Protermosolar), member of the Scientific and Technical Committee of the European Solar Thermal Electricity Association (ESTELA) and Scientific Advisor of the Advanced Technology Center for Renewable Energy (CTAER).



Dr Dilawar Singh

Country: Australia

Year Started Research: 1981

Title of Research: Thermal Modelling of Typical Solar Collectors

University: Indian Institute of Technology, New Delhi, India

Still Active in Research: Yes

Born in India and educated at the Indian Institute of Technology, New Delhi, Dr Dilawar Singh immigrated to Australia in 1992 as a skilled migrant. Dr Singh has over 38 years of experience in renewable energy and holds a Ph.D. in Solar Energy (1984). Dr Singh is founder and promoter of Sun Brilliance Group based in Perth. Sun Brilliance Group is involved in solar power and hydrogen projects developments. Dr Singh is founder and president of International Business Council of Australia. Dr Dilawar Singh was Senior Research Fellow in Curtin University of Technology, Perth and Adjunct Professor in Murdoch University, Perth.



Alistair Sproul

Country: Australia

Year Started Research: 1986

Title of Research: Low energy buildings and PV, Energy efficient fluid handling systems

University: University of New South Wales

Still Active in Research: Yes

Professor Alistair Sproul, BSc (Hons I) (Syd) PhD (UNSW), is Head of the School of Photovoltaic and Renewable Energy Engineering (SPREE) at UNSW, Sydney, which he first joined in 2001. Concurrent to this, from 2012 – 2019, he was program leader for Integrated Building Systems with the Cooperative Research Centres' Low Carbon Living. Having worked in photovoltaics and energy efficiency research and R&D for over 35 years, Alistair has held senior positions in both academia and industry in Australia and around the world. In addition to his career at UNSW as a dynamic leader and teacher, this includes work with BP Solar, Pacific Solar and the Fraunhofer Institute for Solar Energy Systems, in Freiburg, Germany. Professor Sproul currently focusses on research areas of interest including energy efficient buildings, building integrated and building applied PV/energy systems for low energy buildings, as well as highly efficient fluid handling systems. He is the author of over 160 journal and conference papers, as well as two books, and is the recipient of over \$4M in grant funding to date.



Aldo Steinfeld

Country: Switzerland

Year Started Research: 1989

Title of Research:

University: PhD at University of Minnesota-now ETH Zurich

Still Active in Research: Yes

Prof. Steinfeld's research program is aimed at the advancement of the thermal and chemical engineering sciences applied to renewable energy technologies. His fundamental research focus comprises high-temperature heat/mass transfer phenomena and multi-phase reacting flows, with applications in solar power, fuels, and materials production, thermochemical processing, CO₂ capture and recycling, energy storage and sustainable energy systems. He has pioneered the development of solar reactor technologies for producing carbon-neutral transportation fuels. He served as the Editor of the Journal of Solar Energy Engineering, co-Editor of the CRC Handbook of Hydrogen Energy, and in several editorial boards. He has authored more than 300 papers in refereed scientific journals, filed 30 patents, and supervised 52 PhD theses in the field of sustainable energy. Two ETH-spinoff companies spun out from his lab, Climeworks and Synhelion, to implement at an industrial scale the technologies for the direct air capture and solar fuels production. www.prec.ethz.ch



Harry Suehrcke

Country: Australia

Year Started Research: 1984

Title of Research: The performance prediction of solar thermal systems

University: University of Western Australia

Still Active in Research: Yes

Harry Suehrcke became involved in solar energy research while doing his PhD under the supervision of Professor Paul McCormick at the University of Western Australia (1984-1988). The research produced what is believed to be the first long term study of instantaneous solar radiation on the earth's surface. The results showed, for example, that the solar radiation (unlike hourly irradiation) has a distinct bimodal character associated with the passing of clouds. Following an academic appointment at James Cook University (JCU) in Queensland in 1989, Harry continued his research on solar energy by studying a PV pumping system and carrying out further measurements of instantaneous solar radiation. The observed bimodal radiation character enabled him to derive the relationship between sunshine duration and solar radiation, which suggested the relationship is not linear as commonly assumed. Harry also became involved in the commercialization of a rotomolded integral collector-storage solar water heater with Gough Plastics (1992 to 2001). In 1993 he joined the Standards Australia CS-028 committee for Solar Heating and Cooling. In 2002 Harry returned to Western Australia to start Sunspin Pty Ltd, a consulting company specialising in thermal and renewable energy. Harry retained his passion for research on solar radiation and in 2013 published an awarded paper on the relationship between sunshine and radiation with Dr. Ross Bowden and Prof. Terry Hollands. The paper suggested the physical reason for the non-linearity of the relationship is that clouds not only reduce the radiation due to a decreased sunshine duration, but also because they become thicker and less transparent with decreasing sunshine fraction. Currently Harry is involved with the modelling of PV systems including PV water heaters and has joined the ISO TC 180 SC1 Measurement and Data committee. He continues research on the variability of solar radiation on the earth's surface.



Roger Taylor

Country: United States

Area of Research: Photovoltaic Power Systems, Deployments

Education: B.S. degree in Physics from Colorado College M.S. in Mechanical Engineering, University of Arizona

Last worked at: National Renewable Energy Laboratory

Still Active in Research: No

Photo Caption: Roger Taylor at the 2017 solar eclipse.

Reference: Dave Renné & Paulette Middleton

Roger Taylor began his professional career in the 1980s working in photovoltaic power systems, including project engineering, demand side management, inverters, solar cells and arrays, and government policies. He played key roles in NREL's State and Local Programs and conducted early workshops and research to support understanding of how large penetrations of renewable power can be incorporated into electricity grid systems and informing state and local leaders on how to support these programs. In the mid-1990s he became a leader of NREL's Village Power Program where he developed curriculum, workshops, and technology transfer activities in areas of off-grid PV and wind system design, energy access, and productive uses of solar energy as an economical way for unserved communities to become electrified in sustainable ways. At the conclusion of the Village Power Program, he became a leader of the State, Local, and Tribal Integrated Applications Group in the Strategic Energy Analysis and Applications Center. This program promoted tribal energy sufficiency, economic development and employment on tribal lands through the use of renewable energy and energy efficiency technologies. He became a key figure in support of the Institute of Sustainable Development, which was a non-profit organization established by Mark Fitzgerald devoted to developing quality training programs around the world for PV deployments.



Wilfried van Sark

Country: Netherlands

Year Started Research: 1982

Title of Research: Fitting of Current-Voltage Characteristics of Laser Annealed Silicon Solar Cells

University: AMOLF, Amsterdam

Still Active in Research: Yes

Wilfried van Sark is full professor “Integration of Photovoltaics” at the Copernicus Institute of Sustainable Development of Utrecht University. He started in 1982 with silicon solar cell characterization at AMOLF Amsterdam, and he received his PhD in 1989 from Nijmegen University on III-V solar cell and processing development. As a postdoc at Utrecht University he worked on plasma CVD of, thin film amorphous silicon cell and processing, introducing VHF-PECVD in the Netherlands. After fundamental microscopy research on single nanoparticles, he developed spectral shifting processes for next generation photovoltaics (up and down conversion), with a special interest in luminescent solar concentrators. Also, he is a recognized expert in performance analysis of photovoltaic modules and systems, and life cycle and market analysis. In addition, deployment of photovoltaics in residential areas has led to research in building integrated photovoltaics, smart grids with electric mobility and vehicle-to-grid technology, as well as short-term solar forecasting using various techniques such as all-sky imagers.



Werner Weiss

Country: Austria

Year Started Research: 1980 founding AEE Intec

Title of Research: Comparison of the Thermal Performance of a Solar Heating System with Open and Closed Solid Sorption Storage

University: Vienna University of Technology / AEE Intec

Still Active in Research: Yes

Werner Weiss is a founding member and director of AEE - Institute for Sustainable Technologies (AEE INTEC) in Gleisdorf, Austria and is working in national and international solar thermal and energy efficiency projects since the beginning of the 1980s. He is a member of the Executive Committee of the Solar Heating and Cooling Programme of the International Energy Agency (IEA). From June 2010 to May 2014 he was chairman of this IEA Implementing Agreement. Furthermore, he is a board member of the European Technology Platform on Renewable Heating and Cooling. He has been project coordinator of more than 30 national, European and international solar thermal energy projects. His main research activities are on solar combi-systems and solar heat for industrial processes. Since 2007 he has been a lecturer at Vienna University of Technology and faculty member of the continuing education center. More on Werner Weiss' research: https://beta.explore.openaire.eu/search/publication?articleId=dedup_wf_001::66a9c1b0c1a4631d54db382582f9784e



Stuart Wenham (1957-2017)

Country: Australia

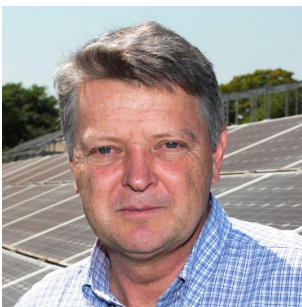
Year Started Research: 1982

Title of Research: The buried contact solar cell

University: University of NSW

Still Active in Research: No

Stuart invented the buried contact solar cell as part of his PhD Thesis. It was commercialised by BP solar as the 'Saturn' technology and sold all over the world including one of the world's MW scale power plants (in Toledo Spain). The buried contact solar cell was awarded the CSIRO Medal for research of commercial significance in 1992 and judged one of the "Top 100 Australian inventions of the 20th century" by the Academy of Technology and Engineering in 2001. He worked in the team at UNSW that developed the world's first 20% efficient cell and the 25% efficiency PERL cell, thereby holding world efficiency cell records almost continuously for decades. Jointly with Professor Green, Stuart was awarded the Australia Prize for Science and Technology in 1999. He also invented or co-invented eight classes of solar cell technologies that have been licensed to manufacturers around the world. Stuart's laser doping, plating and hydrogenation technologies that were commercialised as 'Pluto' by Suntech Power (with CEO Zhengrong Shi and Stuart as CTO) led to a world record 20.3% efficient commercial cell. For his contribution to research, innovation and commercial development, he won countless awards including the Clunies Ross Award, William Cherry Award and an Australian centenary medal. In 2014 he was awarded the AF Harvey Engineering Prize for his advanced hydrogenation technology controlling the charge state of hydrogen to passivate defects allowing the use of cheaper silicon wafers and preventing cell degradation. At the time of his passing in 2017, he was as active as ever in the research space, with around a dozen patents in the pipeline and many millions in grant funding awarded to progress their development.



Roberto Zilles

Country: Brazil

Year Started Research: 1985

Title of Research: Comparative experimental study on flat-plate solar collectors with solar radiation and solar simulator

University: Universidade Federal do Rio Grande do Sul

Still Active in Research: Yes

Roberto Zilles' RE research activities started in 1985 and were associated with the Master Degree Program in Mechanical Engineering of the Federal University of Rio Grande do Sul, Brazil. The first research was about solar flat-plate solar collector efficiency, entitled "Thermal-efficiency of flat-plate solar collectors using outdoor and indoor measurements with a solar simulator", and the results established a correlation between the two test procedures and allowed the use of indoor measurements to reduce the time to evaluate the performance of flat-plate solar collectors. In 1987 he started his studies on mismatch losses in PV arrays that resulted in an analytical model for mismatch losses in PV arrays. In 1993 he concluded his doctor thesis at the Solar Energy Institute of the Polytechnic University of Madrid, Spain, and in 1994 he started his research activities on PV system applications at the University of São Paulo, Brazil, where he founded the Laboratory of Photovoltaic Systems. Since then he has been the coordinator of the research activities of this laboratory, and has been recently appointed Director of the Institute of Environment and Energy of the University of São Paulo.

8.9 Industry Pioneers 1980-1989



Peter Adelman

Country: Germany
Year joined industry: 1983
Company first worked for: Steca
Technology area: PV
Still active in the industry: Yes

In 1983 Peter Adelman started to build PV Systems. He founded and managed the solar department in Steca company. Later he founded Phocos AG. Since 1988 he has been teaching in the Technical University of Ulm. With his students and with his children he started several solar companies (fosera, BOS AG, fothermo AG). As Professor at the University and as director of his institute id-eee he now supports solar-entrepreneurship in an organised way.



Kim Atkinson

Country: Australia
Year joined industry: 1986
Company first worked for: Hyngo Pty Ltd - Natural Technology Systems
Technology area: PV
Still active in the industry: Yes

Kim Atkinson started in the Renewable Energy Industry in 1986 purchasing an established company Natural Technology Systems (NTS) in Prospect South Australia. NTS most critical step was when we attained appointment as BP Solar Distributor for South Australia. Our Association with this company over the next 25 years was the making of NTS a market leader in all facets of the Renewable Energy Industry in Australia including the design and installation of Hybris Solar, Wind, Battery, Diesel Generator Systems. NTS first major contract in 1995 was for SA Government installing the first of the Dale Butler /Siemens manufactured Interactive inverter charger combined with 120volt battery system with Solar and Diesel Generator. Siemens which then was manufactured by Power Solutions Australia which then was taken over by Selectronics Australia and became the very Successful SP PRO range of Interactive inverter chargers. The success of this project lead NTS to being awarded a contract to Install 5 of these systems for National Parks NSW in the Sturt National Park, following this were contracts to install systems on Montague Island and Green Cape. NTS was selected to supply and install a large Hybrid, Solar, Wind, and Micro Hydropower system in the Tumberong district in Brunei in 1996. NTS has been involved as a Renewable Technical Consultant for the National Parks of South Australia and New South Wales and has filled the same roll with the Department of Administrative Services and the Department of Aboriginal Affairs for the South Australia Government. NTS developed for the Grid Connect market in SA developing a roofing framing system prior to the modern roof raling kits. As well built a Modular Grid Connect Solar Battery Pack approved by ETSA and connected to the grid in 2000. NTS is a foundation member of the Solar Energy Industry Association of Australia, and Clean Energy Council of Australia. Kim was involved with SEIA and BCSE and the CEC in helping to organise the Appropriate Technology Retails Association [ATRA] annual conference from 1987 to 2015.



Allan Barker

Country: Australia

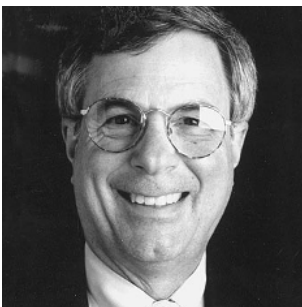
Year joined industry: 1982

Company first worked for: AJ and BA Barker Electrical

Technology area: PV

Still active in the industry: Yes

Allan Barker was operating an electrical wholesale business in Ulladulla, on the south coast of New South Wales, Australia when in 1982 he started supplying solar modules and components firstly to caravan owners and campers and then systems to those people living off-grid in the area. At the time he approached Solarex and became their distributor for the region. As the business grew, he also started wholesaler solar components to other small solar business owners and installers around Australia. The 80's and early 90's the market on off-grid systems and caravan/campers but then by late 90's early 2000's grid connected systems started being installed in Australia. Allan moved into selling and installing these systems. In the early days of the grid connected market he installed systems on a number of schools. When BP Solar took over Solarex in the late 90's Barker Electrical became one of the largest BP Solar distributors in Australia. In the mid-2000's Allan obtained the license for a module framing system that allowed solar laminates to be manufactured into solar roof tiles for the Building Integrated PV (BIPV) market. He later sold license to the tile to a building company in Western Australia. Barker is still providing solar equipment almost 40 years after it started.



Allen Barnett

Country: United States

Year joined industry: 1983

Company first worked for: Astropower

Technology area: PV

Still active in the industry: No

Dr Allen Barnett left the University of Delaware as a Professor of Electrical Engineering in 1983 to become general manager of Astropower, Division of Astrosystems. He became President of Astropower in 1989 when it became a separate company. Astropower started manufacturing monocrystalline solar modules in 1988 using silicon wafers sourced from third parties and then moved onto producing solar wafers from silicon feedstocks. The company was also undertaking R & D on silicon film. The company went public in 1998, reached manufacturing capacity of 25MW and at one time was in the top 5 of module manufacturers. Astropower was sold to Spanish company Astera in 2001. Dr Barnett left the company in 2003 and returned to the University of Delaware. Dr Barnett has also been active in many organisations such as being on the Board of Directors of the SEIA (US) where he also been President of SEIA and Chairman of its Photovoltaics Division.



Todd Bartholf

Country: United States

Year joined industry: 1986

Company first worked for: Northern Power Systems

Technology area: Wind

Still active in the industry: Yes

Todd Bartholf is an independent renewable energy consultant and has been active in the industry for over 35 years. He founded his first solar and wind contracting firm in Colorado at the age of 27, was president of an internationally respected systems integration design-build contractor for high-reliability renewable energy applications from 1988-1991 and a senior program officer with the renewable energy team at the international development assistance NGO, Winrock International, through 1996. More recently he held the position of Global Market Segment Director for Renewable Energy at a multinational Fortune 100 environmental engineering firm where he led the design and delivery of numerous large-scale initiatives for a variety of clients in both the public and private sectors, including as energy team lead for the company's overall project manager role on the MASDAR project in Abu Dhabi from 2006-2010. He has related experience in more than 15 countries and his current work includes providing strategic and technical support to a number of US-based commercial and industrial clients seeking to reduce their carbon footprint through commitments to the purchase of clean energy.



Beverly Blum

Country: United States

Year joined industry: 1987

Company first worked for: Solar Cookers International

Technology area: Solar Thermal

Still active in the industry: No

Bev Blum was a founder of Solar Cookers International (Solar Cookers International, then Solar Box Cookers International) and served as the first President from 1987-89, first Executive Director from 1989-1999 and 2003-2006, and Board President 2010-11. Bev is a woman of vast and varied talents, including box cooker developer, author, trainer, and presenter. Beverly worked with engineers from University of the Pacific in Stockton, California to mobilize efforts to expand awareness for solar cooking and its potential value worldwide. She was instrumental in hosting the first solar cooking international conference held on the same campus. At SCI's world conference in Granada, Spain in 2006 Bev led formation of the Solar Cookers World Network by and for independent solar cooker promoters and organizations for information exchange and collective advocacy. After producing periodic network newsletters 2006-2010, the network is now maintained by the website www.solarcooking.org. At SCI, Bev developed a foldable box cooker in 1992 that fits within its lid, and also coordinated volunteers to create the CookKit in 1994, the lowest-cost family cooker, mass-produced or hand-made. By the Year 2000, CookKits were produced independently in 28+ countries. Starting in 1995, Bev helped SCI launch projects promoting CookKits and training families in Kenya refugee camps Kakuma and Dadaab (27,000), in Ethiopian camp Aisha (3000) for UNHCR and community market-based projects in Zimbabwe (10,000) for United Nations Educational, Scientific and Cultural Organization (UNESCO) with U. Zimbabwe Development Technology Centre and Kenya (6,000) with local NGO, Nyakach Community Development Association (NYACODA). Independent evaluations in each project confirmed wide acceptance, use and benefits - saving time, labor and wood and reducing water-borne diseases. Bev is now retired but enjoys supporting the ongoing progress in solar cookers' ever-widening spread, diversity and transition to wide commercial production, promotion and distribution.



John Bonda (1931-1999)

Country: Belgium

Year joined industry: Early 80's

Company first worked for: Intersolar Group

Technology area: PV

Still active in the industry: No

In the early 1980's John Bonda was representing the Intersolar Group in Western African. He had been living and working in Africa and his vision was of the electrification of Africa and developing countries with PV. Wolfgang Palz recommended that he become the first Secretary General of the European PV Industry Association(EPIA). John moved to Brussels and filled this role from 1986 to his untimely passing in 1999. With his ability to speak a number of languages he was able to build connections within the European Commission and to raise the profile of PV such that he was successful in obtaining donor money for many PV related projects. He led many trade missions on behalf of the fledgling but growing PV industry and in particular in the 80's and 90's when the main markets was still off-grid. Within the EPIA he was very well respected and liked professionally and socially. The later because of his ability to select castles, unique hotels etc for the EPIA conferences. After his passing EPIA inaugurated the annual prestigious Bonda Prize for the Advancement of Solar.



Harold Burris (Deceased)

Country: United States/Kenya

Year joined industry: 1982

Company first worked for: Solar Shamba

Technology area: PV

Still active in the industry: No

Harold Burris was a pioneer engineer of small scale solar in East and Southern Africa. He came to Kenya as a Peace Corps volunteer teacher in the early 1970's and saw the immense demand for rural electrification. He later returned to Kenya and settled in the country in 1979. After attending the Nairobi 1982 UNEP Renewable Energy Conference, a seminal event globally and especially Kenya, he set up Solar Shamba, a company dedicated to marketing off-grid solar home systems. He was working with second-hand ARCO modules for a solar-powered sewing project when he met Mark Hankins and began a 15 year collaboration. In the first stage, he assembled and engineered solar components for 4 solar-powered schools. Subsequently, with Daniel Kithokoi, Solar Shamba began to install solar home systems for clients around the East Side of Mt. Kenya. Between 1984 and 1990, his company (and technicians trained by Burris and Hankins), solar on the order of \$1M worth of solar equipment to households in the first wave of growth of the solar industry in Kenya.



James Caldwell, Jr

Country: United States

Year joined industry: 1983

Company first worked for: ARCO Solar

Technology area: Policy

Still active in the industry: Yes

Jim Caldwell, Jr graduated in chemical engineering from Stanford, and began working in the ARCO oil refinery in Carson while he was still in college. He went on to a 20 year career at ARCO, and after beginning his career in the refinery, rose to become refinery manager, before getting an MBA and becoming a corporate Vice President. In 1983, Jim was asked by ARCO's legendary CEO, Robert O. Anderson, to become president of the newly acquired ARCO solar subsidiary, which had a photovoltaics plant in Camarillo, California. Jim traveled the world, selling expensive solar panels in remote regions, where there was no electrical grid and diesel generators were the only source of electricity. He went on to oversee the construction of the world's largest solar photovoltaics project, in cooperation with PG&E, in the Carrizo Plain, near San Luis Obispo. After putting together a nearly successful deal to buy ARCO Solar, (he lost out to Siemens), Jim became a private consultant working with renewable developers on utility scale solar and wind projects. He also began his three decade association with the Center for Energy Efficiency and Renewable Technologies, where he continues to serve as Technical Director. From 2006-2009, Jim served as Assistant General Manager of the Los Angeles Department of Water and Power, where he worked on plans to phase out LADWP's reliance on imported coal, and expand transmission to bring solar and other renewables to the LA Basin. Jim is currently leading efforts to encourage reliance on hybrid solar and storage projects, both utility scale and behind the meter, to help meet system reliability needs and phase out reliance on natural gas and fully decarbonize the power sector.



Don Coan

Country: United States

Year joined industry: 1980

Company first worked for: Solar Cookers International

Technology area: Solar Thermal

Still active in the industry: No

Don was a lifelong advocate for Solar Cookers International. Don was introduced to solar cookers in 1980 and was known for his many presentations on how to build and use solar box cookers. Don was a global citizen, working with sister city organization between Sacramento and Nicaragua as well as attending numerous solar cooking and sustainable energy conferences worldwide. In June 1992, Don presented at the United Nations World Environment Conference in Rio de Janeiro –which focused on water purity, genocide, and terrorism. In 1993 he attended the Kids World Conference Energy Fair called “Plan it For the Planet” at Nickelodeon Studios in Orlando, Florida, USA. He was a troubleshooter for 6th grade students building their first solar cookers. He also spent time in Zimbabwe for a month doing train the trainer to teach locals how to use cookers. In 1997 Don went to an all-women's university in southern India to present on solar cookers. Additionally, Don visited several Latin American countries including Costa Rica, Nicaragua and Peru to present on solar box cookers. For Don, solar cooking was a tool for living in a manner that reduced carbon emission and helped save the planet. Don was known in Sacramento for sponsoring a solar cooking block party that grew to include several streets in Sacramento over its successful 10 years. He volunteered regularly in the Solar Cookers International headquarters in Sacramento, California, USA, and dedicated countless hours to its promotion.



Richard Collins (1955- 2020)

Country: Australia

Year joined industry: 1980

Company first worked for: Lucas Energy Systems (UK)

Technology area: PV

Still active in the industry: No

In 1980 Richard joined Lucas Energy Systems (UK) which was acquired by BP a few months after he joined, and the company changed to BP Solar Systems. Here he was involved in all technical aspects of BP Solar systems including design, production, system engineering, sourcing and the introduction of Quality Assurance. In 1985 he was seconded by BP Solar Spain where he was based in Madrid and was Assistant Project Manager in the establishment of a fully operational solar cell and solar module production line. In 1986 he was seconded to BP Solar Australia and travelled back to Sydney where his role was to establish the Professional Sales Department. He established the supply of specialist industrial batteries for solar power applications and worked closely with Telecom Australia. This was the period when Telecom Australia was one of the world leaders in using solar to power their microwave repeater stations. He started BP Solar's first company owned retail outlet in Dubbo, NSW and then moved to Darwin to operate the retail business there. He returned to head office in early 90's and he was first Manager of Industrial Sales and then Regional Business Manager for BP Solar for grid connected photovoltaic systems in the utilities and buildings markets. It was in this role that he successfully led the bid for the Sydney Olympics and oversaw the installation of the systems at the village and throughout the Olympic precinct. In 2001 he left BP Solar and formed Punchline Energy – an energy efficiency and renewable consultancy business. In 2016 he joined GSES as as Technical Business Manager.



Douglas Danley

Country: United States

Year joined industry: 1981

Company first worked for: US Peace Corps (1979-83), Integrated Power Corp (1986)

Technology area: PV

Still active in the industry: Yes

Doug Danley designed and installed his first PV water pumping system as a Peace Corps Volunteer in Botswana in 1982 and subsequently received a mechanical engineering degree from MIT. He joined Integrated Power Corporation in Maryland and was a leader in the design of PV and hybrid power systems for the commercial and village power industries, including the Coconut Island Australia microgrid in 1986/87. He founded Orion Energy Corporation in 1983 which developed multiple generations of control and power electronics for advanced PV systems. He managed the design and installation of the 300 kWh/day Padre Cocha microgrid in Peru in the early 2000s. He worked with Mark Mrohs in the mid '90s to do three years of solar training in India. In 2004 Doug joined GridPoint and managed the development of the "Connect" which was one of the first integrated PV+storage systems for residential use. From 2010 until 2019 he worked with the National Rural Electric Cooperative Association as a technical expert in renewable energy. He was the Principal Investigator of the four year NRECA/DOE "Solar Utility Network Deployment Acceleration" project which helped reduce barriers for US electric co-ops to deploy large scale PV systems. He has also worked with EarthSpark International and NRECA-International on various international solar microgrid projects. Since 2017 Doug has been working on the SUNSPOT(tm) solar electric cooking system, which won the prestigious Elsevier / ISES "Renewable Transformation Challenge" in 2019.



James Duffy

Country: United States

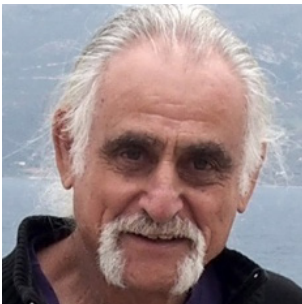
Year joined industry: 1980

Company first worked for: Total Environmental Action

Technology area: Solar Architecture/Buildings

Still active in the industry: No

In 1980 James Duffy was fortunate to discover a company that occupied a small little village in the woods of New Hampshire-Total Environmental Action(TEA). TEA had recently formed as a solar design firm led by Bruce Anderson, and a group of new age hipsters of sorts and was very committed and passionate about solar technology and where it could all lead us to in the future of energy consumption. They had seen the beginnings of gas lines and rising prices that was only going to become more problematic over time and felt the tug of war waging in the White House, when Jimmy Carter left the White House and Ronald Reagan removed the solar panels previously installed. TEA was very concerned in the lack of interest in anything solar and that it would not be investigated and promoted as a partial solution to our energy dilemma, as oil is by nature a finite solution. They were at that time very committed to the idea that using solar energy was not only a valid thought, but, that it would help solve many future issues, such as climate change. It is quite disappointing to James that we are still struggling with these same issues that now are showing the impact of global warming -that are at this very moment ravaging the State of California. James' realizes that this message may not be desirable in the context of this submission, but it is all really the same part of the same story. Energy, Global Warming, Food production all rely on the interworking's of all of these systems.



Max Enfield

Country: Australia

Year joined industry: 1989

Company first worked for: Planetary Power

Technology area: PV

Still active in the industry: Yes

Max Enfield's start in the renewable energy industry was in October 1989 when he co-founded Planetary Power, a small business, specialising in remote area power supplies and operating mostly on the Atherton Tableland in Far North Queensland. In those days, installations were exclusively off-grid. He held the position of Technical Director for 20 years until 2009. During this time he was responsible for site and load assessment, specification, design, project management, installation supervision and ongoing customer support of over 300 remote area power supply installations. While most of the sites were for single dwellings; applications also included systems for multiple dwellings, aboriginal communities and outstations, telecommunications sites, water pumping and community facilities. He had, and retains, a particular interest in the assessment and design of low head micro-hydro in addition to PV. Then in 2009, he established his own business, Boutique Power, which he continues to operate. His focus remains in the assessment, specification, design, project management, installation and ongoing support of off-grid solar systems, spanning, residential, community and resort power supplies and solar powered water pumping. Current areas of operation are mostly in Far North Queensland, including Cape York Peninsular, Torres Strait and also on Norfolk Island. He has also undertaken assignments in Fiji and Pakistan. Max is currently Chairman of the Queensland Chapter of Solar Energy Industries Association Inc. and has previously served on the Australian Clean Energy Council Accredited Installer Reference Group.



Joseph Essandoh-Yeddu

Country: Ghana

Year joined industry: 1989

Company first worked for: Energy Commission

Technology area: All, Renewables and Policy

Still active in the industry: Yes

Dr. Essandoh-Yeddu joined the Ghana's energy sector in 1989 starting as a schedule officer for solar energy in then National Energy Board till his last position as Director, Energy Planning and Policy at Ghana Energy Commission in 1999. He developed and implemented the first major solar power programmes for Ghana between 1989-1999. He was involved in the design of the Renewable Energy Solar Power Project (RESPRO) in Northern Ghana, 1998-2002. Installed almost 1,700 Solar Home systems in 90 off-grid communities. He designed and implemented installation of 50kWp Rooftop Solar PV on the Ministry of Energy office building in Accra, 1999. First of its kind in Ghana then. He oversaw the Solar for Volta Lake Resettlement Areas, 1997-1998. This involved installation of thousand Solar Home Systems deployed in settlement communities displaced by the initial flooding of the Volta Dam. He Installed the first Solar Streetlights in four public universities in Ghana (1996-1997). He participated in developing Solar and Wind maps for Ghana between 2002-2004. He developed initial technical specifications for Off-grid Solar PV systems for Ghana in 1999. He developed Ghana's first Strategic National Energy Plan (2006-2020) that set 10% Renewable Energy target by 2020. Solar is now a common sight in Ghana. Joseph first joined ISES in the early 1990s among the first in Sub-Saharan Africa. He has published number of solar related papers including:

1. Solar Energy as a tool for Social Change: Experiences with Solar Photovoltaic Implementation in Ghana, ISES Solar World Congress, 6-12 August 2005, Orlando, Florida, USA.
2. Current Solar Energy Utilisation in Ghana, 1997, Renewable Energy, Elsevier Science Vol.10, No.2, pp. 433 – 436
3. PV R&D and Applications in Ghana: Current Status and Future Prospects, 25th IEEE PV Specialist Conference, Proceedings, 13-17 May 1996, Washington D.C, USA.
4. Performance Study of Solar PV Refrigeration Systems in Ghana, Proceedings, ISES Solar World Congress, 11-18 September 1995, Zimbabwe.



Bill Finney

Country: Australia

Year joined industry: 1983

Company first worked for: Australian National University (ANUTECH)

Technology area: Solar Thermal

Still active in the industry: No

Bill Finney was the Manager/Operator of the White Cliffs Solar Thermal Power Station, arguably the World's First Commercial Solar Power Station, designed and constructed in 1981 by the ANU. Bill maintained the operations of the station for 10 years and was instrumental in resolving design faults and improving the operating efficiencies of the station. The following are his words describing the operation of the station. "The concept of the White Cliffs Solar Thermal Power Station was to collect the sun's energy to boil water to produce steam to operate a steam engine, turning an alternator supplying electricity. Fourteen 5 metre fiberglass parabolic dishes each with 2000 small mirrors, concentrated the rays to a focal point, one and a half metres from the base of the dish. At the focal point water pumped through a coil of stainless steel tubing called a thermal absorber, converting the water to steam at a pressure 1000 pounds per square inch or four times the pressure of railway steam engines. The high-temperature steam was fed to a steam engine via stainless steel tubing inside insulated metal ducting. The steam engine powered a single phase alternator that supplied 240v to the town and a 300v DC Generator that charged a bank of wet cell batteries. The 25 kilowatts per hour output would supply the town's eight homes and six businesses by an allocation of two kilowatts per household and four kilowatts per business. At sunset, the field windings of the DC Generator would be reconfigured as a DC motor and powered by the batteries, continue to turn the alternator. A clutch would disengage the steam engine. The dishes tracked the sun's position, automatically following the sun or where the sun should be even on cloudy days. At the end of the day's sunlight the dishes would return to the morning start position."



Mark Fitzgerald (1955- 2005)

Country: United States

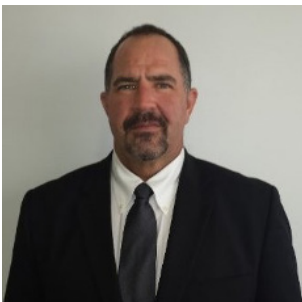
Year joined industry: 1981

Company first worked for: Photovoltaics international

Technology area: PV

Still active in the industry: No

Mark was an early believer in PV and in 1981 was the founding publisher and editor of *PV International* magazine. He was also the Executive Director of the PV Information and Education Association, in the 1980s, and he worked for a number of industry and government organizations, including the U.S. National Center for Appropriate Technology and the U.S. National Renewable Energy Laboratory. Mark was an NREL representative at the *Selling Solar* workshop at the Rockefeller Brothers Foundation Pocantico Centre, in 1995. At that time there was a (regrettable) history of failed PV projects in developing countries, largely because of poor quality systems integration and installation. Mark decided to address the training requirements for systems designers, integrators, installers and maintainers. At the time there were no “training standards” in existence to be applied, so he decided to form the Institute for Sustainable Power (ISP) in October 1996 to develop the standards and to act as an accreditation body. He travelled the world extensively and oversaw training programmes in numerous developing countries including Brazil, China and India. The standard developed by Mark was purchased by the Interstate Renewable Energy Council (IREC) which was the start of the solar training accreditation program operated today by IREC. Mark was also contracted to develop the rules and operational procedures for the start of NABCEP in the about 2003. Mark was the United States representative to the International Energy Agency’s Photovoltaic Power Systems Task 9 expert working group on Photovoltaics in Developing Countries, he served on the ANSI review committee for the ISO/IEC 17024 standard for accrediting bodies that certify persons, and he served on the advisory board of the American Solar Energy Society’s *Solar Today* magazine. He was an author of more than 25 technical and popular articles.



Scott Frier (Deceased)

Country: United States

Year joined industry: 1984

Company first worked for: LUZ Engineering Corporation

Technology area: PV

Still active in the industry: No

Scott’s experience in the Solar Power industry spanned more than three decades and his fingerprints are all over the world’s CSP industry. His career started in Daggett California during the construction of the first commercial CSP plant (SEGS I) as a construction worker of the Blount construction company in 1984. He immediately fell in love with the project and joined its owners a year later as a maintenance Superintendent for Luz Engineering Corporation. From there, his ability to quickly learn the technology and his incredible aptitude to articulate and to transmit his knowledge to others, propelled him to several management positions up to General Manager--first in Daggett SEGS I and II and later to SEGS III-VII at Kramer Junction. In 1991, after the bankruptcy of the original developer LUZ, Scott thrived as he was retained by the equity investors to create and be the Chief Operating Officer of a standalone O&M Company for the plants at Kramer Junction. For 12 years at the helm of KJC, Scott demonstrated his management and motivational skills while helping to promote solar energy, in spreading his passion to his employees and educating the world in proudly promoting the success of the plants. With the extensive expertise in managing all aspects of the development, construction and O&M gained at the SEGS, he decided to further conquer more of the solar world by joining International Companies focused on developing large scale CSP plants worldwide. So, starting in 2005, He served as VP at Solargenix/Acciona in the US Southwest, as Chief Operating Officer at Abengoa in the US and Spain and later as COO of renewables at ACWA Power based in Dubai. During his journey Scott, a truly Solar pioneer was responsible for the formation of hundreds of employees who all became dedicated Solar enthusiasts.



Deepak Gadhia

Country: India

Year joined industry: 1985

Company first worked for: Gadhia Solar Energy Systems Pty. Ltd.

Technology area: Solar Thermal

Still active in the industry: Yes

Deepak Gadhia returned to India from Germany after completing his Process & Environmental Engineering and PG in Energy Conservation and Energy Management from TU Berlin and MIT of USA. Realising that 50 % of the world's population cooks on open fire and that indoor pollution due to smoke in the kitchen caused the death of 3.2 Million Women and Children he decided to offer a Solar Cooking Solution. The Solar Box Cookers that were offered in India were not gaining acceptance so he analysed the reasons and found that they were too slow and could not fry and make chapati (Indian bread). Thus he introduced Parabolic Solar Cooker that was developed by Dr Dieter Seifert, a colleague of his. He indigenised the Cooker by adapting it to Indian material and manufacturing and usage. He found that people who needed it (rural Poor) could not afford it and people who could afford it did not need/want it as it required them to go out in the Sun, so he introduced Fix Focus Flexible Solar Concentrator developed by Wolfgang Scheffler in India. He sold them to Community Cooking organisations especially for mid-day meal program of Indian Government. To meet the request/ demand of Communities for Institutional Cooking to cook 1000's of meals per day with Solar, he developed Worlds first Solar Steam Cooking system with support of HTT GmbH a German company he worked with before his return. GATE/GTZ funded the first Project for NGO Brahma Kumari's. The Company went on to become one of the world's largest Company to offer Solar Steam Cooking Systems with Scheffler Concentrators. He started offering Solar Thermal Systems for Process heating and Cooling. India's first and largest Solar Thermal air-conditioning System of 100 TR (350KWt) was developed and supplied by them to provide cooling for 160 bed cancer hospital.



Stephen Garrett

Country: Australia

Year joined industry: 1982

Company first worked for: Ultra Solar Pty Ltd

Technology area: PV

Still active in the industry: Yes

Stephen Garrett has 38 years' experience in the Renewable Energy Industry and is currently the General Manager of Pyramid Power Group and the Managing Director of Solinta Pty Ltd. Stephen has founded and directed several successful businesses in the Renewable Energy industry with extensive Australian and International technical and project-management experience. Stephen has installed and supervised over a 5000 Grid Connect and Standalone Power Systems. Stephen's international working experience includes countries such as South Africa, Kenya, Ghana, Sri Lanka, China, Mongolia, Indonesia, Viet Nam, Singapore, Malaysia, Cambodia, Myanmar, Thailand, Lao PDR, Philippines, and the Solomon Islands. Stephen collaborated in the development of a "Train the Trainers Course" for Solar Home System technicians in Sri Lanka supported by the World Bank. The training included a Sales course for Solar Entrepreneurs and a Training course for the installation on SHS Monitoring equipment in Sri Lanka for data collection. Funding for the project came via the Australian Greenhouse Office. Other international projects include designing a solar module assembly plant for Chinese Investors and the development of the Strategy for RE Training Development in China, funded by the Australian Government (June 2005-June 2006). The development of a Renewable Energy Training and Accreditation Needs and Capabilities Study of the 21 different APEC countries and a Renewable Energy training accreditation program for the ASEAN region the project partner was the ASEAN Centre for Energy in Jakarta. The project funded by AusAid. Stephen to conducted workshops in Lao PDR, Cambodia, Myanmar and Vietnam. (2004-2006) Stephen also participated in the preparation of the Teachers' Solar Lighting SHLK Product Catalogue-Papua New Guinea- Funded by World Bank (April 2005-July 2005). Stephen was also a supporting team member in the document preparation for the Pacific renewable Energy Training Initiative (PRETI) – Funded by UN ESCAP.



Michael Geyer

Country: Spain

Year joined industry: 1981

Company first worked for: German Aerospace Center DFVLR

Technology area: Solar Thermal

Still active in the industry: Yes

Michael Geyer started his pioneering work in concentrating solar power (CSP) and thermal storage in 1981 at the German Aerospace Center. As Co-Director of the Plataforma Solar de Almeria he originated in the late 90s the development of the EuroTrough parabolic trough collector and the use of molten salt storage in parabolic trough plants. The EuroTrough parabolic collector has become “the mother” of European parabolic troughs and molten salt storage the standard CSP storage technology. In the early 2000s he scaled up the R&D scale results of EuroTrough and molten salt storage developing the worldwide first commercial scale CSP projects with 6 hour molten salt storage - the 50 MW Andasol-1 and Andasol-2 projects in Spain. As Executive Secretary of the IEA SOLARPACES Implementing Agreement between 2001 and 2007 he initiated an international deployment campaign to export the success of CSP with thermal storage to the Mediterranean, North Africa and Middle East by originating the so called SolarPACES START Missions. His subsequent professional engagement with Spanish company Abengoa Solar between 2007 and 2016 allowed him to build up an international team of researchers, engineers, operation, maintenance, legal and finance experts to start development of CSP projects worldwide in Europe, Africa, Middle East and Asia – pioneering with the origination and development of the following successful CSP projects: 100 MW Shams parabolic trough plant in Abu Dhabi, UAE; 100 MW Kaxu and 100MW Xina parabolic trough plants with molten salt thermal storage and 50 MW Khi superheated steam solar tower with steam thermal storage in Northern Cape, South Africa. Currently Michael is focussing on making molten salt thermal energy storage competitive and useful for its application beyond CSP – advising the DLR on the decarbonization of coal plants with thermal storage and Malta Inc. on the market implementation of pumped heat electricity storage.



Lee Gordon

Country: United States

Year joined industry: 1982

Company first worked for: Solarex

Technology area: PV

Still active in the industry: Yes

Lee Gordon started at Solarex in the early 1980s. He co-founded Integrated Power Corporation (IPC) with Ken Gerken in mid 1980s. IPC was one of the earliest systems-engineering companies and including many commercial PV and hybrid systems for telecom and oil/gas customers, village electrification projects in Mexico, Indonesia, Australia, and Papua New Guinea. Lee founded Morningstar Corporation in 1993 to focus on system controllers and power electronics for off-grid PV systems. Lee has been a mentor to multiple generations of system designers around the world, and is a true solar pioneer.



Jenny Gregory

Country: Australia

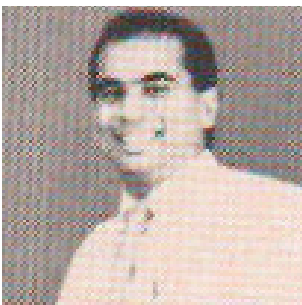
Year joined industry: 1989

Company first worked for: Victorian Solar Energy Council

Technology area: PV, SWH, biomass, energy efficiency, policy, lobbying

Still active in the industry: Yes

Jenny Gregory has had a long career in renewable energy and energy efficiency. In 1989 she worked at the Victorian Solar Energy Council as their Marketing and Public Relations Coordinator. Working with Ken Guthrie they developed the Solar Report (which was part of the ABC Weather) between 1989 – 1999 showing % savings off energy bills (solar hot water system in summer and passive solar-designed house in winter in Mildura & Melbourne, Victoria Australia). She then travelled to UK and from 1991-2001 Jenny was the Market Development Manager for IT Power undertaking renewable energy projects in Europe and the developing world, funded by European Commission, UN, Asian Development Bank, Swedish Development Agency, World Bank, UK government. She returned to Australia and from 2002 to 2003 she was Senior Project Manager - Renewable Energy, Sustainability Victoria. In 2003 she joined the Australian Business Council for Sustainable Energy (BCSE) as the Manager of Industry Development where she was involved in the development of the PV Roadmap and Bionergy Roadmap and managed the PV Designer and Installer Accreditation scheme and the AEPKA Accreditation. After leaving BCSE at end of 2007 Jenny has worked as: National Marketing & Government Relations Manager, Solco. (2008-2009); Manager Sustainable Technology Development, Energy Technology Innovation Strategy, Victorian Government (2009-2013) and: Independent Consultant in 2014 before joining AGL in 2014 as their Manager of their Energy Efficiency Programs. While in the UK she was the inaugural Secretary General, British Photovoltaic Association represented the UK PV industry, and was on the UK Solar Energy Society committee from 1994 to 1999 and their chair from 1996-1999. She was a committee member IEA Heating and Cooling Task 16, Photovoltaics in Buildings from 1990-1996 and was on the UK Department of Trade & Industry Solar Advisory Committee from 1995-2002. She was involved with many conferences, sometimes as organiser. From 1991 – 1994 she was NGO Media Liaison Officer for ISES and Represented ISES at UNCED PrepComs; assisted NGO forums (ISES 2000 Initiative. From 1999 to 2003 she was an associate editor of the ISES Solar Energy Journal.



Lalith Gunaratne

Country: Canada

Year joined industry: 1984

Company first worked for: Power & Sun (Pvt) Limited, Sri Lanka - 1986

Technology area: PV

Still active in the industry: Yes

The pioneering solar-PV business was established in Sri Lanka by three partners – Pradip Jayewardene, Viren Perera and Lalith Gunaratne in 1986. The idea born from a sketch of a mobile solar pump by Micheal Mustachi led the trio to establish a business to manufacture and market solar home systems for lighting and TV for rural farmers in Sri Lanka. Futurist Sir Arthur C. Clarke, innovator Dr. Ray Wijewardene and entrepreneur Mr. Prem Sumanasekera mentored the trio. A USAID funded market/feasibility study concluded that a portion of the 84% rural homes without access to grid power could afford to purchase a system. The findings helped raise capital through development banks of Sri Lanka to purchase a PV manufacturing plant from TPK-Solar in Canada. The trio developed an organization led by Ajit Chanmugam and Prasanna Pathirana on technical and Nimal Lakshpatiarachichi for marketing - to manufacture solar PV modules with the balance of system to market, sell, install and maintain the systems around the country through a network of dealers and agents. The original company, Power & Sun (Pvt) Limited promoted the SUNTEC branded systems to rural farmers who would spend between USD 200 and 400 to purchase a system. Micro financing was made available through Sarvodaya SEEDS to expand the market. Neville Williams of the Solar Electric Light Fund in USA discovered the pioneering venture in 1989 and promoted the business model globally which attracted the World Bank to study it. The World Bank team led by Loretta Schaeffer and Anil Cabraal worked with the trio to establish a USD 100 million fund for solar and other decentralized renewable energy technologies in 1993 which has seen over 120,000 solar homes systems installed. The venture - reorganised as Solar Power & Light Company was sold to Shell Renewables International in 1999.



Ravikumar Gurumurti

Country: India

Year joined industry: 1982

Company first worked for: Quantum Sun

Technology area: PV

Still active in the industry: Yes

Ravikumar Gurumurti joined the solar industry in 1982 as an R&D Engineer in the “National Solar Photovoltaic Energy Development Project” in Central Electronics Ltd., the first solar company and went on to lead the Quality function. In 1995 he moved to Siemens as Quality Head in the module manufacturing plant and was later assigned the training and marketing functions. In 2001, when Shell acquired Siemens Solar, he joined Shell Renewables to set up and develop the B2B business. In 2004 he joined Tata-BP Solar and handled the Customer Support and Training functions. In 2010 he moved to SEMI, the global Semiconductor and PV Industry Association and was responsible for Member Services. Since 2015 he has been freelancing and consults for Solar Promotion and structures the Intersolar India Conference and some solar startups. He delivers training programmes, speaks in workshops and seminars and contributes technical articles. He is a member of the Bangalore chapter of the Green Building Council of India and contributes to the promotion of Net Zero Energy Building concepts. Some of the significant projects he was involved in his 38 years long solar journey include: Development of Space Qualified solar cells; Development of low cost screen printing technology and replacement of silicone potting by lamination for terrestrial PV manufacturing; Development of solar solutions for the National “Literacy Mission” and “Drinking Water Mission”; Solar solutions for Off-shore oil platforms, Airport Navigation systems, Rural Telephony, Cathodic protection, Weather Monitoring etc.; Design, Installation and Commissioning of the first PV power plant (100KWp) in the state of Uttar Pradesh (1993). Other projects included: Training of 150 Engineers and 600 Technicians under World Bank’s Market Development Programme; Development of the first rooftop solar system (25 KWp); Development of solar power solution for the emerging mobile telephone operators, and; Raising solar awareness across the country through the Corporate Programme “Arunodaya”.



Mark Hankins

Country: Kenya

Year joined industry: 1983

Company first worked for: Energy Alternatives Africa

Technology area: PV

Still active in the industry: Yes

Mark Hankins is a pioneer in rural electrification and renewable energy in East and Southern Africa. He began solar PV work in Kenya in 1983 as a Peace Corps volunteer. With Harold Burris, he installed off-grid solar systems in schools and households around Mt. Kenya and trained dozens of technicians to install solar home systems. The technicians he and Harry trained went on to install thousands of solar home systems before 1995 in the growing east African market. The training material developed when Mark was a volunteer eventually became the book Solar Electric Systems for Africa, a basic manual that sold over ten thousand copies and was used to train innumerable technicians all over Africa. Through his work in training, policy development, advocacy and market study, Hankins helped build early off-grid solar industries in Kenya, Tanzania, Uganda, Somalia, Rwanda, Ethiopia and elsewhere. From his base in Kenya, and utilizing his fieldworker experience, Mark used his strong writing talents to make the case for off-grid solar energy access in Africa and all over the developing world. He worked with distributors, policy-makers, international agencies and advocates to press for off-grid solar and trained many early players in East and Southern Africa. He was also a pioneer player for grid connect solar in East Africa, as he lobbied governments and donors to support C&I solar in the early 2000’s. Mark has experience in training and conducting projects in more than 20 African countries and has worked for private clients, the UN, the World Bank, UNIDO, the GEF, Sida, USAID, relief agencies and others. Today, he is MD of African Solar Designs, Ltd., he is a permanent resident of Kenya. Today he specializes in training, commercial market development, policy, system engineering and project development. He is an author of 5 books on solar energy and renewables, a Certified Energy Manager and trainer and he lives in a wind/solar hybrid residence in the Ngong Hills. Mark is also an active musician and father of two girls.



Richard Hansen

Country: United States

Year joined industry: 1984

Company first worked for: Enersol Associates, Inc.

Technology area: PV

Still active in the industry: Yes

In 1983, Richard Hansen, a pioneer in PV for rural electrification in developing countries, visited the Dominican Republic, where he learned that over 500,000 rural families still relied on kerosene lamps and dry cells. In November 1983, he purchased a 36W, ARCO 16-2000 PV module. On January 21, 1984, Hansen returned to the DR with the PV module and designed a system to power lights, radio and TV, which he demonstrated to rural families. In April 1984, he sold the system under a 48-month micro-credit payment plan, to Felipe & Altagracia Martinez for their home/store in Bella Vista, Sosua. On September 27, 1984 Hansen founded Enersol Associates, Inc., a Boston-based non-profit organization, to introduce PV for rural electrification. Other families took interest in Martinez's PV system hoping to purchase one on credit. In 1985 Hansen arranged for Enersol to train the US Peace Corps, combined with a \$2,000 grant from USAID to establish a micro-credit fund to finance PV for the interested families. In 1986 Hansen formed a local PV supply enterprise that served as a model from which others learned. In 1987 Enersol was contracted by the USDOE through the University of Massachusetts to document the work which had led to the electrification of 100 households. By 1990 about 1000 Dominican households had PV, installed by local enterprises trained by Enersol. Starting in 1989 Enersol was contracted by the USDOE to replicate Hansen's model in Honduras. In 1993 a World Bank team visited Hansen's work in the DR to draw lessons learned for the initial integration of PV into World Bank rural electrification projects. Hansen's early work inspired many. In 1993 Hansen founded Soluz, Inc., a Massachusetts corporation, to raise impact capital to commercialize PV for rural electrification. In January 1994 Soluz, Inc. established Soluz Honduras, an impact enterprise that has provided over 25,000 PV systems for rural households, enterprises and schools. To assist the global transition Hansen has consulted for the World Bank in Asia, Africa & Latin America.



Lindsay Hart

Country: Australia

Year joined industry: 1981

Company first worked for: Selectronic Australia

Technology area: PV

Still active in the industry: Yes

Lindsay has spent all of his career except 3 years in the Renewable Energy sector. Specializing in the manufacturing of battery storage inverters for both On Grid and Off Grid. In 1994 Lindsay put his money where his mouth is and decided to build a new home in Victoria, Australia which was totally Off the Grid, he lives with his family in this home still today. Lindsay has been heavily responsible for the success of some of the most well respected battery inverters in the world from Selectronic Australia. Driving market success by ensuring new products are suitable for the purpose as well as innovative has always been a passion, preferring to look at the long-term viability of products and companies vs short term gains. Over the years Lindsay has provided the industry with many technical presentations often delivered in a more entertaining fashion than normally associated with technical presentations.



Steve Helleur

Country: Australia

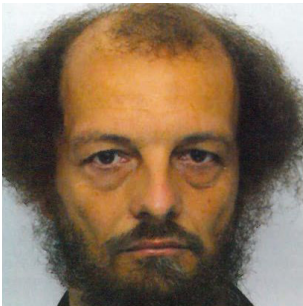
Year joined industry: 1989

Company first worked for: Solarex

Technology area: PV

Still active in the industry: No

Steve Helleur joined the Australian PV industry in 1989 as a member of the sales team at Solarex (one of two Australian PV manufacturers back then), responsible for growing a small national network of independent solar retailers and installers primarily involved in off-grid solar applications. In 1996 Steve moved to Canon to promote and sell their unique triple junction amorphous silicon technology, with stainless steel as the substrate instead of glass, which was installed at Singleton solar farm (200kW) then part of the largest PV system in the country at the time and on various other ground-breaking PV projects. When Canon withdrew from the market in 2001, he moved to RFI, one of the largest solar distributors, where he spent 15 years as a product manager responsible for the introduction of some of the major PV brands which entered the market over that period. Steve retired in 2016 after 27 interesting years in PV and after seeing the Australian market grow from a few hundred people and a couple of MW annually, mainly off-grid, to the enormous success it is today.



Christian Holter

Country: Austria

Year joined industry: 1989

Company first worked for: Oekologisches Projekt Graz, SOLID

Technology area: Solar Thermal

Still active in the industry: Yes

Christian Holter's passion was to bring solar heating and cooling to new options and applications, starting with his own solar heated house with seasonal storage in 1990 through many systems in industry, district heating and solar cooling. As well policy advisory and new business models (first ESCO contract in 1994) went hand in hand with the development. Finally, he is using his experience now to convert cities into solar heated cities with seasonal storage. Speeches and presentations Christian held include MIT, Harvard, Nanyang Technology University Singapore, Imperial College London and many others but as well the World Bank, EBRD and Asian Development Bank.



Jami Hossain

Country: India

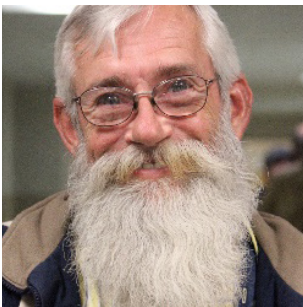
Year joined industry: 1985

Company first worked for: RRB Consultants & Engineers Pvt Ltd.

(Vestas)Technology area: Solar Water Heating

Still active in the industry: Yes

Dr. Jami Hossain, a mechanical engineer and a PhD in wind energy, working at the confluence of industry and research since 1985 - has persistently pursued large-scale integration of renewable energy. Presently, as the Technical Chair and the elected Vice President of WWEA, he has collaborated with prestigious institutions across the world such as MIT and many other institutes to come up with a Vision for 2050 (<https://library.wwindea.org/download/wind-energy-2050-on-the-shape-of-near-100-re-grid/>). Years before Climate Change emerged as a Global concern, Dr. Hossain in collaboration with industry and institutions across the world advocated large scale use and main streaming of renewable energy. He has participated and spoken at international forums of the Union of Concerned Scientists, TERI, IEA, IRENA, European Parliamentary Forum, COP, WWEA, ADB and EWEA. He has worked closely with institutions and bodies such as Rutherford Appleton Laboratory, UK. Within India, his major contributions include Project Engineering of the first windfarm projects in India (also Asia) with Vestas wind turbines and complete installation of nearly 4 MW of installed capacity in 1985-86; application of the learnings as Policy recommendations for wind energy program (presented in the EWEA conference at Leeuwarden in 1987); Implementation of the first production facility for solar selective coatings in India (1985-86); First Grid Integration Study for large scale wind power (1992), published in energy policy. Technology transfer of gearless wind turbines to India with Enercon GmbH (1994), which emerged as flourishing RE business for several decades; First Assessment of potential for Windfarms in India (2011); India Director of EU Sponsored First Offshore Wind Project of India (FOWPI) (2016). Dr. Hossain has authored many publications and has written two path-breaking books – Earth@Risk and Energy and Humanity.



George Kelly

Country: United States

Year joined industry: 1980

Company first worked for: Solarex

Technology area: PV

Still active in the industry: Yes

Mr. George Kelly is an industry-recognized expert on module reliability, certifications and qualification testing, with a leadership role in development of international standards through IEC and ASTM. He serves as secretary of IEC Technical Committee 82 and the US National Committee of IECRE conformity assessment system for renewable energy. He has comprehensive experience in assembly, design and testing of PV modules; and developed innovative products and assembly techniques for diverse applications ranging from spacecraft to automotive to BIPV. As Secretary of TC 82, he is the formal conduit for all communications with the IEC central office in Geneva, Switzerland. TC 82 consists of seven working groups, each targeted on different aspects of PV, as well as six joint working groups collaborating with other IEC technical committees. Mr. Kelly is presently managing the efforts of more than 500 experts with the largest work program of any IEC committee. In addition to this standardization work, Mr. Kelly is working with several other technical committees and the IEC Conformity Assessment Board (CAB) to establish the new system for assessment of renewable energy projects (IECRE). This new system provides assurance to investors and other stakeholders regarding the “bankability” of projects in the solar, wind and marine energy industries. Mr. Kelly serves as Secretary of the US National Committee of IECRE, which is part of the functional implementation of US government policy for international trade, representing US national interests in the RE industry. He is also a founding member of the American Renewable Energy Standards and Certification Association (ARESCA), formed in 2015 to foster renewable energy standards and certification efforts. ARESCA’s goal is to make participants involvement in standards simpler through cost-effective and clear administrative processes, and to facilitate harmonization of US renewable energy standards and conformity assessment schemes with IEC and other international organisations.



Daniel Kithokoi

Country: Kenya **Year joined industry:** c. 1984

Company first worked for: Solar Shamba

Technology area: PV

Still active in the industry:

Daniel Kithokoi started working as a solar technician with Harold Burris in his business Solar Shamba in about 1984. He served as a field installer and sales agent, handling the area between Embu and Meru to the east of Mt. Kenya. He helped Burris manage an assembly workshop and develop a standard design, delivery and installation method for early solar home systems that was widely imitated by other companies. In 1987 Daniel starts American Solar Technology in Meru Kenya after Harold returns to the USA and supplied solar home systems within rural Kenya. In 1992, Mark Hankins formed Energy Alternatives Africa (EAA) with Daniel Kithokoi as a partner. Their work helped the company to become the most important PV actor in the region at the time undertaking a number of demonstration and training activities in Kenya, Tanzania, Somalia and Uganda. Daniel worked with Mark Hankins in helping to establish the KARADEA Solar Training Facility (KSTF) that was run by Oswald Kasaizi.



Klaus Langner

Country: Australia

Year joined industry: 1985

Company first worked for: Latronics

Technology area: PV

Still active in the industry: Yes

1985 is when Klaus Langner first began designing a standalone Square wave Inverter. In 1995 Latronics got their first and only R&D Grant to develop a range of Sine wave Inverters. In 2001 the first Grid Connect Inverter was launched but the breakthrough came in 2008 when Latronics supplied 1000 Grid connect Inverters to a local community association. This put Caloundra on the map as having the highest percentage of Solar in Australia at the time thanks to Government support of \$8000 grants for 1 kw systems. All of this coincided with the GFC, and caused a global shortage of Inverters. Latronics grew by 400% in 16 months, which was a challenge indeed, but what rises quickly often falls just as fast, and so in 2012 the subsidies were removed, with the out of the blue “from midnight tonight”. As the market exploded with growth, so did the investments from “big money”, which brought unbeatable competition from China and Germany. Products came on the market at a third of the price. At this time Latronics was investing profits heavily into R&D and as a result developed a transformer less fully sealed and cloud connected 5kw Grid Connect Inverter. However, the R&D investment had paled in comparison to these new giant competitors and the high cost of manufacturing in Australia made it no longer feasible. Latronics did not have the capacity to re-enter the Grid Connect mass market and focused R&D resources towards a new standalone product, the Inverter-Charger. Although getting to it to a stage where it could have been certified, Latronics decided to scrap the project, as the previous experience and research indicated that the product could not have been made cost-effective enough for the market due to the high manufacturing costs. Whether it was due to quality control, personal principals, or the love for Australia, Klaus never wanted to manufacture anywhere but here. So today, with the small family of employees, most whom have been with Latronics for over a decade, the focus is on what Latronics has done best, and from the beginning, producing custom reliable off-grid inverters.



Stefan Larsson-Mastonstråle

Country: Sweden

Year joined industry: 1986

Company first worked for: Lartec Thermal Solar AB

Technology area: PV/Solar thermal/Biofuels etc

Still active in the industry: Yes

Stefan Larsson-Mastonstråle has been working in the renewable energy sector since 1986. He is an expert at designing, managing, and operating small to large scale solar power plants. Stefan has been at the forefront of creating new technologies and the implementation of a number of those in the renewable energy market. He is an accomplished inventor and many patents have been commercialized through the years such as a few of the first solar collectors that were in operation in +25 years in real calendar time; hot water storage systems in small and large scale; early solar heating and cooling heat pumps; some of the early products in PVT technology for high temperatures; and early system designs of solar fuels systems. Stefan has studied computer science, mechanical engineering, electrotechnology, and project management, and served as researcher and project manager at the Dalarna University, at the School of Industrial management and Engineering, and the European Solar Engineering School, ESES, and the Solar Energy Research Center, SERC. He has served as senior research project manager at the Vattenfall power utility company in renewable energy (including solar PV, PVT and CSP), department of Power and Chemical Processes and Distributed Energy in 1998 – 2010. A part of the work in research management was also done as R&D programme secretary for the Swedish Energy Agency 2001-2004, managing the national development and technology demonstration FUD-programmes including their respective national funding budgets. Stefan is board member of the Lumicum Laboratory and the foundation for research in concentrating solar energy at the Mid Sweden University. Stefan have been member of the International Solar Energy Association, ISES, for many years, and has published a number of peer-reviewed scientific articles in solar energy, is an author and contributor of educational literature, engineering courses and presentations/lectures in renewable energy.



Gaspar Makale (Circa 1960-2007)

Country: Tanzania **Year joined industry:** late 80's

Company first worked for: His own company and also Karadea Solar Training Facility

Technology area: PV **Still active in the industry:** No

Gaspar Makale was one of the pioneers of solar electrification in the African Great Lakes. During the 1990s, he was the Chief Solar Technician at the KARADEA Solar Training Facility (KSTF) in Karagwe district, Kagera region in Northern Tanzania, situated between Lake Victoria and Rwanda. From 1993 to the mid 2000's KSTF gave regular three-week-long training courses which were attended by people from all over the African Great Lakes region (Tanzania, Kenya, Uganda), as well as from further afield. The courses were held in partnership with Energy Alternatives Africa (EAA), run by Mark Hankins and Daniel Kithokoi (and for several years, Frank Jackson) who were based in Nairobi, Kenya. Gaspar managed the practical sessions as well as arranging for the fieldtrips during which course participants installed solar electric domestic systems in the Karagwe district. KSTF also ran a solar apprentice scheme for which Gaspar was responsible. He was also involved in other solar training courses in Tanzania, Course participants, many of whom later went on to set up solar businesses and work in the growing African Great Lakes solar industry, got their first hands-on experience of installing solar electric systems under Gaspar's experienced and expert guidance. He installed an Ampair Hawk 100 wind turbine at KSTF for charging batteries, the first wind turbine installed in that part of Tanzania. He also ran his own solar business. While working with KSTF, Gaspar installed numerous solar systems in local schools, hospitals, clinic refrigeration systems, two-way radio systems, domestic lighting systems. He also installed systems in the refugee camps that sprung up in Karagwe after the Rwanda genocide in 1994. He also ran a solar-powered disco in his own village where he lived with his family on a small farm. Gaspar also worked closely with Harold Burriss of Solar Shamba.



Dr. Mrs. Janak Palta McGilligan

Country: India

Year joined industry: 1985

Company first worked for: Barli Development Institute for Rural Women

Technology area: Solar Thermal

Still active in the industry: Yes

Dr. Mrs. Janak Palta McGilligan is a leading voice for women empowerment and solar cooking through sustainable community development in India. She has devoted over 30 years of her life studying issues related to rural and tribal women, a group that wields the least power in the social order of the country. She has created, sustained, and managed institutions that help these women become agents of social change. Dr. McGilligan is a Padma Shree Awardee and Director of the Jimmy McGilligan Centre for Sustainable Development. She is also Co-founder of Jaivik Setu, the National Coordinator for the Solar Food Processing Network India. The Jimmy McGilligan Centre for Sustainable Development has trained more than 40,000 students in sustainable development. She was the Director of the Barli Development Institute for Rural Women Indore from 1985 to 2011, which trained more than 6000 tribal girls and young women from 500 villages of India in solar cooking, food processing, and installed 500 SK 14 solar cookers in Indian villages. The Institute uses solar cookers for cooking food for its more than 100 residents for 300 days a year. The trainees are also trained in use and maintenance of portable solar cookers so they can continue to use this sustainable method of cooking at home. In her lifetime spent mentoring tribal girls, Dr. McGilligan understood the impact of good training. Dr. McGilligan is a Solar Cookers International (SCI) Global Advisor. She received the SCI Order of Excellence award in 2018 for her dedicated efforts on the 6th SCI World Conference 2017 organizing committee. Hundreds of people from around the world came together to share solar cooking knowledge. Dr. McGilligan joined the SCI United Nations advocacy team to advocate to government leaders at events such as the High Level Political Forum for environmentally friendly, clean, sustainable solutions including solar cooking.



Bob Mulligan

Country: Australia

Year joined industry: 1987

Company first worked for: Cairns Solar Equipment

Technology area: PV

Still active in the industry: Yes

Bob Mulligan started with power generation in the late 80's doing diesel power stations with integrated solar in remote communities, mainly doing design and consulting. In the early nineties he was mainly involved in solar with my marine electrical business, but soon it became evident that solar power was starting to become prevalent in remote cattle properties so started selling and installing solar to remote regions. Around 1993 he became the distributor for Solahart Hot Water Systems for North Queensland which provided opportunities to promote PV into the area. By 1995 the Daintree area was one of the major regions in Australia that became solar dependent, in doing so the Daintree region became a large consumer of panels, batteries etc and provided opportunity for the industry to grow in the region. He then became a BP Solar Distributor which meant that he could sell to dealers within the region and provide support for the products. By having a BP Solar Distributor in the region, he felt it provided a huge boost for the promotion of PV in the NQ region for over a decade in the stand-alone arena. He then started distributing, retailing, and installing BP Solar grid connect systems throughout Queensland through several dealers. It was a sad day when the BP Solar network had to close within Australia. By 2012 he started setting up purchasing agreements with other reputable suppliers up until 2015 when Solahart started providing PV products in addition to solar hot water and continued to do so up until March 2020 when he decided that retirement was now due. He is still active doing consultancy work for installers and designers in the PV and power generation field.



Urs Walter Muntwyler

Country: Switzerland

Year joined industry: 1982

Company first worked for: Hasler AG

Technology area: PV+EV/ Solar thermal/ Wind/ Solar Architecture/ Policy

Still active in the industry: Yes

Urs Walter Muntwyler started in 1982 as PV engineer with the telecomm company Hasler AG. They had the first Pilot- and demonstration program for Wind- and PV- for remote power supplies. First applications were radio transmitter repeater stations with PV and a PV installation for a hospital in Rwanda. In 1985 he worked in a solar thermal company. Due to the solar car race "Tour de Sol"-first in the world-Urs started his own company Ingenieurbüro Muntwyler in Bern which developed solar regulators for PV and planned PV off grid installations around the world. Later he concentrated on the organization of solar car races-Tour de Sol, Alpine Solar Europe championship and Tour de Sol Alpin (winter race). His company organised congresses and exhibitions and moved into consulting. From 1982-1998 they were responsible for the Pilot and demonstration program of the Swiss Federal Office of Energy SFOE for "light weight electric cars". His company has managed over 100 projects, the biggest was the "Big fleet test for EVs in Mendrisio" which started 1995. The Ingenieurbüro Muntwyler is still active in consulting. In 1988 Urs Walter added Muntwyler Energietechnik AG which was focused on projects in PV and solar thermal. The company was official importer from PV companies Solarex (USA), BP Solar and later Sharp, and imported first SI 3000 PV inverters in 1988. In the hot water business, they imported Solahart hot water systems and solar hot air systems from GRAMMER (D). The company was active in the off-grid business, was official importer of Steca (D), AERL (Au) and had their own battery brand. The first "PV on grid systems" were installed in 1988. In 2010 they installed over 200 systems a year and had 35 employees. At the end of 2010, Urs walter got a job as Professor of the PV LAB BUAS so he sold the company. From 2012-2014 he was member of the parliament of the state of Berne



Les Nelson (1955-2020)

Country: United States

Year joined industry:

Company first worked for: Solvis

Technology area: Solar Thermal

Still active in the industry: No

Les Nelson was one of CALSSA's longest-serving board members and solar energy leader. He was the former board president and interim executive director. He was chair of the Solar Heating and Cooling Committee and was always a guiding hand for the staff and the businesses we support. Les was a walking encyclopaedia of knowledge of both policy and market data, and he truly supported the growth of all forms of solar energy – thermal, PV, and batteries alike. He worked tirelessly across several decades to pass the Solar Rights Act as well as the first net metering law, to name just a few of his many signature contributions. Les was our parliamentarian on the board, always keeping us in proper working order. More important than his intellect and commitment to CALSSA and the industry we serve, Les was the commensurate team player, never ruling from ego, always helping in ways many of us could not see, and never expecting anything in return. In this way, Les was not only a leader in the day-to-day governances of this Association, but a true leader of the heart and spirit of CALSSA. Les passed away at the age of 65 and he will be deeply missed.



Susan Neill

Country: Australia

Year joined industry: 1986

Company first worked for: Quirk's Victory Light Co. Pty. Ltd.

Technology area: PV

Still active in the industry: No

In 1986, Ms Neill joined Quirk's Victory Light Co. PL (Quirks) which was founded by her great-grandfather for the development and installation of the 'Victory', an air gas lighting plant which was used for street lighting in Australia. When Ms Neill joined Quirks, it was both a retailer and wholesaler of small wind generators, PV systems and specialist DC equipment. She developed Quirks to include quality DC equipment and the design and installation of stand-alone solar applications equipment. In 2005 Conergy Australia purchased the business and Ms Neill became the Technical Services Manager, Engineer – Business Development. Ms Neill was one of the four founding partners of Global Sustainable Energy Solutions Pty Ltd (GSES). In 2009 she joined GSES full time as a director and managed the Sydney headquarters. The company undertook Training, Engineering & Consultancy in the PV sector. She oversaw the growth of the company from 4 full time employees to over 20. She retired at the end of 2016 but remains a shareholder of GSES. Ms Neill was a keen supporter in the professional growth and development of the industry. In 1991 she joined the NSW committee of the renewed Solar Energy Industries Association of Australia (SEIAA). In 1995 she became the National President, a role she maintained until 1997 when the Association became the Sustainable Energy Industries Association (Australia) (SEIA(A)). She was a founding director of SEIA(A) and was on the executive committee until 2002 when it became the Business Council for Sustainable Energy. From 2005 until her retirement, she was an Advisory Board member for the ARC Centre of Excellence for Solar Energy Systems, Australian National University, Canberra ACT.



Steve Nusco

Country: Australia

Year joined industry: 1981

Company first worked for: Maritime Services Board-Solar Technology Australia P/L

Technology area: PV

Still active in the industry: Yes

Steve Nusco has been involved in the solar industry since the early 80's, designing and installing solar powered navigation aids in Sydney Harbour and throughout NSW. This progressed to Design & Install of grid connected systems, the first he did was a 7kW system in 1996 for Energy Australia in Newcastle NSW.



Bruce Page (1939-2019)

Country: New Zealand

Year joined industry: 1982

Company first worked for: Page Solar Energy Systems

Technology area: PV

Still active in the industry: No

Stanley Bruce Page was born 21st January 1939 in Nelson, New Zealand. The war years were spent in Hokitika, his father was a P.O.W in Germany, on his Dad's return the family moved back to Nelson where Bruce attended Nelson College. Bruce's interest was in Electronics, working in a local TV, radio repair shop before moving to Wellington and training at the New Zealand Post office as a radio technician. He and then wife moved to Auckland and started Page Electronics, a repair business for TV's and radios while also offering TV rentals. After his divorce he married Janet in 1974, adopted her son Phillip and Jennifer was born in 1978. Realizing TV repairs were diminishing, in November 1982 Bruce imported some solar panels, making their way to remote areas around NZ including Great Barrier Island, he then established the company Page Solar Energy Systems. Bruce designed a trailer displaying these panels and water pumps, travelling around NZ to agricultural shows and festivals. During the 1980's Bruce invented Solagen, an energy efficient DC light using fluorescent tubes, proving to be popular in remote homes, caravans, boats and eventually the Pacific Islands. In March 1989 Independent Power was formed with two partners. In 1991 the partnership dissolved and Bruce took over IPNZ with support of his wife Janet. Over the next 30 years IPNZ grew, employed staff, imported efficient domestic refrigeration from Denmark and other products such as wind turbines. Thousands of Solagen lights were made and sold within NZ and exported to many Pacific Islands. Many remote solar systems have been designed and installed by the company's staff and network of valued electricians and partners. In 2006 his daughter Jennifer joined IPNZ and is currently Managing Director. Bruce died on 22nd November 2019 and will be sadly missed by many.



Dr Stephen Pickard

Country: Australia

Year joined industry: 1984

Company first worked for: BP Research Centre (London)

Technology area: PV

Still active in the industry: No

Dr Pickard began researching into PV powered pumping systems at BP's research centre in Sunbury, London. After a couple of years, he transferred to BP Solar International in Aylesbury (UK). In 1988 he was the first technical manager at the Tata-BP JV in Bangalore. In 1990 Dr Pickard moved to Australia. Now retired he still, occasionally, is involved with some informal consulting within the industry. His interest now is more in how to reduce CO2 emissions in agriculture - energy, vehicles, stock and crops.



Richard Potter

Country: Australia

Year joined industry: 1983

Company first worked for: ARCO Solar

Technology area: PV

Still active in the industry: No

Rick first developed an interest in solar energy during the oil crisis of the early 1970s and by 1975 was at Melbourne University studying science with an eye on the future. He went on to a Masters and PhD at Colorado State University in solid state Physics focussing on semiconductor materials for PV solar cells and after graduating in 1983 joined ARCO Solar in Los Angeles. Rick worked in Research and Development leading a group developing CuInSe₂ based cells with world leading efficiency. Rick returned to Australia in 1987. Work colleagues remarked that Rick was a rare mix of scientist and practical hands-on. He joined Elante P/L, a shareholder in Solar Cells Australia, a “ModCo” based in Perth. Through the late 80s and 90s he and Graham Leggo (one of Elante’s owners) designed and installed small solar and wind power systems around Victoria. In 1994 Rick Elante merged with Solar Charge in Brighton, working with John Paton who had started the business in the early 1970s. Rick offered some input to Ray Prowse as he developed the first SEIAA Accreditation course and along with around a dozen others, attended the first course at Bega in 1993, which has evolved into the CEC Installer Accreditation. In 1992 Rick had joined the National Executive of the Solar Energy Industry Association of Australia and then the EL42 Standard Committee in 1996 as they worked to develop the first Australian Standards for renewable energy generation. Rick went on to design and install one of the very early privately owned grid-connected residential PV systems in Victoria in 1998. It took many months to get the electricity company United Energy to agree that it was not going to affect their grid quality. In 2001 Rick purchased the Solar Charge business from John Paton and built the business as interest in solar power for domestic homes in Melbourne grew. During this period Rick applied his knowledge to the design and construction of a solar efficient home for his family that won the 2008 National HIA Greensmart award. The house was a regular feature of the Sustainable House Day event for 8 years. In 2016 Solar Charge was sold and Rick briefly contracted to GSES delivering SHW and PV courses in Africa and the Pacific.



Ray Prowse

Country: Australia

Year joined industry: 1983

Company first worked for: Industry Association

Technology area: PV

Still active in the industry: No

Ray Prowse started working in 1983 in his own building business concentrating on energy efficient building design and solar water heating systems. His high point was the installation of an active solar central heating system on his own house in Gippsland, Victoria, Australia, centrally heating a 210 sq m house for the price of running two 30 W circulating pumps. After working with Energy Victoria from 1989 as an education officer and energy advisor he started with the Solar Energy Industries Association of Australia (SEIAA) in the early 1990s as executive officer responsible for the development of standards, training and accreditation. Once courses were set up he travelled Australia presenting training courses to industry participants. He also managed the national office of SEIAA, represented the industry in various government fora and represented the industry on Standards Australia committees. The accreditation scheme formed the basis of industry accreditation now managed by the Clean Energy Council. Ray also spent several years managing and presenting the Certificate IV in Renewable Energy Technology at Chisholm TAFE in Frankston. Ray moved to Canberra in 2000 to follow SEIAA’s national office. SEIAA merged to form the Business Council for Sustainable Energy, which went on to form the basis of the Clean Energy Council. Ray left SEIAA / BCSE when the office moved back to Melbourne and he took a position as Centre Manager at the Centre for Sustainable Energy Systems at the Australian National University. After 6 years at the ANU he took a position with the Department of Climate Change and Energy Efficiency. Various roles ensued, culminating in a position with the National Solar Schools Program, which administered grants for government and non-government schools to install photovoltaic systems and other energy efficiency measures within schools. Ray retired from the public service in early 2016, moved back to Victoria and nowadays uses his woodworking skills to make products to sell at local markets and on-line.



Markus Real

Country: Switzerland

Year joined industry: 1982

Company first worked for: Alpha Real

Technology area: PV

Still active in the industry: Yes

After 6 years of solar thermal research at Federal Reactor Research Institute Markus Real left and formed Alpha Real in 1982. The company focussed on solar and wind projects however in 1985 Real worked with Mercedes Benz to build a solar powered cart which won the first Tour de Sol. In the summer of 1986 Real launched Project Megawatt – to find 333 power plant owners (3kW each). The project was a success and within a year, the 333 solar systems with an output of one MW were connected to the grid. For the first time worldwide, the large-scale implementation of building-integrated solar systems was demonstrated. The smart grid, the concept of decentralized consumers and producers, was born and the controversy about reimbursement of the energy that was fed back into the grid broke out. This led to the development of a net metering meter. Alpha Real developed the solar roof tile to facilitate the integration of solar into roofs. In 1995 Real decided to withdraw from the development of photovoltaics. In 1997, Real, together with Peter Varadi founded the NGO Photovoltaic Global Approval Program (PVGAP) based in Geneva in order to obtain an internationally recognized seal of approval (PVGAP) for photovoltaics. In 1998, Real installed the first heat pump for hot water generation in the Brazilian state of Bahia, which, thanks to ambient temperatures of around 30 °C, achieves a coefficient of performance of 10 and performs better in terms of energy than solar collector systems with electrical backup in tropical climates. In 2002 he founded Bagasse Biorefining AG with Andre Reynier and Stefan Grass to produce high-quality industrial fibres from sugar cane waste. In 2009 Real also started a joint venture with Pierre Landolt for the realization of solar power plants in Brazil.



Tjerk Reijenga

Country: Netherlands

Year joined industry: 1980

Company first worked for: W/E Adviseurs Gouda (Nederland) / CJ de Bruin Architect

Technology area: Solar Architecture/Buildings

Still active in the industry: Yes

Tjerk Reijenga finished his masters at Delft University of Technology in 1980 with a design for an integrated sustainable solar city. He received an award for his work from the Delft University of Technology. This award was given for the 'Innovative design and thinking' about future Sustainable Cities. During his study he founded a company with others for the consultancy and design of more energy efficient housing. This company 'W/E adviseurs' still exist. From 1980 his focus was to make Solar buildings. One of the first opportunities was in 1983 in Schiedam Woudhoek. A project of over 650 row houses and apartments was designed following the rules for Passive Solar Design. The vice-mayor of Schiedam (ir. Chris Zijdeveld, President of the International Solar Cities initiative) supported the principles and made it possible in his city. Tjerk's holistic approach can be found in early projects like 'Bio-climatic houses in Goirle', 1984 and 'Flatrenovatie met klimaatgevels in Tilburg' 1985. Both are thermal solar projects within the EU Thermie program. He started his own architectural office 'BEAR Architecten' in 1985. The first project was 20 Passive solar Eco-houses in Gouda followed by solar projects like "The Small Earth" in Boxtel (Thermie), "The Green Roof" in Utrecht, "Green house dwellings" in Spijkenisse (Thermie), renovation of labs for ECN in Petten (Thermie) and renovation of thermal solar dwellings "Zonnewende" in Leiden into the first BIPV project in NL. During the period 1990 to 1995 Tjerk Reijenga and his company BEAR Architecten became one of the leading Sustainable Design Companies in the Netherlands. The transparent roof integration in "The Small Earth" in Boxtel became one of the first in the world. He was a member of the IEA PVPS Task 7 on 'Building Integration of Photo-Voltaics'. He also contributed to over 12 books on solar.



Claude Remy

Country: France

Year joined industry: 1981

Company first worked for: Photowatt

Technology area: PV

Still active in the industry: No

In 1981 while working with Conference Des Granded Ecoles (CGE) Subsidiary Alsthorm Claude Remy was asked to become the chief executive of Photowatt. This solar company was a subsidiary of CGE's SAFT battery company. Photowatt was the largest European PV manufacturer during the early to mid 80's. In 1987 Chronar France obtained a majority shareholder and Remy returned to work for CGE. However, Remy with a few others formed Solar France and in 1988 bought back Chronar's shareholding and he returned as chief executive of Photowatt . However, to survive in these early years, Photowatt still required support to continue operating and that came from the European Commission and also investment from Shell. After Shell withdrew its support in 1998 Photowatt was acquired by the Canadian ATS group. Remy retired in 1999 however he established a research facility that investigated silicon ribbon processes . Remy was the recipient of the first EPIA's Bonda Prize in 2000.



Alfred T. Ritter

Country: Germany

Year joined industry: 1980's

Company first worked for: Alfred Ritter GmbH & Co. KG

Technology area: Solar Thermal

Still active in the industry: Yes

As the owner of the world-famous chocolate factory, Alfred Ritter was affected by the Chernobyl catastrophe in 1986, as he was no longer able to obtain non-irradiated hazelnuts for his premium chocolate. Not able to buy an ecological heating system on the market, he decided to do what was necessary. Together with Klaus Taafel, the owner of the "Paradigma engineering office", he founded the company "Paradigma - Ritter Energie- und Umwelttechnik" in 1988. They initially composed high-quality, market-available components such as solar collectors, wood pellet and gas condensing boilers into intelligent and sensible systems and established a distribution system with very well-trained partner installers. With its own highly innovative development department, control concepts were developed and later a production facility for highly efficient CPC vacuum tube collectors was built in Dettenhausen. Today, these solar collectors form the core of Paradigma Systems' heating systems in detached, semi-detached and multi-family houses, covering up to more than 50% of the heat demand. In addition, a department for large-scale solar plants Ritter XL was established, which builds large-scale turnkey solar plants since 2006 and is able to provide high temperature levels even without the support of conventional heat generators. Alfred Ritter's goal has always been to strive for the best ecological solution with the highest possible proportion of renewable heat. The combination of highly efficient solar thermal energy and wood pellet boilers is an expression of his vision. After more than 30 years of successful work in the heating sector, he is still active as member of the board of directors. Alfred Ritter and his former CEO Klaus Taafel, who unfortunately passed away in 2018, were a dream team that very early on pursued the goal of completely regenerative heating and with their spirit never lost sight of it, even in the most difficult times.



Frank Rosenkranz

Country: Austria

Year joined industry: 1982

Company first worked for: Former AMP Austria (now TE Connectivity)

Technology area: PV

Still active in the industry: Yes

Frank was involved in several patents and researches at both companies. The invention is for a connector system used mainly in the solar industry (DC current) for a quick reliable easy installation. The installation is at the site with environmental difficulties (on roof, wind, cold, ...) and without any special tooling and/or preparation. The application is as follows: Simply cut the solar wire (no matter if size 2,5 or 4 or 6mm² [AWG 14-10] as all three wire sizes will work in this one/same connector). Measure the cable insertion length on the indication mark of the outside of the connector with the depth indicator. Mark the insertion length with your thumb and insert the blank cut cable into the housing with the full pre-defined, measured length. Once fully inserted just use simple (parallel head) pliers and close top- and lower-part to each other. Once both half's are correct terminated/closed the shiny indicator show correct closing (you can measure as well with a simple cheap special gauge). The connector is equipped with a known reliable industry standard IDC technique and is filled with a special developed Gel that grant IP68 (1m/24 hrs) tightness. The Gel itself is used since decades in the Power connecting industry for water tightness.



Rabindra Satpathy

Country: India

Year joined industry: 1983

Company first worked for: Orissa Renewable Energy Development Agency , Bhubaneswar, Odisha, India

Technology area: PV

Still active in the industry: Yes

Rabindra Satpathy started with 1.1 MWp Wind Power project in 1984 along with 25 KWp PV - Diesel Hybrid System in Odisha, India. This was followed by several Solar PV power projects all over India with 110 KWp first grid connect solar plant near Pune, India. This was followed by India's first 5 MWp solar plant in Rajasthan and 1 MWp rooftop solar plant in 2010 at Delhi. He has been involved with village electrification project in Kuming and Urmuxi province, China (2004-06); BIPV project in Hong Kong Science Park, in Malaysia; First 460 KWp rooftop solar plant in Bangkok – 2004; and several other solar projects in Cambodia, Vietnam, Indonesia and Malaysia between 2002-2007. He was Involved in solar cell and PV module manufacturing at Tata BP Solar and Reliance Solar Group in India; several village solar electrification projects in India and Asia Pacific region; large MWP IPP Solar PV power plant for private Indian companies; and, development and field testing of several solar PV products and systems including development of solar PV modules and systems. He has also undertaken several oil and gas project solar power energisation through few Australian companies. Rabindra has worked for solar companies like Tata BP Solar India, Siemens Solar, Shell Solar, Solar World, RIL Solar Group, Trina Solar, Emami Power and Jakson Solar Business and has been leading solar companies since 2007. He has published +30 Solar related papers in conference, Journals, books and is Currently writing a book - Solar PV Power - Sand to Systems. Rabindra is currently on the Board of Director of International Solar Energy Society.



Herman Scheer (Deceased)

Country: Germany

Year started promoting RE: 1980's

Company first worked for: German Politician

Technology area: Policy

Still active in the industry: No

Herman Scheer was a Social Democrat member of the German Bundestag (parliament) from 1981 to 2009. In the mid 80's he became a supporter/promoter of renewable energy which he dedicated his life to. Scheer believed that the continuation of current patterns of energy supply and use would be environmentally, socially economically, and politically damaging, with renewable energy being the only realistic alternative. Scheer had concluded that it is technically and environmentally feasible to harness enough solar radiation to achieve a total replacement of the fossil/nuclear energy system by a global renewable energy economy. In 1988 he created the Association Eurosolar and was first president. Scheer presented the idea of an IRENA for the first time in 1990. He intervened successfully at the UN in New York and its General Assembly voted indeed in December 1990 for the creation of IRENA which came into existence in 2009. In 2001 Scheer created the World Council for Renewable Energy and was the General Chairman. Scheer was instrumental in having the Bundestag adopt the 'FIT' that became legally binding for Wind Energy in 1990 and for PV and other Renewable Electricity in several steps in 2001. Scheer created the intellectual ground for the Solar Revolution: before his passing in 2010 almost every second day he was lecturing somewhere in the World based on a sheer endless list of publications. He published a dozen books most of which are translated into English and other languages. He received many accolades and awards including: Time Magazine named him a 'Hero of the Green Century'. The Swedish Parliament awarded him the 'Alternative Nobel Prize'. He also received as a first winner the 'World Photovoltaic Prize' by the World PV Community. In 2009 he was awarded the Karl Böer Solar Energy Medal of Merit.



Wolfgang Scheffler

Country: Germany

Year joined industry: 1982

Company first worked for: Self employed

Technology area: Solar Thermal

Still active in the industry: Yes

Wolfgang Scheffler has invented and promoted flexible fix focus reflectors since 1982. From the 90s the design was named "Scheffler Reflectors". He developed a unique concept that allows the focal point of the concentrating reflector to maintain its position at all times. This is achieved through a combination of the flexible paraboloid changing its shape in the course of the seasons and a daily tracking around earth axis parallel. Tracking can be achieved manually, semi- or fully automated. Scheffler worked with people, organizations and companies in many countries of the Global South in order to give free access to energy by sharing his knowledge. Scheffler Reflectors are used in wide range of applications ranging from small school kitchens to a solar power plant (IndiaOne). The range of application is from direct cooking with a pot in the focal point, to steam generation at large scale and high pressure. The most wide spread use is institutional canteens, second is process steam for industries. Thousands of reflectors are in use worldwide with sizes ranging from 2m² to 60m², most of them coupled in arrays for steam generation.



Cesare Silvi ISES President 1999-2001

Country: Italy

Year joined industry: 198

Company first worked for: Directorate, Nuclear Safety and Radioactive Protection

Technology area: Nuclear, solar - technologies, safety, policies and history

Still active in the industry: Yes

Cesare Silvi holds degrees in mechanical engineering and nuclear engineering, commencing work as an engineer in the early 1970s. In 1973, he top-scored an entrance test for the Directorate, Nuclear Safety and Radioactive Protection; in 1975, the directorate tasked him to examine and analyse threats to nuclear power plants from the outside environment. In 1981, Silvi shifted to nuclear disarmament with the Agency for Promotion of European Research; in 1991-2, he was part of a NATO delegation sent to Moscow to inventory atomic supplies throughout Russia. 1981 - 1996 Cesare worked in the International Affairs Department of ENEA (New Technologies, Energy and the Environment), dealing with bilateral collaborations with developing countries, Eastern Europe and the former USSR. 1996 - 1998 he was Director of Italian Agency for the Promotion of European Research. ISES Vice President 1977-1999 and President 1999-2001, Cesare promoted increasing attention in the history, art and culture of solar energy and supported the ISES 2000 Initiatives. He was made a Fellow of ISES in 2019. Cesare published many technical reports and articles on the safety of large high-risk industrial and energy plants, international collaborations in scientific and technological fields, nuclear disarmament, energy policies, renewable technologies, environmental protection. He coordinated the organization of solar art exhibitions held in Rome at the Mercati di Traiano in 1992 (Secrets of the Sun) and in 2000 (New Light on Rome). In 1994, he founded the ISES ITALIA newsletter *IISolea369gradi*. In 1999, Cesare co-founded the Group for the History of Solar Energy, whose goal is to understand how man has used solar energy for millennia to instruct its use in the future. Cesare now has many publications on the history of solar, including *History and Future of Renewable Solar Energy* (2008) and *The Use of Solar Energy in Human Activities Throughout the Centuries* (2010).



David Skelton

Country: Australia

Year joined industry: 1986

Company first worked for: BP Solar

Technology area: PV

Still active in the industry: Yes

David Skelton completed his degree in Electrical Engineering at NSWIT in 1984 following a 6 year cadetship with Wormald International then Started with BP Solar in 1986 as a Sales Engineer at the Brookvale factory working under Tim Ind. He developed two new products for BP Solar - the teak framed MSR (Marine self Regulating) marine solar modules and the floating solar pump. In 1988 David was seconded to BP South Africa in Johannesburg for 6 months to assist with startup of a BP Solar presence there. On return from S.A. he travelled with BP Solar to assist with operations in Sri-Lanka, Vietnam, Indonesia, PNG, Fiji and New Zealand. He also worked as the project engineer on telemetry and navigational aid power supply systems for offshore oilfield/ and gas pipeline projects such as Roller/Skate, Santos and Mount Newman Mining. Around 1992 David was seconded for 6 months to Rockhampton to assist establishing a solar presence in BP Solar's newly acquired business in Rockhampton, Aqua Industrial. On return from Rockhampton he relocated to Coffs Harbour to assist with the establishment of a retail outlet, BP Solar Coffs Harbour where he worked as sales engineer under the manager, Barry Greenwood. In 1998 David became manager of BP Solar Coffs Harbour where they sold, apart from solar power systems (off-grid only at that time) solar hot water, pumping and irrigation equipment, wood heaters, electric fencing etc. In 2000 BP Solar decided to sell its retail outlets in Coffs, Dubbo, Rockhampton and Darwin. Coffs Harbour was sold to Ashley Graetz - who had previously worked for many years at the Darwin branch. When the Coffs Harbour business was sold he decided to go out on his own doing PV solar systems only so David started his own business, North Coast Power Systems. He did, and continues to today, still work closely with North Coast Power and Water. For the last 5 years David has specialised in Off-Grid systems only.



Ted (Edward) Spooner

Country: Australia

Year joined industry: 1987

Company first worked for: University of NSW

Technology area: PV

Still active in the industry: Yes

In approximately 1987 Ted Spooner through UNSW worked with NSW Dept of Energy, testing small stand-alone systems. Then in 1988 developed a stand-alone sine wave with Geebung company. The first licensed grid connected PV system was next, at Little Bay in Sydney which was used as a test lab for inverters including for the Olympic village. Ted retired in 2009 but keeps his linkage with the University of NSW where he is a Visiting Fellow in the School of Electrical Engineering. He is very actively involved in standards development in Australia where he has been a member of the Australian committee for renewable energy systems since 1998. He chaired this committee for 10 years from 2004 to 2014 which saw the development of standards for grid connection, stand-alone systems and PV arrays. From 2000 Ted has represented Australia on the International Electrotechnical Commission committee TC82 - Photovoltaics. He was International Chairman of TC82 for 2003-2004 and has been a member of working group WG3 – Systems, WG6 – BOS components and the JWG on developing country systems since joining in 2000 and is the current co-convenor of WG3 since 2007. Ted was project leader for a renewable energy test lab funded by an ARC grant - ACRELAB which was established at Murdoch University in Perth. It was an internationally recognized laboratory participating in many aspects of renewable energy system design, system standards and systems testing. Australian and international standards development, due to the rapid innovation and expansion of the industry and the need to keep systems safe continues to be a challenging area and Ted continues to be heavily involved. Ted has been honoured by a number of awards for his work in the industry over the years culminating in an AM for significant service to the renewable energy sector in 2019.



Wilhelm Stahl

Country: Germany

Year joined industry: 1980

Company first worked for: Fraunhofer Institute for Solar Energy Systems

Technology area: Solar Architecture/ Buildings

Still active in the industry: No

He started research in 1980 at the Fraunhofer-Institute for Solar Energy Systems in Freiburg. Main Research objectives were Transparent Insulation Systems and Thermal Conversion of solar radiation with fluorescent collectors. He was project manager of the Self-sufficient Solar House in Freiburg - the worldwide first house with a transparent insulated South facade and a complete Solar Hydrogen system with electrolyser, fuel cell and seasonal hydrogen and oxygen storage. The Self-sufficient Solar House had no connection to the public grid. After FhG ISE in 1990 he founded the Energy consultancy Office Stahl+Weiß in Freiburg. Important first solar projects were the Heliotrop architect Rolf Disch and the totally renewable energy supplied Solarfabrik architects hotz+architekten. During 30 years Stahl+Weiß accompanied around 1500 buildings in energy conservation and solar energy use.



Geoff Stapleton

Country: Australia

Year joined industry: 1987

Company first worked for: BP Solar Australia

Technology area: PV

Still active in the industry: Yes

Geoff Stapleton specialised in solar (PV) energy in the final year of his electrical engineering degree in 1981. His thesis was on solar water pumping systems. In 1985 while working for Australian Dept of Aviation he was involved in the design of the first solar powered obstruction light located at a rural airport. He started work full time in the solar industry in late 1987 when he joined BP Solar Australia. In 1989 he started his own company on the south coast of NSW where he designed, installed and maintained off grid power systems. 1995-2000 he worked as a consultant with an electricity utility involved with designing and installing off-grid and grid connected systems. In 1998 he was one of the co-founders of Global Sustainable Energy Solutions Pty Ltd (GSES). GSES is a multi-disciplinary organisation specialising in professional engineering and training services across the Renewable Energies sector. Geoff has undertaken projects in Australia, Africa, Asia and the Pacific islands. He was a part-time senior lecturer at the UNSW School of PV and RE Engineering from 2003 to 2015. He played an active role in the various Australian industry associations from 1991. From 1992 to 2002 he was chair of the NSW chapter of Solar Energy Industry Association of Australia (SEIAA) which later evolved to Sustainable Energy Industries Association (Australia). He was a member, and later Chair, of the Renewable and Sustainable Technical Advisory committee for 10 years, that oversaw the ongoing management of renewable energy training units in Australia. He was member of IEA PVPS Task 9 Deployment of PV in Developing Countries. In 2020 Geoff is still: Member of Standards Australia EL42 Working Groups and IEC TC82 JWG1; Board Member and Treasurer of International Solar Energy Society (ISES); and Secretary of the Sustainable Energy Industry Association of Pacific Islands (SEIAPI).



Jeff Stevens (Deceased)

Country: Zimbabwe

Year joined industry: 1980

Company first worked for: London Area Flight Information Centre

Technology area: PV

Still active in the industry: No

Jeff Stevens wanted to bring the ISES Solar World Congress to Zimbabwe since 1983; in 1987 he proposed it to the Board of Directors in Hamburg, and it was accepted at the 1989 Kobe Solar World Congress. As a result, he worked almost full-time on organising the conference, with reports presented at the 1991 Denver and the 1993 Budapest Solar World Congresses. Jeff was not originally trained in solar, rather he was a meteorologist, for many years providing meteorological information to aircraft, including in World War II. After finishing his British Military Service in 1947, followed by a tour of duty in India and Pakistan, Jeff served for three years as the Senior Meteorological Officer at the London Area Flight Information Centre. As serious air travel started in Africa (1951), Jeff was put in charge of the Meteorological stations in Northern Rhodesia (Zambia). He stayed on, becoming the Director of Meteorology in Zimbabwe. It was after he retired in 1980, Jeff 'found' solar. He co-founded the Solar Energy Society of Zimbabwe (SESOZ) and served as Treasurer, Chairman and Honorary Secretary. In bringing ISES to Africa, Jeff made a big impact: President Mugabe not only opened the Congress with a major speech, he also visited the ISES exhibition, bringing with him other Heads of State who were officially visiting Zimbabwe at the time. The 1995 World Congress in Zimbabwe helped raise the profile of all renewable energy technologies in Africa, including solar home systems for off-grid homes. It also kindled an interest in the ISES Board to reach out to Africa in terms of knowledge transfer. Cruelly, Jeff died less than a month after the Congress whilst fighting a brush fire in his garden. However, his foresight in bringing ISES to Africa and opening up the opportunities for solar live on.



Tony Stocken

Country: Australia

Year joined industry: 1986

Company first worked for: BP Solar

Technology area: PV

Still active in the industry: Yes

Joining as a young engineer in the '80's in the UK and progressing over 30 years to leadership positions in Australasia, China, Middle East and SE Asia, Tony Stocken has been a true veteran of the Industry. His legacy to the Industry has been the pioneering of 'first-of-the kind' solar PV projects and products. Most notable was his leadership of BP Solar's submission and subsequent award of Federal Government's Flagship project which kickstarted the subsequent massive investment in Utility-scale solar on the Australian grid. Other projects of note were some of the first building-integrated PV projects in the Middle East, Australia, China and South Korea back in the early 2000's; these proved the technology and now, 15 years on, are mainstream in many countries as the technology has become economic.



Richard Swanson

Country: United States **Year joined industry:** 1985

Company first worked for: Sunpower

Technology area: PV

Still active in the industry:

In 1985 Richard Swanson founded Sunpower based on the cell technology research he had been researching at Stanford University since 1974. He continued as a professor Stanford University until 1991 when he then took on the fulltime role as President of Sunpower. SunPower solar cells powered Honda to victory in the 1993 World Solar Challenge, and powered NASA's high altitude solar powered airplane, Helios, to 96,500 feet, a record altitude for any non-rocket aircraft. Sunpower received the NASA Public Service Award for its contribution to the Helios program. These record-setting cells received the IR100 award in 1995. Sunpower initially focused on cell production particularly cells for concentrator market however later moved into the market of solar modules with a manufacturing plant established in the Philippines. Prof. Swanson retired from SunPower in 2012. Prof. Swanson has received widespread recognition for his work. In 2002, he was awarded the William R. Cherry award by the IEEE for outstanding contributions to the photovoltaic field, in 2006 he was awarded the Becquerel Award from European Commission and in 2011 the Karl Boer Solar Energy Medal of Merit.



Klaus Taafel

Country: Germany

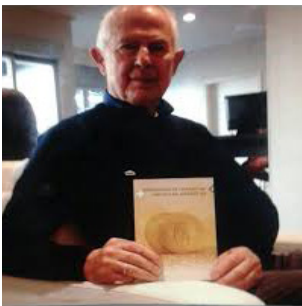
Year joined industry: 1980's

Company first worked for: Paradigma engineering office - as owner

Technology area: Solar Thermal

Still active in the industry: No

Klaus Taafel had a vision. Instead of earning his money simply and successfully in the automotive industry like others, he decided early on to dedicate his life to renewable heat production with solar collectors and biomass. He founded the engineering office "Paradigma" in order to implement his renewable heating system concepts in an exemplary manner and thus bring about a change in the heat supply towards environmentally friendly technology. He met like-minded Alfred Ritter and together they founded the company Ritter Energie- und Umwelttechnik in 1988. Driven by a common spirit, which they also transferred to the rapidly growing number of employees, highly innovative new system concepts and products such as the CPC vacuum tube collector with plasma coating were created under Taafel's leadership. His infallible instinct is also the reason why solar systems do not necessarily have to be operated with an antifreeze mixture, but with simple heating water. For him there were no prohibitions to think, only tasks that were waiting to be done. In 2001, a joint venture with China was founded. This put him ahead of his time in the solar industry and in systems technology. His legacy and spirit have been preserved in the Ritter Company and still ensures that it is the technological leader in heating systems and large-scale solar installations. Klaus Taafel was and will always be the intellectual and technical father of Paradigma. Together with his friend and companion Alfred Ritter he is a legend of solar history. Both therefore definitely belong as pioneers in the history book of solar energy.



Bruno Topel

Country: Brazil

Year joined industry: 1981

Company first worked for: Heliodinamica

Technology area: PV

Still active in the industry: No

Bruno Topel started Heliodinamica in 1981 after being introduced to PV at an energy exhibition in Australia. Heliodinamica was the first solar power company in South America. In 1983 the company started manufacturing solar modules and then 2 years later started manufacturing solar cells. In the 1990's Bruno closed the manufacturing plant down and continued as an energy consultant in Brazil. He advised Technometal about starting a PV manufacturing plant and in 2011 Technometal built a 20MW manufacturing plant. He was the recipient of the August Mouchot award at the 1994 Eurosolar.



Mark Twidell

Country: Australia

Year joined industry: 1986

Company first worked for: BP Solar

Technology area: PV

Still active in the industry: Yes

Mark Twidell first came to Australia in 1986 as an engineering intern with BP Solar and has been privileged to have worked with many talented, committed and wonderfully people that have been involved in growth of the PV industry from kW to GW scale. This involved the early remote area power systems, at the time the words largest village electrification programs in Sri Lanka, first Solar suburb for the Sydney Olympics, first MW scale system in China, working with Industry and Government on early programs that helped build scale, lower costs .Mark has worked in Australia, India, USA and Europe in Solar related industry and government leadership roles. Past roles have been Managing Director of SMA, CEO of the Australian Solar Institute and a variety of leadership roles during 20 years with BP Solar. He has served on the Boards of the Australian Renewable Energy Agency (ARENA) the Clean Energy Council (CEC) and various private sector companies throughout Asia Pacific through his roles with SMA and BP. Since May 2016 Mark has been leading Tesla's growth into the Asia Pacific energy markets with the mission is to accelerate the transition to sustainable energy through storage deployment. This has included installing the world's largest battery in South Australia, Virtual Power Plants that deliver lower cost electricity to consumers and micro-grids from remote and island communities across the region. Mark has an Electrical and Electronic Engineering degree from the University of Edinburgh and an MBA from Sydney University. Mark is the son of a pioneering renewable energy academic and proud father of a budding solar installer!



Sudhanshu Varma

Country: Canada

Year joined industry: 1983

Company first worked for: Central Electronics Limited in India

Technology area: PV

Still active in the industry: Yes

Dr. Sudhanshu Varma was initially involved in solar cell research for eight years in India before joining Central Electronics Limited in 1983. He was responsible for commercial production of solar modules. He moved to Canada in 1984 and worked at TPK Solar Systems Ltd. from 1984 till 1988. He played a lead role in the development of solar cell and module manufacturing technologies, development of solar cell and module production and testing equipment, supply of solar cell and module production equipment and complete lines on turnkey basis to customers in India, China, Rumania, The Netherlands, Sri Lanka and Zimbabwe. Although China is now global leader in solar cell and module manufacturing, the first silicon wafer, solar cell and module manufacturing plant in China was set up on turnkey basis by TPK in Kunming in 1986. Dr. Varma led the module production line installation and technology transfer teams to customers' sites in Zimbabwe and Sri Lanka. Dr. Varma started his own company, Supan Technologies Inc in Ottawa, Canada to focus on solar business. Supan offers solar business consulting services including advise on solar manufacturing equipment and technology. Supan offered Dr. Varma's services to NewSun Technology Ltd in Ottawa in 2000, where he acted as Director of Technology till 2002 to supply turnkey solar cell production lines to customers in Norway and Taiwan. Supan Group has now grown to about a dozen companies and Dr. Varma is CEO of these companies. He is involved in solar power project development in Canada and other countries, solar system design, solar power project implementation on EPC basis, and co-owning and operating a few rooftop solar projects. Supan has formed a joint Canadian company with Switzerland based The Meeco Group, which is named Oursun Canada Inc. and Dr. Varma is CEO of this company as well.



Roberto Vigotti

Country: Italy

Year joined industry: 1982

Company first worked for: ENEL

Technology area: PV

Still active in the industry: Yes

Roberto Vigotti graduated from University of Pisa in Electrical Engineering – 1971. In 1974 he joined ENEL, research and development division. In 1982 he coordinated research and demonstration programs in new renewable energy, Wind, PV and CSP. Initial work was in the areas of off grid systems particularly for the islands. In 1998 at Cesi laboratory, he was in charge of strategic marketing, then joined Enel Green Power Unit seeking out business opportunities for renewable energy. From 2002 to 2005 he was senior advisor in Enel International Department. He occupied various positions from 2006-2009 at Enel Corporate. After leaving ENEL in 2009 he went onto other transnational activities with the IEA such as Observatoire Mediterranee de L'Energie and being Secretary General for initiative for renewable energy in the Mediterranean (res4MED). He is currently Secretary General of RES4Africa Foundation. He has been active in many organisations including encouraging the IEA to have an Implementing Agreement of Photovoltaic Power Systems which he chaired from 1992-1997. He was Chairman of Renewables and Distributed Generation Working Group of Eurelectric from 1998 to 2004. He is member of various international organizations, has been Vice President of the Italian Section of ISES, and a Board Member of ISES. He published many papers and editor of various Italian Magazines in Renewable Energy.



Muriel Watt

Country: Australia

Year joined industry: 1980

Company first worked for: South Australian Department of Mines and Energy

Technology area: Policy

Still active in the industry: Yes

Muriel Watt completed her PhD on Energy Analysis at Murdoch University, Western Australia, and started work in 1980 at the Energy Division of the South Australia Department of Mines and Energy where she worked on a range of renewable energy projects and energy policies. She then worked at the New South Wales Energy Authority where some of the first renewable energy-based remote area power systems (RAPS) were tested and the first government RAPS support program was established. She joined the University of NSW in 1992, where she worked for 25 years on a range of photovoltaics (PV) and other renewable energy policy projects. She co-authored a textbook on Applied Photovoltaics with Martin Green and Stuart Wenham, which is now available around the world and has been translated into 4 other languages. She was involved in the establishment of the world's first Photovoltaics and then Renewable Energy engineering degree programs. She established courses on Energy Policy and Life Cycle Analysis of Energy Systems and assisted with courses on Renewable Energy for Developing Countries and PV in Buildings. She also supervised many honours and PhD students. Muriel began collating the annual PV in Australia report in 1995 and prepared the report for the IEA PV Power Systems (PVPS) program for 20 years. She was the Australian representative on the PVPS for 10 years and also established the Australian PV Association, now the Australian PV Institute (APVI). The APVI links university researchers with industry and government, facilitates Australian participation in PVPS programs, shares key PV information and statistics and promotes discussion of policy development. Muriel is now a Principal Consultant at ITP Renewables and works on renewable energy implementation and policy development projects in Australia and the Pacific region.



Stuart Wenham (1957-2017)

Country: Australia

Year joined industry: 1981

Company first worked for: Tideland Energy

Technology area: PV

Still active in the industry: No

Stuart Wenham worked with Dr Bruce Godfrey in the early 1980s to set up Australia's first solar cell manufacturing lines for Tideland Energy in Brookvale on Sydney's northern beaches. The following decade, Stuart worked closely with BP Solar (after they bought Tideland Energy) to commercialise the Buried Contact Solar Cell, which he invented during his PhD under Prof. Martin Green at UNSW. The buried contact solar cell was awarded the CSIRO Medal for research of commercial significance in 1992 and judged one of the "Top 100 Australian inventions of the 20th century" by the Academy of Technology and Engineering in 2001. Known as BP's 'Saturn' technology, it was sold all over the world, including to one of the world's first MW scale power plants in Toledo, Spain. Stuart invented or co-invented eight classes of solar cell technologies that have been licensed to manufacturers around the world, now valued at hundreds of millions of dollars annually. In the 1990s Zhengrong Shi founded Suntech Power, with Stuart as Chief Technology Officer. Suntech then grew to be the largest PV cell manufacturer in the world. In more than a decade in this role, Stuart managed hundreds of scientists and engineers on a range of R&D projects. Through successfully commercialising his laser doping, plating and hydrogenation technologies as 'Pluto', Suntech Power made the first 20.3% efficient commercial cell. Stuart's Advanced Hydrogenation technology, which could boost the lifetime of solar cells over one hundred times, won him the 2013 A.F. Harvey Engineering Prize. Just before his passing in 2017, eight industry partners signed agreements with UNSW to use this technology in production. Stuart further advanced industry through driving the creation of the world's first PV degree (at UNSW). He also co-developed the "Virtual Production Line" software which simulates PV production lines for manufacturers to optimise processes, and for students to learn. Another of Stuart's legacies is the Solar Industrial Research Facility (SIRF) at UNSW, which enables UNSW researchers to implement world-leading lab developments on commercial tools to rapidly advance the process of solar technology transfer to industry.



V John White

Country: United States

Year joined industry: 1989

Company first worked for: CEERT

Technology area: Policy

Still active in the industry: Yes

V. John White is the co-founder and Executive Director of the Center for Energy Efficiency and Renewable Technologies. Founded in 1990 by a group of renewable developers, including solar thermal pioneer Luz, CEERT is a unique partnership between environmental public interest groups, and renewable energy and clean tech companies. John has played a leading role in designing, negotiating, and advocating innovative public policy solutions to accelerate renewable development and decarbonize the power sector. In addition to leading campaigns for renewable procurement, CEERT has worked to remove barriers to renewable development. The Renewable Energy Transmission Initiative was a consensus-based stakeholder process, organized by CEERT, which led to the alignment of transmission planning and the build out of renewable development zones. John also established and facilitated a unique collaboration between environmental groups and utility scale solar and wind developers, to negotiate, siting, permitting, and planning of more than 10,000 megawatts of utility scale projects in California. In 2004-5, John worked with CEERT co-founder Jan McFarland, on the legislation and regulatory initiatives which became the million solar roofs initiative, which provided \$3 billion over 10 years to support the rapid expansion of rooftop solar. Since the early 1980's, John has been a leading advocate and political consultant working on solutions and strategies to reduce air pollution and global warming from fossil fuel power plants, including AB 32, the Global Warming Solutions Act. He has also worked with local activists and political leaders in Los Angeles to reform and revitalize the Los Angeles Department of Water and Power, leading to the phase out of their reliance on coal and expanded renewables. In 2019, Mayor Eric Garcetti announced that LADWP would shut down its last remaining coal plant, phase out reliance on natural gas, and achieve 100% clean energy by 2035.

8.10 ISES Institute Member- SPF Institute for Solar Technology



The history of the SPF Institute for Solar Technology (by Stefan Brunold)

The oil crisis at the beginning of the 1970s leads to a first boom in solar thermal energy not only in Switzerland. This triggers numerous developments of materials, components and concepts for solar thermal systems, some of them serious, some exotic. In this pioneering phase that lasts until the 1980s, numerous manufacturers, dealers and fitters appear on the market, with products of partly questionable quality. As a result, the Federal Office of Energy Industry, BEW (now Swiss Federal Office of Energy, SFOE) advertises the research project 'Service life and operational safety of solar systems'. Ueli Frei, a recent graduate from the engineering school 'Interkantonales Technikum Rapperswil, ITR', gets the contract, thus laying the foundations of the Swiss Institute for Solar Technology SPF in 1981.

From the very beginning, SPF establishes close contacts with industry and commerce, but also with other organizations worldwide. Thus, already in 1983, the first highly acclaimed publication with the topic 'Durability of Absorber Coatings' is published together with the Paul-Scherrer-Institute PSI (back then Institute for Reactor Safety EIR), which at that time is still active in the field of solar thermal research. Soon thereafter, increasing emphasis is also placed on international cooperation within the framework of the International Energy Agency's Solar Heating and Cooling Program (IEA-SHCP), resulting in new impulses and productive collaborations with research institutions worldwide. SPF's participation in international conferences and the number of scientific publications is steadily increasing, culminating in the so-called 'red series booklets', which becomes extremely popular in the German-speaking world and are sold in several editions of up to two thousand copies between 1984 and 1986. This five-part series summarizes the results of the research project 'Service life and operational safety of solar systems'.

After the PSI's research goals in the field of solar energy utilization are redefined in 1986 and, as a consequence, their work on thermal collectors is discontinued, the BEW comes to the far-reaching decision to expand SPF into the national competence center for solar thermal energy. As a result, SPF continues to develop rapidly in terms of staff and structure. The previously used static racks for the solar collectors in test are replaced by a series of dual-axis trackers. Placed on the roof of the ITR laboratory building, these trackers are at that time the core of the new infrastructure. The successful setup of the laboratory roof is the occasion for the formal inauguration of the SPF on May 16, 1990.

In the following years, SPF develops numerous test methods and certificates, which support the solar industry in the development and marketing of new products. These include the SPF quality label for solar collectors, the SPF Solar Glass Certificate, test methods for hydraulic connectors, for solders and thermal insulation, just to name a few. In international cooperation, a standard for accelerated aging testing of solar absorber coatings is being launched which enjoys worldwide recognition under the name 'Task 10 - Test'. The 'Concise Cycle Test Method' (CCT), which is now frequently copied, is developed in order to determine the performance of solar combi-systems within the shortest possible time.

Moreover, SPF also sets new standards in product development. From 1990 on SPF starts developing the simulation software Polysun. In 2007, version 4.0 goes commercial by the SPF spin-off 'Vela Solaris AG'. Through continuous further development, Polysun is now much more than 'just solar software'. With the 'Solkit', SPF introduced in 1995 one of the first solar compact systems for domestic hot water production. Designed as a kit, production and installation costs are reduced and faults during the installation can be prevented. In 1999, the Swiss Electrotechnical Association SEV awards its Innovation Prize to two SPF researchers for a new type of solar absorber layer developed in collaboration with the University of Basel. The coating is produced in a resources saving vacuum process that is patented worldwide.

Because of the restructuring of the Swiss educational landscape, in 1997 ITR became HSR (Hochschule für Technik Rapperswil), a part of the University of Applied Sciences Eastern Switzerland FHO. Three years later, the HSR begins implementing the Bologna reform. In 2001, the SPF, grown to 20 employees and independent at that time, becomes an institute of HSR and thus part of FHO. This step supports the integration of solar technology into the education of future engineers at HSR. The number of bachelor and master theses

completed at SPF increases significantly.



With the steadily growing size of the institute, it is necessary to split it into the two departments 'SPF-Research' and 'SPF-Testing'. This results in a clear separation between research and development on the one hand and testing and services on the other. The latter is accredited by the Swiss Accreditation Service (SAS) since 2001 under the registration number STS 0301 with worldwide recognition as a 'testing laboratory for systems and components for the supply of heat in buildings and for testing the resistance and optical-thermal properties of exterior components in accordance with ISO 17025'. The range of testing services is being further expanded and now also includes, for example, hail tests with ice balls, snow load tests up to 2'000 kg/m² and 15 m² surface area and the determination of the stratification efficiency of water stores.

During the past years, solar thermal systems and components have become increasingly efficient and reliable. Now it is essential to support the energy transition with all its might. For this reason, SPF is increasingly focusing on research of sustainable energy systems with the emphasis on solar energy as a source and the provision of heat for residential buildings and industry. The constantly falling costs of photovoltaic modules increasingly enable a broader use of electricity-based technologies. These circumstances are taken into account by carrying out more and more research projects in the field of systems technology. Different energy sources, such as solar radiation, ground heat, waste heat, wood, etc. can be combined in order to meet the demand for heating and cooling as sustainably as possible. As solar energy is mainly available in the summer months, storage technologies are being researched which allow to make the surplus of energy gained in summer available in winter. For this purpose, heat pump systems with ice storage or borehole regeneration, for example, are increasingly being investigated. In 2020, SPF receives the Innovation Award of the 'Stiftung FUTUR' for a completely new concept of seasonal energy storage. In this concept, renewable energy is stored utilizing an aluminum-redox-cycle that even exceeds the volumetric energy density of coal, oil or methane.

This increasing importance of systems engineering is also reflected in the expansion of the infrastructure, which is used for both, 'SPF-Research' and 'SPF-Testing'. In the meantime, systems in connection with PV modules, inverters and air and ground source heat pumps can be tested in the CCT test bench. A mobile test laboratory with flasher for characteristic curve recording, electroluminescence measurement, IR camera and high-voltage testing is also available for testing PV modules.



1981: Ueli Frei explaining the solar collector test rigs to councilor Dr. A. Gilgen ("Züricher Oberländer", 13.07.1981)



2020: The dual-axis trackers for solar collector testing, as installed in 1991. The people in the picture are participants of the annual Industry Day, during which SPF's 50 employees present their work.

8.11 ISES National Section- Hungary

Hungarian Section of the International Solar Energy Society (H-ISES)

I. Farkas

Chairman of the H-ISES

E-mail: farkas.istvan@szie.hu

The Hungarian Section of the International Solar Energy Society (ISES-Hungary) has been established the July 12, 1983 with 20 members.

In that time SES-Hungary was going to be in contact with those specialists who were ready for activity in a co-operation aiming at the realization of the common targets in the field of solar energy, and decided to establish the Hungarian Solar Energy Society (HSES) on September 6, 1990. The recent number of members in the Society is 50.

ISES-Hungary organised an International Workshop with the title of "Development and Use of Efficient Solar Systems", on June 2-3, 1988 in Budapest. In the program, outstanding ISES experts from 11 countries presented keynote lectures in 11 Sections. Total number of participants were 60, from 14 countries. Abstracts of the lectures have been published.



In 1989 the Hungarian Section of ISES established the "Foundation for the Environmentally Friendly and Renewable Energy Resources" aiming at to support of the activity of ISES-Hungary, with special attention to the organization of the ISES Solar World Congress 1993. The motto of the Congress was: "Harmony with the nature". The logo of the Congress represented the beam of rays of the Sun aiming at the Earth.

The World Congress has been taken place on the August 23-27, 1993. The Program included also seven ISES Meetings, and the following Seminars, Workshops, Forums, and Training Courses. Number of participants of the World Congress was 960, from 73 countries. The Technical Program consisted of 5 plenary and 140 technical sessions, where 853 oral and poster presentations were given. Abstracts of the Solar World Congress 1993 Budapest have been published. The Book of Abstracts contains the summary of 813 lectures of the Congress. The Proceedings has been published in 8 volumes edited by the sections' chairmen. The Solar World Exhibition was held in parallel with the Solar World Congress. The exhibition area was about 3000 m². The exhibitors were from 49 companies from 14 countries.

The Organizing Committee of the ISES Solar World Congress 1993 decided to call the attention of the youth generation to the importance of the Sun in our life, and therefore an International Childrens' Drawing Competition was launched with the motto: "The Sun and We Ourselves". More than 10.000 drawings were submitted from 12 countries. A Calendar has also been prepared using the prize drawings.



On the Press Conference of the SWC 1993 Prof. László Imre, the general chairman answered the questions of the journalist and the great number of specialists together with Prof. Adolf Goetzberger, president of ISES, Mr. Michael Nicklas vice-president of ISES and Prof. András Zöld technical program and editorial chairman of the congress.

In 1984, the Hungarian Section of ISES established a close contact with the Division of Technological Research and Higher Education of UNESCO and an effective and active co-operation has been realized in the European Solar Energy Network (ESEN) Committee of UNESCO. A Hungarian Solar Participation Program (SPP) has been prepared by considering the aims of the World Solar Summit Process of UNESCO. In the main regions of the country eight Solar Regional Centres have been established, most of them at high-schools and universities. Additionally, 60 secondary schools and 40 university departments received technical and scientific textbooks. ISES-Hungary proposed for the UNESCO ESEN to establish a closer co-operation with the FAO in the field of renewable energy technologies participating in several international meetings organised by the contribution of FAO.

Hungary served also actively in the Board of ISES and ISES-Europe. Prof. L. Imre was a director for small sections for the period of 1992-1998. Prof. I. Farkas served for ISES-Europe as a vice president for 1999-2001 and as a president for 2001-2003. He was a member of the ISES Governing Board for the period of 2003-2008.

Due to the initiation of ISES-Europe, the Hungarian Section of ISES regularly organised the Sun-Day programs. It was the first time in 1994, when H-ISES with the active contribution of the "Organization of Our Environment" organised the event. Since that time, the Sun-Day has been successfully celebrated in every year by the central event organised at the Szent Istvan University Gödöllő, under the direction of Prof. I. Farkas.

The HSES Society operates five (5) Working Groups as: Solar architecture; Photovoltaic application; Solar thermal applications; Energy politics and Youth.

With the support of HSES successful events in the series of the Seminar/Workshop on Energy and Environment (EE) were organised yearly since 1995 under the auspices of the Department of Physics and Process Control, Institute for Environmental Engineering Systems, Szent István University Gödöllő, Hungary, including active participation also from foreign institutions working in the field of the application possibilities of renewable energy resources. These events provide a forum for the presentation of new results in research, development and applications in connection with the issues of energy and environment with an especial attention to the use of solar energy resources.

Under the auspices of the Society the following projects were/are running: UNESCO Solar Participation Program; PHARE program; Solar School Forum; EU Terminology research to identify the most suitable Hungarian equivalents to around 249 corresponding English IATE entries in the field of solar energy.

The HSES keeps close contact and active co-operation with the national companies working on the fields of solar energy installations. The most important firms are as follows: Abutex Bt, EU-Solar Zrt, Elti Kft, Energoplan Kft, H.M. Mérnöki Iroda, Höfle Légtechnika Bt, Hungaroklima Bt, Klimasol Kft, Naplopó Kft, NVSolar Energia Kft, Nyílhegy Tanácsadó BT, Solart System Kft, Super Solar, Wagner Solar Hungaria Kft.

The academic co-operation with the universities and also with the Scientific Energy Committee of the Hungarian Academy of Sciences are active. At the same time daily co-operation is going on with the related governmental institutions.

9. 1990-1999

9.1 ISES 1990-1999

1990

- ISES *Utility Initiative for Africa* seminars were held in Johannesburg, South Africa and was in Nairobi (co-sponsored by UNEP): both declared universal energy access a basic human right.
 - The first World Renewable Energy Congress was organised by Professor Ali Sayigh.
 - ISES works was presented at the UN Conference on Environment & Development (UNCED).
 - ISES 2000 program, a plan for transforming ISES was debated and adopted.
 - ISES Sponsorship Program to assist developing countries to form ISES Sections was announced.
 - A regional secretariat office in Europe – ISES Europe was established.
 - Cyprus was accepted as a Section.
- International Association for Solar Energy Education (IASSEE) became an ISES Working Group.

1991

- Turkey, Croatia, Romania, Malaysia and the USSR were accepted as Sections.
- ISES Europe became the umbrella organization for all the European Sections.
- ISES provided recommendations to the Rio Earth Summit.

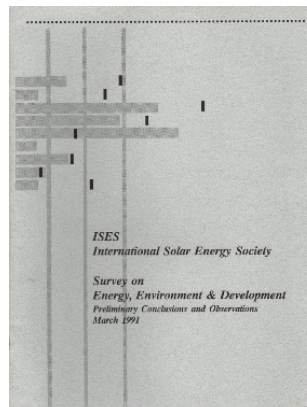


Figure 35: Survey on Energy, Environment & Development, Preliminary Conclusions and Recommendations March 1991

- ISES participated in the Conference of the Parties for UNCED 3 in Geneva.
- ISES contributed to the successful Consortium for Action to Protect the Earth



Figure 36: Debating energy policy in the UNCED Working Group 3, Geneva

- Professor Adolf Goetzberger (Germany) was elected President.
- ISES facilitated four international preparatory round tables, as envisaged by the ISES/UNCED program.
- 200 experts representing sixteen national ISES Sections concluded that the use of renewables in the industrialized countries was a political as well as a technological challenge.



Figure 37: Mike Nicklas (Vice President ISES), Maurizio Cumo (ISES Board member), Corrado Corvi (ISES Board member and chair ISES Italy) and Adolf Goetzberger (ISES President)

1992

- The Board of Directors meeting coincided with the Rio Earth Summit, 3–14 June 1992.
- ISES publications *Recommendations to the United Nations Conference on Environment & Development – Solar Energy Solutions for an Environmentally Sustainable World* and *ISES 2000 – Recommendations to the Commission of Sustainable Development*, not only helped to sway opinions at the Earth Summit, but also served as a major step for reshaping ISES.

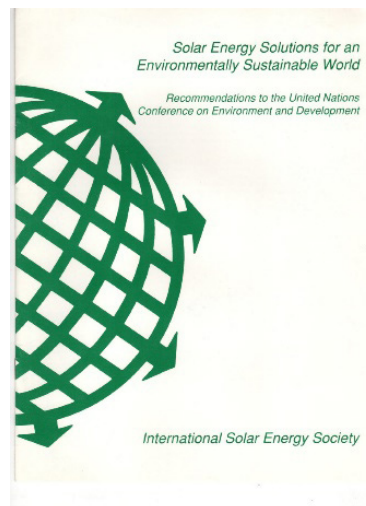


Figure 38: Solar Energy Solutions for an Environmentally Sustainable World

- A new *Special Service Award* was announced by Harry Tabor and bestowed upon Mike Nicklas.
- *Rio Declaration on Environment and Development* and the *Statement of principles for the Sustainable Management of Forests* incorporated many ISES principles.
- An ISES section organised solar art exhibition, *Secrets of the Sun – Millennial Meditations*, celebrated the Rio Earth Summit.
- The editing, design, production and distribution of *SunWorld* was entrusted to the Franklin Company Consultants, with Dr Leslie F Jesch as Editor.
- ISES is accepted by the United Nations as a non-governmental organisation (NGO) with consultative status and actively participates in the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro, Brazil.



Figure 39: Dr Leslie Jesch, President ISES-Europe, who became editor of SunWorld in 1992

1993

- The UK Section held its 20th Anniversary Conference at Brighton.



Figure 40: Dr Nicola Pearsall, Northumbria University and ISES UK member, Brighton

- In February, the first Karl Böer Solar Energy Award (Recognition of Distinguished Contribution to Global Solar Energy Utilization) was awarded to former President Jimmy Carter



Figure 41: Former US President Jimmy Carter on his acceptance of the first Karl Böer Medal

- ISES joined the World Solar Summit Process (WSSP).
- ISES collaborated in the UNESCO World Solar Summit.



Figure 42 : Members of the international WSSP organising Committee. Adolf Goetzberger far left, Hubert Nacfaire (CEC) and Boris Berkovsky (UNESCO) centre front



Figure 43: Opening session of the World Solar Summit, with Boris Berkovsky seated far left with Philippe Chartier (Scientific Director ADEME) and Hubert Nacfaire far right

- ISES initiatives included the NGO Renewable Energy Summit, NGO Regional Conferences and the Global Communications Project.
- An ISES NGO Committee was formed.

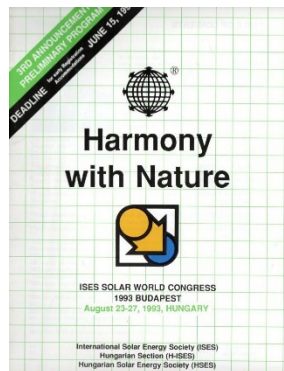


Figure 44: The ISES World Congress conference in Budapest was a huge success

- The ISES 2000: global solar agenda was launched at this Congress and included establishing regional offices in Europe, Africa and South Africa.
- The ISES Working Group for Architecture was revived, with Steve Szolay as chairman.
- Hungarian Section co-sponsored the International Children Drawing Exhibition.



Figure 45: The ISES 1995 calendar, starting pictures of the sun painted by children across Hungary

1994

- ISES convened two preparatory renewable energy NGO meetings.
- ISES participates the second meeting of the United Nations Commission on Sustainable Development (CSD) in New York to discuss issues of sustainable development and the interlinkages to renewable energy technologies.
- SunDay – to popularise the use of renewable energies -was instigated in the USA and Sweden.
- ISES hosted the NGO Renewable Energy Summit in New York.



Figure 46: Summary panel, ISES NGO Summit NY.
L to R: Alicia Barcena Ibarra, Griff Thompson, Fred Morse & Don Aitken

- The NGO process, culminating in the New York Summit, was led by Mike Nicklas, the NGO Committee, the ISES NGO Liaison Officers (Jane Willeboordse and Jenniy Gregory)
- This Summit was followed by three regional NGO conferences.



Figure 47: Alison Patterson, Assistant Editor Sun at Work in Europe and member UK SES, promoting the first European SunDay

- Terry Hollands became editor of Solar Energy.
- IASEE, the Education Working Group, had 370 members in 70 countries.



Figure 48 : ISES Board meeting, Cypress

- ISES Board of Directors announced that Freiburg would host the new ISES headquarters.



Figure 49: Villa Tannheim in 2000. Transparent thermal insulation is just visible on the wall behind the ISES Flags



Figure 50: Villa Tannheim in 1920

- ISES worked with the World Solar Summit Process (WSSP) in selecting projects, and ISES started a global solar projects program called the *World Solar Programme*.
- *Empowerment for Africa*, co-hosted by the Solar Energy Society of South Africa and ISES aimed to assist development of local, practical energy related community needs.

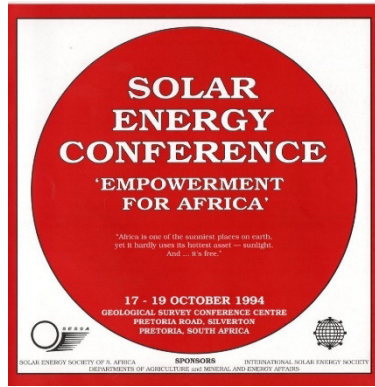


Figure 51: Empowerment for Africa

- The Declaration of Madrid provided the framework to assist renewable energy technologies at both pre-commercial and R&D stages of development.

1995

- ISES Executive Director Burkhard Holder opened the new ISES headquarters at Villa Tannheim.



Figure 52: The new Executive Director Burkhard Holder, Lord Mayor of Freiburg Rolf Böhme, and President Mike Nicklas at the opening of Villa Tannheim



Figure 53: HQ staff at the opening of Villa Tannheim



Figure 54: The retiring Australian HQ staff, 1995, in their offices at the Chisholm Institute of Technology in Caulfield, Victoria. Wal Read sits in front of Peg Bilston (left), another staff member and Barbara Rozen (right). Peg and Wal served ISES for 24 years at ISES HQ Melbourne.

- In 1995 Eduardo de Oliveira-Fernandes was elected President.
- ISES Projects, an HQ initiative of HQ, included resource assessments and Global Environment Fund (GEF) projects.
- Mike Nicklas presented the ISES NGO Initiative conclusions to the UN Committee on New and Renewable Sources of Energy and Energy Development.
- SunDay Europe was held on 25 June, with 10 countries participating.
- The first ISES World Congress on Solar Energy held in Africa, was hosted in Harare, Zimbabwe.
- Harare Declaration launched a World Solar Programme for 1996–2005.
- Adolf Goetzberger was awarded the Farrington Daniels Award.
- Monica Oliphant (Australia), Dr Flora Mosaka-Wright (South Africa), Alison Patterson (UK) and Jenniy Gregory (UK) established the ISES Women in Energy group and launched a Women in Energy Internship for women from eastern or southern Africa.



Figure 55: Some of the ISES solar women who met at the Congress

- The new ISES Information Gateway received over 60,000 visitors in 1995.

1996

- Renewable Energy Supply Systems for Indonesia became the first international project undertaken by ISES HQ outside of Europe.
- Mike Nicklas was awarded the ASES Charles Greeley Abbott Award.
- The first EuroSun Conference was conducted in Freiburg, Germany.

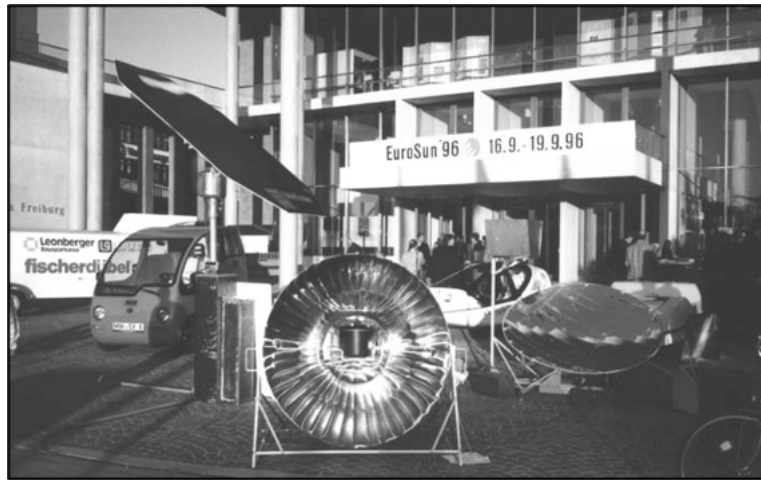


Figure 56: The Entrance to the EuroSun Conference at them newly opened Congress Centre, Freiburg (1996)



Figure 57: The oldest and youngest participants at EuroSun



Figure 58: Environment Minister Angela Merkel meeting ISES-Europe President Leslie Jesch (second from left), Fraunhofer SE Director Joachim Luther (second from right), and ISES Vice President David Mills (extreme right) (1996)

- Within the framework of the ISES Global Renewable Energy Network, a project called the Worldwide InformationSystem for Renewable Energy (WIRE, was announced at EuroSun.

1997

- An Energia (Women and Energy) workshop was held at the Solar World Congress.
- Marta Weeks who helped ISES purchase Villa Tannheim, was made the first Friend of ISES.



Figure 59: Mrs Marta Weeks in 2003

- Under the auspices of the United Nations Framework Convention on Climate Change, the historic Kyoto Protocol was signed.
- The first ISES Summer Academy for Solar Architecture was held in Freiburg.

1998

- ISES President became co-chair of the DOE-sponsored International Performance Measurement and Verification Protocol (IPMVP) project.
- ISES project themes intended to provide a framework for extensive solar technology usage included *Solar Cities*, *Islands in the Sun* and *Solar Oasis*.
- ISREE, the educational symposium, and ISES became coordinated.
- *Solar Cities* became a new task within the IEA.
- ISES grew relationships with IPMVP, European Wind Energy Association (EWEA), IEA SolarPACES, IEA Solar Heating and Cooling, and the European Commission: Directorate General for Energy.
- Dr Joachim Luther (Fraunhofer Institute, Germany) became editor of the *Solar Energy Journal*.
- The new WIRE Managing Board included Larry Sherwood, Burkhard Holder and Bernard McNelis.
- Karl Böer and David Mills agreed that ISES and ASES should co-sponsor the publication *Advances in SolarEnergy*.
- The Australia and New Zealand Section committed US\$1,700 for three years to create the Wal Read Memorial Award for the support of new sections.
- ISES HQ, in cooperation with the South African Regional Office, launched a new Utility Initiative for Africa.

1999



Figure 60: After Dr Mary Archer's presentation on solar energy at the Royal Institute London, following the conference presentations.

L to R: Lady Dr Mary Archer, Koti Jesch, Leslie Jesh and Adolf Goetzberger

- Under the Sun: an outdoor exhibition of light began its national tour of the USA.
- Under a new contract negotiated with Elsevier Publishing, SunWorld became Refocus.

Table 12: Officers of ISES 1991-2001

Years	President	Vice President	Secretary or Secretary / Treasurer	Director
1991-93	Adolf Goetzberger	Michael Nicklas Eduardo de Oliveira Fernandes	Wal R Read	
1993-95	Michael Nicklas	Eduardo de Oliveira Fernandes David Mills	Wal R Read	
1995-97	Eduardo Oliveira de Fernandes	Bernard McNelis David Mills	Dieter Holm Adolf Goetzberger	Burkhard Holder
1997-99	David Mills	Donald Aitken Cesare Silvi	Larry Sherwood Adolf Goetzberger	Burkhard Holder
1999-01	Cesare Silvi	Torben Esbensen Anne Grete Hestnes	Donald Aitken Sakae Tanemura	Burkhard Holder

Table 13: Conferences and Meetings 1991-1999

Year	Location	Overview
1991	Denver USA	Theme: <i>World Solar Energy Congress</i> 1500 participants, 100 displays Farrington Daniels Award: Prof. Tetsuo Noguchi (Japan) Christopher A. Weeks Achievement Award: Solar Energy Research & Development Group, University of Melbourne (Australia)
1993	Budapest Hungary	Theme: <i>Harmony with Nature</i> 1000 participants (60 countries) 560 papers and 87 industry Exhibitors from 15 countries. Conference Chair: Wal Read Farrington Daniels Award: Prof. William W.S. Charters (Australia) Christopher A. Weeks Achievement Award: Fraunhofer Institute for Solar Energy Systems (Adolf Goetzberger) For services to solar energy, Achievement through Action, awarded: Adolf Goetzberger and Mike Nicklas The first recipient of the Karl W Böer Award for distinguished contribution to global solar energy: ex-President Jimmy Carter (USA). Special Service Award: Michael Nicklas (USA) and Douglas Lorrinan (Canada).
1995	Harare Zimbabwe	Theme: <i>In Search of the Sun</i> 1,100 participants Chair of Organising Committee: Gilles Gloutier Farrington Daniels Award: Prof. Adolf Goetzberger (Germany) Christopher Weeks Achievement Award: NM Institute for Rural Technology, Tripura (India) & OM Institute, Japan (Prof. Akio Okumura) Karl W Böer Award: Dr David E Carlson Special Service Award: Wal Read (Australia)

1997	Taejon South Korea	<p>Theme: <i>Future Globe in the Sun</i> 1,700 participants (54 countries) 900 accepted papers, large exhibition Farrington Daniels Award: Prof. Chris G. van Koppen (Netherlands) Christopher Weeks Achievement Award: Arnold J Goldman, Jerusalem (Israel) Karl W Böer Award: Prof. Adolf Goetzberger (Germany) Special Service Award: Dr Harry Tabor (Israel)</p>
1999	Jerusalem Israel	<p>Theme: <i>Solar is Renewable</i> 700 participants (54 countries), 450 Verbal presentations and 150 Posters. Solar car and solar boat display with first Japanese Solar Boat race being held. Conference Chair: Dr T Noguchi Farrington Daniels Award: Prof. Ken-ichi Kimura (Japan) Christopher Weeks Achievement Award: Panos Lamaris, SOLE S.A. Athens (Greece) Karl W Böer Award: Stan Ovshinsky (USA) Special Service Award: Terry Hollands (Canada)</p>

9.2 ISES Presidents 1990-1999



Figure 61: Professor Adolf Goetzberger, President 1991-1993

Adolf Goetzberger

Adolf Goetzbergere (Germany) received his doctoral degree in Physics from the University of Munich in 1955 and then spent 10 years in the USA—five years with the Shockley Transistor Laboratory, Palo Alto, California, and five years with Bell Telephone Laboratories, Murray Hill, New Jersey where he published fundamental work about the Si-SiO₂ interface. In 1968, he returned to Germany to accept the position of Director of the Fraunhofer Institute for Applied Solid State Physics, and in 1981 he founded the Fraunhofer Institute for Solar Energy Systems, in Freiburg, which grew into one of the major solar energy laboratories in Europe. In 1993 he retired as a Director of the Institute, but he carried on many publishing and advisory activities in the field of solar energy. Some of his scientific achievements included: fluorescent solar collectors, the first theory of light trapping in thin silicon solar by diffuse reflectors, development of transparent insulation for buildings, and the planning and construction of the first self-sufficient grid-independent solar house in Germany in 1992. In 1995 he became Doctor Honoris Causa of the Uppsala University in Sweden.



Figure 62: Mike Nicklas, President 1993 - 1995

Mike Nicklas

Mike Nicklas (USA) graduated from the University of North Carolina with a Bachelor of Architecture and formed the company Innovative Design in the late 1970s. By 1977, his company had completed 600 solar projects. By the 1990s the firm was involved in the research and development of a building-integrated PV system with heat recovery, and a roof-integrated high temperature solar thermal system for industrial process heat applications. Nicklas served on many state and federal committees and was in succession Chair or President of the North Carolina Solar Energy Association, the North Carolina Home Builders Association, the Passive Solar Industry Council, and ASES. He was passionate about solar energy and a global visionary, seeing a future for ISES as a huge grassroots environmental NGO rather than a rather small technical society. His argument was that this would deliver the message of ISES to many more people.



Figure 63 : Eduardo de Oliveira-Fernandes, President 1995 - 1997

Eduardo de Oliveira Fernandes

He was the founder of an R&D group on Building Thermal Physics with major pioneering activities in Portugal on passive solar technologies in buildings, indoor air quality, and energy and the environment in the urban space. He was a consultant for energy in buildings for DGXII-European Union (1988–92), for EXPO '98—Lisbon and its urban development (1993–98) and for various urban projects in Europe. He was the leader of several EU large RTD projects on IAQ issues for DGXII and on energy issues for DGXVII. He was chair of the Department of Mechanical Engineering (1980–82); Vice-Rector of the University of Porto (1986–91); Secretary of State for Environment of the Portuguese government (1984–85); and Chair of Portuguese Mechanical Engineers(1992–94).



**Figure 64: David Mills,
ISES President
1997 -1999**

David Mills

David Mills (Australia) is a physicist and active solar energy researcher at the University of Sydney who worked on a variety of technical areas in direct solar conversion. Born in Canada, he was active in solar energy research for many years and had many patents in the field. In the late '70s as a student, he developed theoretical limits for asymmetrical and general linear maximal concentration optical systems, together with new asymmetrical non-imaging optical designs like the prism PV concentrator and asymmetrical mirrors for seasonal output bias, which are the ancestors of some modern Swedish solar thermal arrays. In the 1980s he developed the first pressurized water storage solar cooker, displayed at the Hamburg Congress, and a solar industrial steam technology using non tracking reflector technology. He also improved theoretical limits for selective coating performance that allowed the possibility of low emittance high temperature coatings. In the 1990s he led the project which produced the advanced double ceramic-metal (cermet) layer selective absorber coating, now in large-scale production under license in China. In 1993, he originated a new low-cost solar thermal electric power plant design called the compact linear Fresnel reflector (CLFR, now commercialized), using direct boiling and innovative optics. This has led to much increased general interest in linear Fresnel systems as a low- cost alternative to parabolic troughs for large power plants. Mills also was also very involved with ANZSES in the 1980s and 1990s as Chairman of the New South Wales Branch and ANZSES Vice President and was the ANZSES political lobbyist during the Australian Ecological Sustainable Development process. He presented a paper on Greenhouse mitigation impact of solar technologies to the Australian Senate in 1988 and helped write the energy policy for two political parties.



**Figure 65: Cesare Silvi,
President 1999 - 2001**

Cesare Silvi

Cesare Silvi (Italy) has a degree in Mechanical Engineering and Nuclear Engineering from the University of Rome and Bocconi University. Within ISES, he supported the strengthening of traditional technical-scientific aspects and at the same time promoted the association's attention to the history, art and culture of solar energy. From 1975 to 1981, he was at the Nuclear Safety and Environmental Protection Directorate of the CNEN (National Nuclear Energy Committee). From 1981 to 1996 he worked in the International Affairs Directorate of ENEA (Italian Body for New Technologies, Energy and the Environment). In 1986/1987 he was Resident Fellow at the Institute for East-West Security Studies in New York. From 1996 to 1998 he was Director of the Italian Agency for the Promotion of European Research. During his professional career, he published various technical reports and popular articles on industrial safety, international collaboration in the scientific and technological fields, disarmament, energy policies, renewable energy, environmental protection and recently on the history of solar energy.

9.3 PV 1990-1999

During the 1990's the market for PV shifted from the off-grid systems to the grid connected systems. Rooftop solar programs started in Japan and in the USA by **Sacramento Municipal Utility District (SMUD)**. **Pacific Gas and Electric** demonstrated the first large grid connect PV systems used for grid support. The **International Energy Agency Photovoltaic Power Systems (IEA-PVPS)** commenced to produce annual trend reports providing information on installed capacity, manufacturing capacity, Research and Development expenditure, pricing and the policies driving the growth of solar. In 1990's these reports focussed just on IEA countries where much of the production and installation occurred at that time but later the annual reports expanded to cover non-IEA countries. MW started to replace kW when quoting PV installation capacity.

In accordance with the IEA-PVPS Trend reports during the 1990's:

- Annual installations grew from 26MW in 1993 to over 120MW in 1999.
- Cumulative installed capacity grew from 110MW in 1992 to approximately 520MW in 1999.
- In 1993 off grid systems represented 62% of the annual installations and by 1999 this had decreased to 26%.
- Cumulative installed capacity off grid systems reduced from 70% in 1992 to 47% in 1999.

Table 14: Average Module Prices for Large and Small Orders

Year	Small Module Order (USD/Wp)	Large Module Order (USD/Wp)
1993	8.5 (less than 1kW _p)	5.6
1995	5.5 (less than 1kW _p)	4.9
1997	5.0 (less than 5kW _p)	4.1

Source: IEA-PVPS PV Trends Report

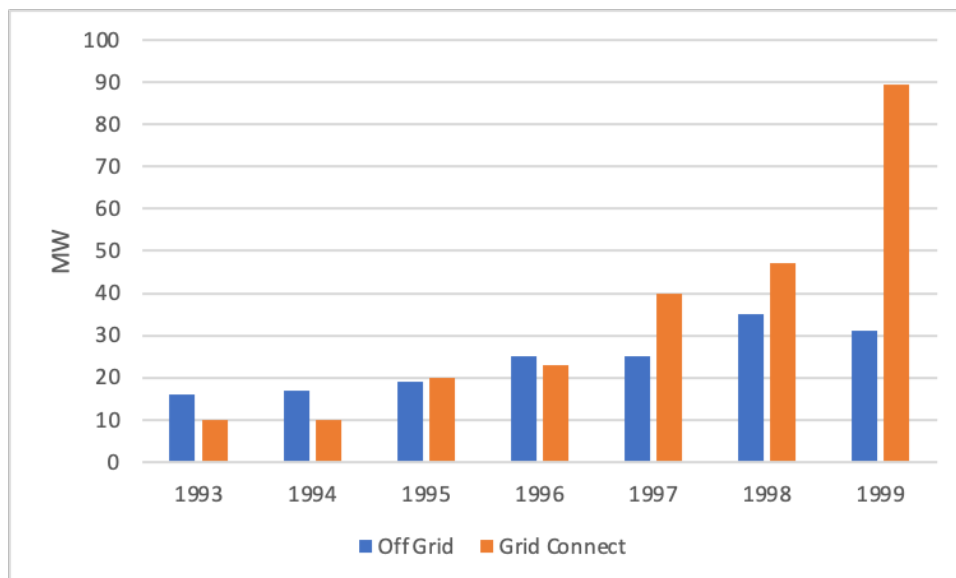


Figure 66: Annual PV Installed Capacity (1993-1999)

Source: IEA PVPS 1999 Trends Report

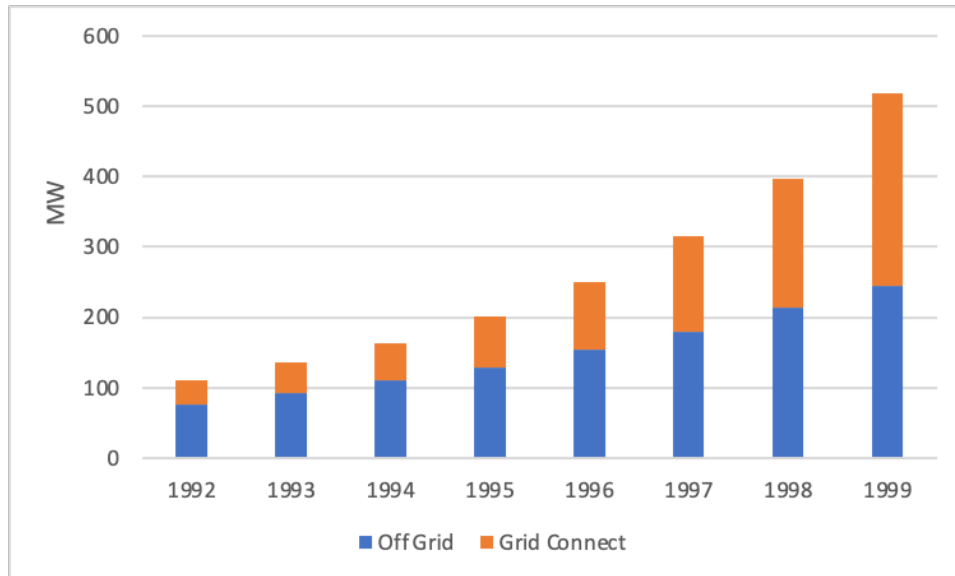


Figure 67: : Cumulative PV Installed Capacity (1992-1999)

Source: IEA PVPS 1999 Trends Report

Table 15: Percentage of Total Annual PV Installed by IEA Member Countries (1993-1999)

	1993	1994	1995	1996	1997	1998	1999
Australia	6.1%	7.2%	5.2%	6.5%	4.3%	4.7%	2.3%
Austria	0.9%	1.1%	0.9%	0.8%	0.7%	0.8%	0.7%
Canada	1.1%	1.0%	1.0%	1.5%	1.2%	1.3%	1.1%
Denmark	0.3%	0.1%	0.1%	0.2%	0.3%	0.1%	0.5%
Finland	0.5%	0.4%	0.4%	0.5%	0.8%	0.2%	0.1%
France	1.1%	1.4%	1.5%	3.2%	2.5%	1.9%	1.2%
Germany	12.5%	12.7%	15.5%	21.9%	20.2%	14.7%	12.6%
Great Britain	0.4%	0.3%	0.1%	0.1%	0.2%	0.1%	0.4%
Israel	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Italy	13.7%	7.2%	4.9%	0.5%	1.0%	1.2%	0.6%
Japan	20.1%	25.0%	35.1%	35.3%	45.7%	51.6%	60.5%
Korea	0.6%	0.2%	0.3%	0.7%	0.5%	0.6%	0.4%
Mexico	6.5%	6.2%	1.2%	1.7%	1.4%	1.2%	0.7%
Netherlands	1.4%	1.2%	1.3%	1.9%	1.1%	3.0%	2.2%
Norway	1.1%	1.1%	0.7%	0.5%	0.4%	0.3%	0.3%
Portugal	0.2%	0.1%	0.2%	0.2%	0.1%	0.1%	0.2%
Spain	2.7%	3.6%	2.6%	0.8%	0.2%	1.1%	0.9%
Switzerland	4.1%	3.3%	2.3%	2.0%	1.9%	2.2%	1.5%
Sweden	0.9%	1.1%	0.8%	0.5%	0.4%	0.3%	0.2%
USA	25.9%	26.9%	26.0%	21.1%	16.9%	14.6%	13.8%

Source: IEA PVPS 1999 Trends Report

1990

- **Energy Conversion Devices Inc. (ECD)** and **Canon Inc.** established a joint company, **United Solar Systems Corporation**, for solar cell production.
- **Siemens** bought **ARCO Solar** and established **Siemens Solar Industries**.

1991

- President George Bush redesignated the U.S. Department of Energy's **Solar Energy Research Institute** as the **National Renewable Energy Laboratory**.
- The Magdeburg Cathedral installed solar modules on the roof, marking the first installation on a church in East Germany.
- Efficient Photoelectrochemical cells are developed and the dye-sensitized solar cell are developed
- **BP Solar Systems** was renamed to **BP Solar International (BPSI)** and became an independent unit within the British Petroleum Group.

1992

- The University of South Florida developed a 15.9% efficient thin-film photovoltaic cell made of cadmium telluride, breaking the 15% barrier for the first time for this technology.
- A 7.5-kilowatt prototype dish system using an advanced stretched-membrane concentrator becomes operational.
- The **PV Pioneer Program** started at Sacramento Municipal Utility District (SMUD). It was the first broad based commercialization of distributed, grid-connected PV system ("rooftop solar").

1993

- **Pacific Gas & Electric (PG & E)** installed the first grid-supported photovoltaic system in Kerman, California. The 500-kilowatt system was the first "distributed power" project to reinforce a weak feeder. **PG&E** found that distributed systems like this have measurable benefits such as increased system reliability and peak-shaving capabilities.

1994

- The **National Renewable Energy Laboratory** developed a solar cell made from gallium indium phosphide and gallium arsenide that became the first one to exceed 30% conversion efficiency.
- Japan started the "**70,000 Solar Roofs**" PV subsidy program, to increase the use of photovoltaic system in the residential sector.

1995

- Thomas Faludy filed a patent for a retractable awning with integrated solar cells. This is one of the first times solar cells are used in recreational vehicles. Later, this feature would become a popular way to power recreational vehicles (RVs).

1996

- The world's most advanced solar-powered airplane, the "**ICARE2**", flew over Germany. The wings and tail surfaces of the Icare are covered by 3,000 super-efficient solar cells, with a total area of 21 m².
- At the **École Polytechnique Fédérale de Lausanne**, Lausanne, Switzerland Grätzel achieved 11% efficient energy conversion with dye-sensitized cells that use a photoelectrochemical effect.

1998

- The remote-controlled, solar-powered aircraft, "**Pathfinder**" set an altitude record of 80,000 feet, on its 39th consecutive flight on August 6, in Kauai Hawaii. This altitude was higher than any prop-driven aircraft thus far.
- Subhendu Guha, a noted scientist for his pioneering work in amorphous silicon, led the invention of flexible solar shingles, a roofing material and state-of-the-art technology for converting sunlight to electricity
- **Free Energy Europe** (Netherlands) buys the a-SI manufacturing plant of **NAPS-France**.

1999

- **Spectrolab, Inc.** and the **National Renewable Energy Laboratory** developed a photovoltaic solar cell that converts 32.3 % of the sunlight that hits the cell into electricity. The high conversion efficiency was achieved by combining three layers of photovoltaic materials into a single solar cell. The cell performed most efficiently when it received sunlight concentrated to 50 times normal. To use such cells in practical applications, the cell is mounted in a device that uses lenses or mirrors to concentrate sunlight onto the cell. Such “concentrator” systems are mounted on tracking systems that keep them pointed toward the sun.
- The **National Renewable Energy Laboratory** achieved a new efficiency record for thin-film photovoltaic solar cells. The measurement of 18.8 percent efficiency for the prototype solar cell topped the previous record by more than 1 percent.
- **Solar Cells, Inc. (SCI), True North Partners, and LLC** of Phoenix, Arizona merged to become **First Solar, LLC**.

The following table provides a breakdown of solar module manufacturers in IEA PVPS countries in 1999. It provides an overview of the variety of manufacturers that existed and the size of the manufacturing capacity

Table 16: Breakdown of Solar Manufacturers in IEA Countries in 1999

Country	Manufacturer	Cell Manufacturing (MW _p)	Module Production. (MW _p)	Production Capacity (MW _p)	Module Type
Australia	BP Solar	5.0	5.0	6.0	sc-Si
	Solarex Note: These two companies were merging	2.0	2.0	5.0	Mc-Si
Canada	Canrom	No Information			sc-Si
Denmark	Gaia Solar	0.0	0.075	0.33	mc-Si,sc-Si
France	Photowatt	8.5	3.0	10.0	mc-Si
	Free Energy Europe	0.4	0.4	1.0	a-Si
Germany	>20 Manufacturers	4.1	8.8	27.0	mc-Si sc-Si EFG a-Si
Great Britain	Intersolar	1.5	1.5	2.5	a-Si
Italy	Eurosolare	0.4	0.4	2.5	mc-Si
		1.1	1.1		sc-Si
	Helios Technology	2.1	2.05	2.2	sc-Si

Japan	Kyocera	30.2	30.2	36	mc-Si
	Sharp	8.5	8.5	10.0	sc-Si
		21.3	21.3	22	mc-Si
		0.2	0.2	2.2	a-Si
	Sanyo	4.6	4.6	5.0	a-Si
		5.9	5.9	8.0	a-Si/sc-Si bifacial
	Canon	1.31	1.31	10.0	a-Si
	Showa Solar	0.5	1.5	5.0	sc-Si
		Makes triangle and square modules for building facades			
	Air Water	0.1	0.94	1.0	sc-S
0.01		0.03	1.0	mc-Si	
Mitsubishi Electric	4.5	4.5	10.0	mc-Si	
Kaneka	3.0	3.0	20.0	a-Si	
MSK	0.0	3.0	10.0	mc-Si	
	0.0	0.0	3.0	sc-Si	
	0.0	0.0	2.0	a-Si	
Netherlands	Shell Solar Energy	0.8	4.0	6.0	mc-Si
South Korea	LG Industrial	0.0	0.2	1.0	sc-Si
	Samsung Electronics	0.0	0.3	0.5	mc-Si
Spain	Atersa	0.0	1.0	1.5	sc-Si
	BP Solar Espana	4.4	4.6	10.0	sc-Si
	Isofoton	0.643	3.37	5.0	sc-Si
Sweden	GPV	0.0	0.5	2.0	mc-Si
		0.0	0.5	2.0	sc-Si
Switzerland	Star Unity	0.0	0.5	1.2	sc-Si makes solar tiles
	Atlantis Solar	0.0	0.4	1.2	sc-Si
		Have production facilities in Germany and USA of 1 MWp capacity. Produces laminates and solar tiles			
USA	Siemens Solar	22.2	27.0	25.0	sc-Si
		0.0	0.0	4.0	CIS
	BP Solarex	16.0	12.0	20.0	mc-Si
		2.0	2.0	5.0	a-Si
	AstroPower	11.0	4.0	20.0	sc-Si
		1.0	0.0	5.0	Si film (thin film)
	Solec International	0.6	0.6	0.6	sc-Si
	ASE Americas	4.0	4.0	5.0	EFG-Si
United Solar Systems Corp	3.0	3.0	4.5	a-Si Triple Junction	
Other	1.0	1.0	5.0		
Other companies nearing production: Evergreen Solar, Ebara Solar, First Solar, Energy Photovoltaics, plus companies specialising in concentrator cells					

a-SC : Amorphous Silicon
mc-SC : Multi crystalline Silicon
sc-SC : Single crystalline Silicon
CIS- copper indium and selenium

9.4 Solar Thermal 1990-1999

Key points from the IEA SHC data:

- IEA SHC collected data from Australia, Austria, Brazil, Canada, China (1997-1999), Germany, Lebanon, The Netherlands, Sweden, Turkey, and USA. The Chinese data is only available from 1997 and 1999.
- Without that data available earlier in the decade, USA in 1990 installs 63.3% of the recorded capacity.
- When the Chinese data is included in the years 1997 to 1999, China's installs between 55.3% (1997) and 69.5% (1999) of the recorded capacity. Figure 68 shows the total recorded capacity breaking down the data between China and the Rest of World (ROW).
- The figures provided for China showed that 80% of their installed capacity was evacuated tube collectors (ETC) while in 1996 the total recorded installed ETC capacity for the ROW was only 1.88% compared with Flat Plate Collectors (FPC).
- Figure 69 shows the growth in installed water heater collectors for 1990 to 1999 broken down into FPC and ETC.

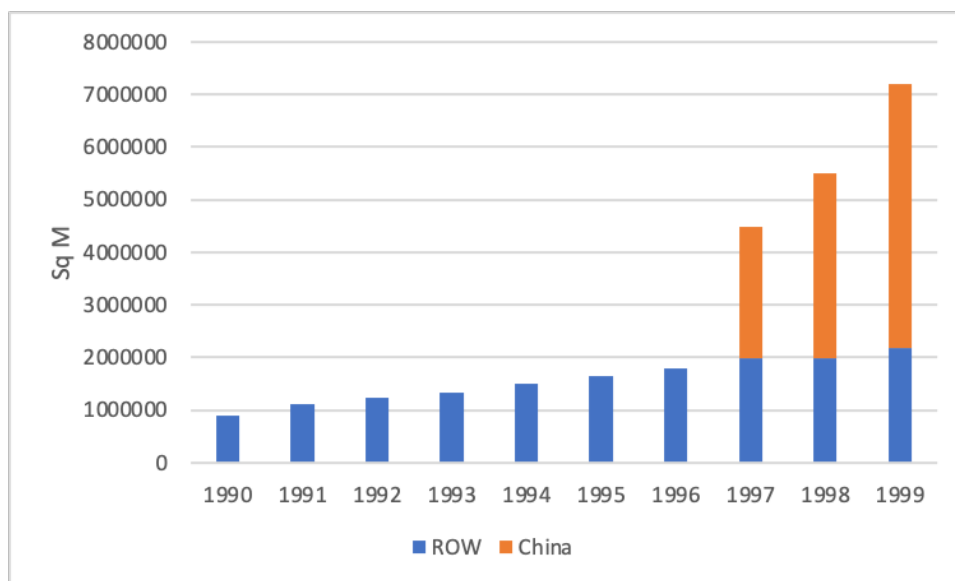


Figure 68: Annual recorded installed solar water panels capacity 1990-1999 broken down into ROW and China
Source: IEA SHC

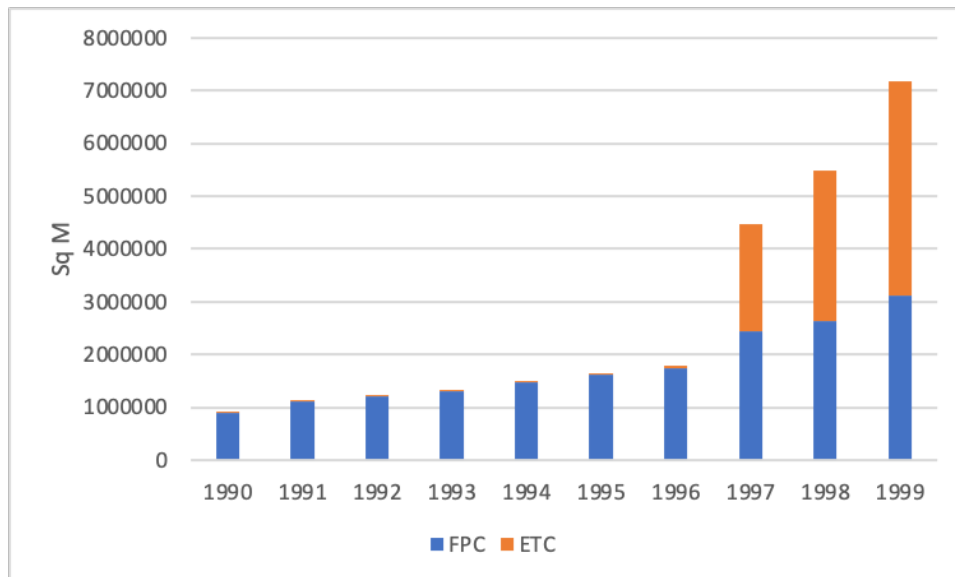


Figure 69: Annual recorded installed solar water panels capacity 1990-1999 broken down into ETC and FPC
Source: IEA SHC

1991

- Development of ultrasonic welding improved collector manufacturing techniques
- The “Solar Energy Research Group” has been founded at the University of Marburg, Germany moved 2001 to the neighboring University of Kassel and hosted there i.a. the ISES Solar World Congress 2011.

1992

- The **European Solar Industry Federation** (ESIF) is created on January 18th, 1992 in Athens, Greece, with its founding members being Dansk Solvarme (Denmark), ENERPLAN (France), EBHE - Greek Solar Industry Association (Greece), Dutch Solar Association / Holland Solar (The Netherlands) and Solar Trade Association (United Kingdom).

1993

- Development of blue selective coating in Europe by **TiNOX**, later followed by Alanod and Interpane

1994

- Technical committee CEN/TC 312 ‘Thermal solar systems and components’ CEN European Committee for Standardization assigns the CEN TC312 Secretariat to Greek Standardization Body ELOT.

1995

- **GREENoneTEC** (Austria) starts the mass production of its iconic FK 7000 tray collector.

1996

- The biennial Eurosun conference series has been launched, held in even years complementary to the ISES Solar World Congresses. The first Eurosun took place in Freiburg (DE). Until 2018, 13 conferences have been arranged by ISES-Europe. Since 2020 Eurosun is organised by ISES together with IEA-SHC. Eurosun attracts people from all over the world, 2018 came about a quarter of the participants from outside Europe.

1997

- **ThermoSolar** (Slovakia) starts large-scale manufacturing of a flat vacuum collector (TS400).

1998

- Development of laser welding.

1999

- The City of Barcelona, Spain required new buildings with more than 20 dwellings to have solar water heater .
- "PHOTONIO" The world's largest solar air- conditioning project with 2664m² of panels and 700kW of absorption chillers is installed in Sarantis, Greece.
- **China National Center for Quality Supervision and Inspection of Solar Water Heaters of China** was set up with the help of UNDP project. Since then, China began to establish the system of testing, standardization, and certification of solar thermal energy.

9.5 CSP 1990-1999

1991

- Luz, the company that built and operated the SEGS plants, went bankrupt when the price of natural gas fell, and certain policies expired. The SEGS plants continued to operate as the owners took over their operation.

1992

- SEGS 3-7, now operated by KJC Operating Company, started a 6-year O&M improvement program funded by DOE and managed by Sandia National Laboratory.

1995

- Solar 1 was reconfigured into Solar 2, a 10 MW molten salt tower with thermal energy storage and began operation.

1998

- A consortium of European companies and research centres commenced development of the Eurotrough, a parabolic trough collector, with funds from the EU.

1999

- Solar 2 successfully completed its tests and ceased operation.

9.6 Solar Architecture Buildings 1990-1999

1990

- In Japan a new solar cell roofing tile combining a building material (a glass Japanese-style roof tile) and an amorphous silicon (a-Si) solar cell was developed. It was made possible by developing new technologies for uniformly fabricating a-Si film on complex curved surfaces such as Japanese tiles and for patterning integrated-type solar cells on large-area curved surfaces.

1994

- German Architect Rolf Disch designs and builds the Heliotrope in Freiburg, Germany **The Heliotrope** was the first building in the world to capture more energy than it uses, all of which is entirely renewable, emissions free and CO₂ neutral. The structure physically rotates to track the sun, which allows it to harness the maximum natural sunlight and warmth possible.

1998

- Construction was completed on 4 Times Square, the tallest skyscraper built in the 1990s in New York City. It incorporates more energy-efficient building techniques than any other commercial skyscraper and also includes building integrated photovoltaic (BIPV) panels on the 37th through 43rd floors on the south- and west-facing facades that produce a portion of the buildings power.
- The **Florida Solar Energy Centre** undertook a demonstration project called the “Zero Energy Home.”

9.7 PV in Developing Countries 1990-1999

In the 1990s more multi-lateral and bi-lateral projects relating to solar are starting to be implemented in the developing countries. These were often demonstration projects and typically included subsidies for buying down the upfront cost. More businesses were opening up in some of the larger markets. New delivery models were being trialled such as micro-finance and later, fee-for-service.

- In 1990 1.5 billion people in the world did not have access to electricity, representing 28.6% of the total population. This had decreased to 1.35 billion by 1999, representing 22.4% of the total population.

Note: Though these figures show unelectrified people, there are also many people (estimated over 1 billion still in 2019) who live on unstable grids.

Table 17: Percentage of Population without access to Electricity 1990-1999

1990	28.6%
1991	28.4%
1992	27.4%
1993	26.8%
1994	26.5%
1995	26.0%
1996	24.8%
1997	24.1%
1998	23.5%
1999	22.4%

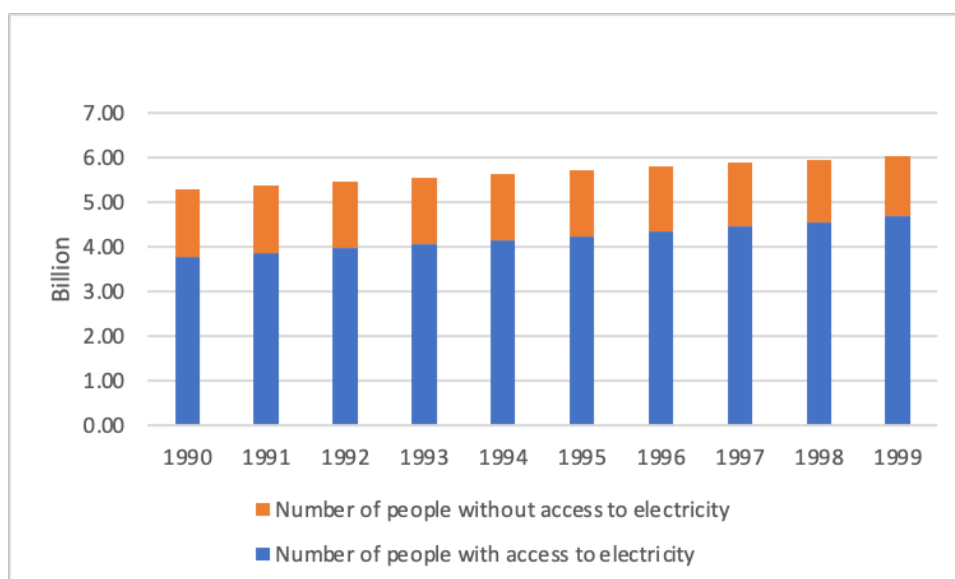


Figure 70: Access to Electricity 1990-1999

Table 18: Access to Electricity by Regions 1990 and 1999

Region	1990		1999	
	Number of People without access (million)	% of Total Population	Number of People without access (million)	% of Total Population
East Asia and Pacific	289.4	15.9%	196.6	9.7%
Latin America and Caribbean	64.3	14.4%	44.8	8.7%
Middle east and North Africa	34.6	13.5%	28	9.0%
South Asia	673.4	59.4%	581.7	42.7%
Sub Saharan Africa	430.5	84.1%	499.2	74.4%

Source for above data: <https://ourworldindata.org/energy-access>

- During the 1990s the Kenyan solar home system market becomes known as one of the most successful “commercially” driven markets. More companies entered the market during the 1990s including:
 - **Hensolex; Marathon Marketing** (1990).
 - **Energy Alternatives AFRICA** – founded by Mark Hankins and Daniel Kithokoi (1992).
 - **Rodson Electronics; Woodventure Kenya** (1992).
 - **Solagen** (1993).

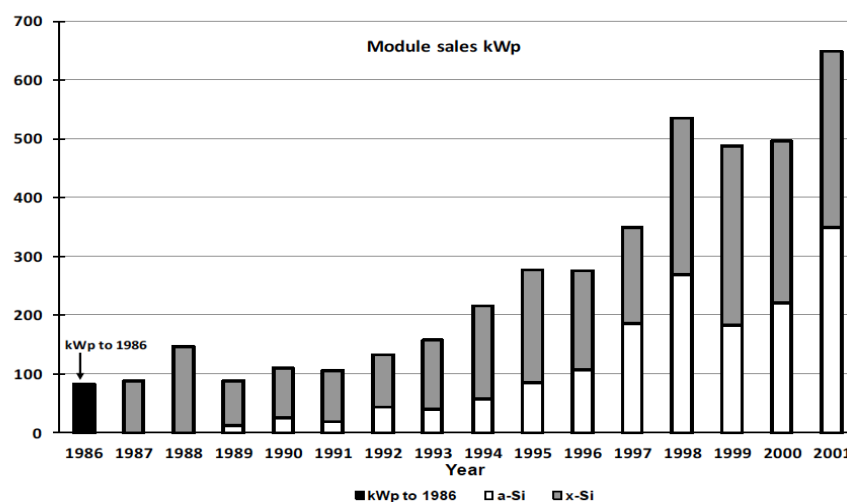


Figure 71: Estimated sales in solar modules in Kenya from 1986 to 2001. a-Si: amorphous silicon modules, x-Si crystalline silicon modules

Source: Mark Hankins

1990

- By 1990 **Enersol** had financed and supplied 1000 systems in Dominican Republic.
- In June, Neville Williams launched the **Solar Electric Light Fund (SELF)** with a mission to bring solar electric lighting to rural people in the developing world. It obtained grants which were then used to establish pilot projects in countries providing solar home systems. The owners paid back the systems, and this provided Seed funding to buy more systems and keep expanding.

1991

- **SELF** partners with the **Sarvodaya Economic Enterprise Development Services (SEEDS)** in Sri Lanka. to establish a solar fund within **SEEDS**. Dr A. T. Ariyaratne had founded **SEEDS** to provide small loans (before the term microfinance was used) to rural families.

1993

- In Kenya the **KARADEA Solar Training Facility** is constructed and runs its first solar training course; Hankins and Kithokoi are involved in the training.
- **Sundaya** is established by Bernard Castermans and Maurice Adema who believed in commercialising solar energy in Indonesia. They become one of the early manufacturers of solar home system packages including a battery box with inbuilt controller that was widely used in the 1990s and 2000s. The founders had a product design background and focused on developing products that are aesthetically pleasing in houses – not just system components.
- UN project planned by Neville Williams installs 11,000 SHS (lighting) in Zimbabwe in mid 90s, financed by local banks.
- Neville Williams with Professor Wang Anhua (Gansu Natural Energy Research Institute) with funding from Rockefeller Foundation launches the **Gansu PV Company** to manufacture plug and play solar electric systems.
- Harish Hande visits the SELF office in Washington with the aim of working for SELF and to take solar electrification to the rural people in India. **SELCO India** was co-founded by Harish Hande and Neville Williams in March 1995 and celebrated 25 years in 2020.
- **SELF** worked with the **Council for Renewable Energy (CRE)** and a newly formed business, **Solar Electricity Company (SEC)** of Kathmandu to provide solar lighting to a village in Nepal, Pulimarang. **SELF** obtained the funding for 65 homes in the village and within one year increased to 100 homes using the income from the revolving fund. This led to the government arranging a 50 per cent subsidy through the country's network of agricultural banks, for borrowers to purchase solar home systems using one of the now three approved solar companies: SEC, Lotus Energy and Wisdom Light company.
- Priyantha Wijesooriya starts **RESCO** in Sri Lanka, originally supplying systems through the Sarvodaya program.

1994

- In 1994 **SELF** signs an agreement with the Vietnam Woman's Union to provide systems within Vietnam. Initial funds obtained from Wallace Global Fund and then from Rockefeller Brothers Fund.

1996

- Neville Williams registers the **Solar Electric Light Company (SELCO)** as a for-profit business. At first Neville liaises with S. David Freeman, however, then works with John Kuhns in order to raise working capital for the new company. He resigns from SELF and it is taken over by Bob Freling.
- Dr. Muhammad Yunus, started **Grameen Shakti** (**shakti** meaning "energy" in Bengali) as a not-for-profit company under the **Grameen Bank**. The goal of **Grameen Shakti** is to promote and supply renewable energy technology at an affordable rate to rural households of Bangladesh.
- Peter Varadi after consultation with the industry launches **PV GAP** with the objective of developing quality products standards and a quality mark for the PV industry.

1998

- **IEA PVPS** approves a task not focusing on member countries. **Task 9: PV in Developing Countries**, led by Bernard McNelis of IT Power, had its first meeting in October 1999 in the Netherlands. The task continued in a number of different forms until about 2018. Over the years many Recommended Practice Guides were developed, and workshops undertaken in Africa and Asia.

Donor Projects in the 1990s

Multi-lateral and bi-lateral donors' interest in supplying solar power to rural communities grew in the 1990s. The following provides a brief sample of projects from the German Technical Cooperation Agency GTZ (Gesellschaft für Technische Zusammenarbeit) now GIZ and the World Bank Group. These have been included to provide an overview of the type of projects that were undertaken. All these projects led to the industries developing in the various countries where the projects were undertaken.

German Technical Cooperation Agency GTZ

The following were projects listed in a case studies document prepared by the IEA-PVPS Task 9 – PV in Developing Countries.

- In 1990 the German Government funded an “International Field-testing and Demonstration Programme for Photovoltaic Water Pumps (PVP)”. The PVP programme was being conducted by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH (now GIZ). The GTZ implemented the PVP Programme in co-operation with national energy and water authorities in Argentina, Brazil, Indonesia, Jordan, the Philippines, Tunisia and Zimbabwe. In the course of the PVP Programme, a total of 90 PVP systems had been installed at selected sites in the project countries. Those systems provided potable water to people of the village communities and their livestock.
- In Namibia (1996) GTZ launched a pilot phase with approximately 100 SHS to provide the background information for the design of a dissemination strategy. The findings from the pilot phase revealed that local availability of skilled manpower, sound solar companies as system suppliers, as well as private ownership of the SHS and avoidance of direct government subsidies are crucial success factors for the sustainable dissemination of SHS in rural areas. The so-called Home Power! Program 4 was then launched in all 13 provinces of Namibia in 1997 and implemented in four annual phases up to 2001. Each phase was subject to a public tender to select accredited suppliers.

World Bank Group

In the early 1990s, the World Bank Group (World Bank and International Finance Corporation IFC)) recognized that solar home system technology was maturing, costs were declining, and commercial markets were developing. At the same time, population growth was outpacing the ability of electric utilities to extend rural electricity grids and developing countries were increasingly recognizing the economic difficulties of achieving full grid-based rural electrification. The World Bank and many governments began to perceive that solar home systems could provide least-cost rural electrification and could supplement grid-based electrification policies. Between 1992 and 2000 the World Bank Group approved 10 projects. The following table provides information on those approved during the 1990s.

Table 19: World Bank Group Solar Projects in Developing Countries: Approved 1990-1999

Country	Project	Systems	PV Capacity (kWp)	Total Project Costs # (\$ millions)	Year Approved
World Bank Projects					
India	Renewable Resources Development	45,000	2,500	24.0	1992
Madagascar	Energy Services/Delivery/Integration of Renewable Energy *	15,000	625	7.5	1996
Sri Lanka	Energy Services Delivery	19,400	776	7.8	1997
Indonesia	Solar Home Systems	8,500	425	3.8	1997
Laos	Southern Provinces Rural Electrification	4,000	160	1.3	1998
Argentina	Renewable Energy in the Rural Market (PERMER)	8,300	1,521	18.3	1999
Cape Verde	Energy and Water Project	4,500	129	2.5	1999
International Finance Corporation (IFC) Global Programs					
Bangladesh, Vietnam, Honduras, Dominican Republic	Loans to Solar Home Systems Companies through SME Program	15,800	732	6.3	1994
Kenya, Morocco, India	Support to Solar PV Companies - PV Market Transformation Initiative (PV MTI)®			19.0	1996
Global	Renewable Energy and Energy Efficiency Fund				1996
Global	Solar Development Group			16.0	1998
TOTAL		120,500	5,218	106	

Source Anil Cabraal: World Bank (retired)

9.8 Research Pioneers 1990-1995



Pietro Altermatt

Country: Switzerland

Year Started Research: 1990

Title of Research: 24% efficient silicon solar

University: UNSW Sydney Australia

Still Active in Research: Yes

Pietro started researching SIPOS cells as a student assistant in Ernst Bucher's group at Konstanz University, Germany, in 1990. He joined Martin Green's group at UNSW in Sydney, Australia, in 1993, for his Master thesis, supervised by Armin Aberle and Gernot Heiser. In subsequent years, Pietro revived numerical modelling of Si solar cells and derived the literature value for the intrinsic carrier concentration of Si, consistent with band gap narrowing and Auger recombination. This formed the basis of the Si solar cell modelling that is standard today. Pietro contributed to the following laboratory world records at that time: 24% PERL cell in 1994, 25% PERL cell, 18.2% multicrystalline PERL cell, and 21.1% n-type Cz solar cell. His models showed the feasible potential for Si solar cells, which helped foster large-scale industry investments in Japan and Germany. Pietro moved to Germany in 2005 to set up a modeling group at Hannover University and ISFH, headed by Rolf Brendel. Pietro extended the models successfully for the first time to industrially fabricated cells, in collaboration with the German PV industry. The models triggered for example the removal of phosphorus clusters in the emitter and contributed to efficiency improvements across the entire PV industry in subsequent years. In 2015, Pietro became Principal Scientist at the State Key Laboratory of PV Science and Technology (SKL) at Trina in Changzhou, China, led by P. Verlinden. Pietro's modelling and experience from UNSW helped introducing PERC cells in China, and he contributed to the following world records of industrial, large-area cells at that time: 21.25% multi PERC, 22.13% mono PERC, 19.2% multi PERC module, 25.05% screen-printed IBC cell, 24.58% i-topCon cell, 23.2% quasi-mono n-type cell, and 23.39% PERC. Pietro currently promotes the development of transparent passivating contacts for the next generation of industrial solar cells.



Richard Corkish

Country: Australia

Year Started Research: 1990

Title of Research: Doctor of Philosophy in Electrical Engineering. Thesis: Limits to the Efficiency of Silicon Solar Cells. Supervisor: Professor Martin A. Green.

University: UNSW, School of Electrical Engineering

Still Active in Research: Yes

Dr Richard Corkish has been working in photovoltaics research and education, mainly at UNSW, since 1990. From 2003 to 2013 he led, as Head of School of Photovoltaic & Renewable Energy Engineering (SPREE), the globally leading photovoltaics research team and pioneering photovoltaics education program at UNSW. In that decade, the School's budget approximately quintupled, the student numbers reached almost 600 and SPREE alumni changed the face of the national and international industries. Dr Corkish is currently Chief Operating officer of the Australian Centre for Advanced Photovoltaics, the premier Australian photovoltaics R&D partnership, an Advisor to the Indian National Centre for Photovoltaics Research and Education and an Editor for the IEEE Journal of Photovoltaics. His current research activities are life cycle assessment of photovoltaics technologies and photovoltaics recycling. He has supervised the projects of over 200 students, including for the UNSW ERV project, educating through practice while bringing light and power to remote villages in Vanuatu. He has published over 50 journal papers, book chapters and books and over 150 conference papers.



Harald Drück

Country: Germany

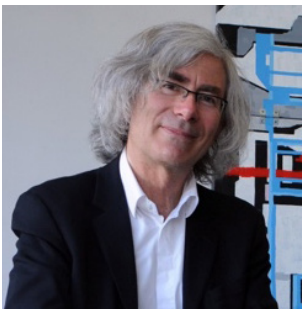
Year Started Research: 1990's

Title of Research: Testing of controllers for thermal solar systems - [oldest found]

University: Stuttgart University

Still Active in Research: Yes

Dr.-Ing. Harald Drück is a Mechanical Engineer who has been working at the Institute for Thermodynamics and Thermal Engineering (ITW), University of Stuttgart for more than 20 years. Since 1999, he is the head of the Research and Testing Centre for Solar Thermal Systems (TZS). His main research interests lie in the field of solar thermal technology focusing on advanced heating and cooling systems as well as thermal energy storage and the development of performance testing methods as well as energy efficient solar buildings. He is convenor of several German and European working groups related to standardisation and testing of solar thermal systems and components such as the Global Solar Certification Network, the German standardisation committee for solar thermal products and the Solar Certification Fund. With regard to education and knowledge transfer, he globally acts as an advisor to several high-level organisations, is chairman or member of the scientific board of several conferences and workshops and teaches a highly successful post-graduate course on solar thermal energy at the University of Stuttgart. Furthermore, he was one of the initiators of the German and European Solar Thermal Technology Platforms and is today a member of the steering committees of both platforms, as well as a director in the Board of Solar Heat Europe since 2016. More on his research: <https://www.sciencedirect.com/science/article/abs/pii/S0038092X08000443>



Roger Fay

Country: Australia

Year Started Research: 1990

Title of Research: Sustainable Suburbia

University: Deakin University

Still Active in Research: No

Emeritus Professor Roger Fay has undertaken research, teaching and consultancy projects in the discipline of architecture at Deakin University and the University of Tasmania. His teaching included building technology and design – all with a focus on built environment sustainability. He held a number of positions within the University including Professor and Head of the School of Architecture & Design, Associate Dean, Chair of the university's Social Sciences Human Research Ethics Committee and the Institutional Research Grants Committee and a member of the University Built Environment Committee under whose auspices Professor Fay established and chaired the University Environment Management Committee. His research areas include sustainable suburbia, life cycle energy costing, embodied energy, energy efficiency, building environmental rating systems, affordable housing, place making, and later in his research career, the design of sustainable residential aged care facilities for people with dementia. Professor Fay has been published in key international research journals and has delivered research papers at conferences within Australia and internationally. He has also contributed to the Australian Institute of Architects with articles to EDG (the Environment Design Guide) and served on the AIA's Education and Environment Committees and the National Environment Notes Editorial Sub-Committee. A key research project includes the development of the National Australian Building Environmental Rating System (NABERS) with Professors Robert and Brenda Vale. Professor Fay has supervised a number of higher degree students, many of whom have gone on to illustrious academic and research careers in the field of life cycle energy efficiency including Associate Professor Graham Treloar and Dr Mark Dewsbury. He has served on a number of committees including the CIB Working Commission (W100-Environmental Assessment of Buildings) as well as the PLEA Technical Committees and International Reviewer. Professor Fay has served as both an International and an OZReader for the Australian Research Council.



Paul Funk

Country: United States

Year Started Research: 1991

Title of Research: Analysis of a solar box cooker for East Africa

University: University of Minnesota

Still Active in Research: Yes

Paul Funk has been an ardent researcher and solar cook for over thirty years. Dr. Funk realized firsthand the need for alternatives to cooking over open fires when he saw women in Tanzania spending 20 hours a week collecting firewood. The experience compelled him to change his master's thesis topic at the University of Minnesota to solar cooking. He continued solar cooking research for his doctorate in Agricultural Engineering at the University of Arizona. His dissertation work eventually led to the development of the international standard "Testing and Reporting Solar Cooker Performance," published by the American Society of Agricultural and Biological Engineers (ASABE). Paul served on Solar Cookers International's (SCI) Board of Directors from 2000 to 2002, advocating for the harnessing of free solar thermal energy. Dr. Funk has published numerous peer reviewed journal articles and presented papers at many international conferences. Dr. Funk also designs solar cookers. ASABE is recognized worldwide for developing voluntary standards for food, agricultural, and biological systems. In 2013, it replaced its solar cooker testing standard with Dr. Funk's "Testing and Reporting Solar Cooker Performance" standard. The standard promotes uniformity and consistency in the terms and units used to describe, test, rate, and evaluate solar cookers. Dr. Funk's international test standard allows people to test solar cookers with inexpensive tools in remote locations. Dr. Funk spent three months in a rural village living in a mud hut, so he appreciates that test conditions may not be supported with urban infrastructure or utilities. This standard is now a part of the standards produced by the International Organization for Standardization (ISO) for clean cookstoves and clean cooking solutions. SCI has automated the standard in its Performance Evaluation Process, which has brought Dr. Funk's work into the forefront of providing accountability to the solar cooking sector.



Oliver Hartley

Country: Australia

Year Started Research: 1994

Title of Research: Electrochemical Solar Cells

University: Hahn-Meitner-Institute, Berlin, Germany

Still Active in Research: No

In 1994, Oliver Hartley started out as a research assistant with Prof. Lewerenz at the Hahn-Meitner Institute (now part of the Helmholtz Zentrum Berlin), Germany. His initial work was to create technical drawings on the physics of solar cells for the book "Photovoltaik" by H.J. Lewerenz and H. Jungblut, published in German in 1995. His first research work in 1994/95 as part of his Masters Thesis was on electrochemical solar cells and electrochemical modification of silicon surfaces for solar cells followed by first publications in 1996. In parallel, Oliver was part of a team of authors of a study called: "Sustainable energy supply in 2020: A critical survey of energy scenarios for Germany" which was presented in 1996 at the International Congress of Engineers and Scientists: "Challenges of Sustainable Development", Amsterdam (Aug. 1996) and then published in the magazine "Solarzeitalter" 1/1997. After this initial work he joined Prof. Martin Green at the University of New South Wales to carry out his PhD research on silicon thin-film solar cell technology between 1997 and 2000. Finally, Oliver was responsible in running the mono-crystalline high-efficiency silicon cell research at BP Solar in the UK until BP shut its European Technology Centre for solar cell research in 2003. At that stage he said goodbye to research, and moved over into the business world of the solar industry. Over the years, he has been responsible for the commercialisation of various thin-film solar technologies, M&A activities in the solar energy space, business development and finally entrepreneurship in the solar industry when he founded Epho Pty Ltd in 2014 to provide solar power solutions for commercial and industrial clients across Australia. It is now that Oliver has come full circle and focuses his efforts more on R&D again to develop solutions for solar energy integration into Australia's national electricity market.



Isaac Itodo

Country: Nigeria

Year Started Research: 1990

Title of Research: The effects of media materials, temperature and total solids concentration of poultry waste on biogas yield

University: University of Ibadan, Nigeria/Agricultural Engineering Laboratory

Still Active in Research: Yes

Prof Itodo research has always been about anaerobic bio-digestion an area important in the filed of biomass. Here Prof Itodo describes the research he undertook. The anaerobic bio-digestion of fresh poultry waste was investigated under three situations. In the first, the effect of suspended obeche media materials occupying 0%, 5% and 10% of the digester volume on biogas yield was determined during a 15-day detention period at ambient temperature. In the second, waste was biodegraded and compared at the mesophilic and thermophilic temperatures. The thermophilic temperature was achieved by putting a digester in a solar house that was designed and built. In the third, the effect of temperature fluctuations on biogas production was investigated. The results showed that the use of Obeche as media materials improved the initiation of biogas production even in slurries of high TS. Biogas production commenced 18h after the introduction of waste into the digester as against 48h in the digester without media materials. The gas yield increased as the TS of the slurry reduced from 28% to 5%. It was found that even minimal temperature fluctuation from the thermophilic into the mesophilic range results in substantial reduction in biogas yield. Thirty colonies of bacteria cells, two fungi species and thirty two yeast cells were observed on samples of media materials which remained reasonably intact after 9 months' use. The highest gas yield was from 107 L/KgTS from a slurry of 5% TS in a digester of 0% media fill ratio at the mesophilic temperature range. The lowest gas yield of 7.62 L/kgTS from a slurry of 28% TS in a digester of 0% media fill ratio at the mesophilic temperature. The efficiency of bioconversion varied from 18% to 49%. This study showed the advantage of using media materials in the rapid start-up of the anaerobic digestion process and the adverse influence of temperature fluctuation on gas yield.



Soteris Kalogirou

Country: Cyprus

Year Started Research: 1992

Title of Research: Use of Solar Parabolic Trough Collectors for Hot Water Production in Cyprus - A Feasibility Study

University: Higher Technical Institute (HTI) - Cyprus University of Technology (CUT)

Still Active in Research: Yes

Professor Soteris Kalogirou is at the Department of Mechanical Engineering and Materials Sciences of the Cyprus University of Technology, Limassol, Cyprus. He is currently the Dean of the School of Engineering and Technology. He received his Ph.D. in Mechanical Engineering in 1995 and the D.Sc. title in 2011. He is a Fellow of the European Academy of Sciences and Founding Member of the Cyprus Academy of Sciences, Letters and Arts. Since the early 90's, he is actively involved in research in the area of solar energy and particularly in the design of improved flat plate and concentrating collectors for solar water heating and solar steam generating systems and he was one of the first who designed hybrid PV/T collectors. Other areas include solar desalination, photovoltaics, geothermal heat exchangers and absorption cooling. He was also involved in solar meteorology and he developed the TMY for Cyprus. Additionally, he was involved in a pioneering research dealing with the use of artificial intelligence methods, like artificial neural networks, genetic algorithms and fuzzy logic, mainly for the modelling and performance prediction of energy and solar energy systems. Another pioneering research area is on building integration of solar thermal systems (BISTS), for which he chaired also COST Action TU1205. He has a large number of publications as books, book chapters, international scientific journals and refereed conference proceedings. His current h-index in Scopus is 64. He is Editor-in-Chief of Renewable Energy and Deputy Editor-in-Chief of Energy, and Editorial Board Member of another twenty journals. Among other books he is the editor of the book McEvoy's Handbook of Photovoltaics, and author of the books Solar Energy Engineering: Processes and Systems, and Thermal Solar Desalination: Methods and Systems, all published by Academic Press of Elsevier. He is a member of International Solar Energy Society (ISES) since 1992.



Linda Koschier

Country: Australia

Year Started Research: 1995

Title of Research: Multijunction and novel silicon photovoltaic device structures

University: University of New South Wales, Sydney

Still Active in Research: No

Linda Koschier has more than 20 years' experience in the solar energy industry covering a broad range of areas across the entire value chain. Early research began in 1994 with her undergraduate thesis focusing on the multijunction multilayer solar cell that went on to be commercialised by Pacific Solar, a UNSW spin off formed in 1995. Following her undergraduate research further research was undertaken during her PhD on multijunction and other novel silicon photovoltaic devices. This work involved the novel use of aluminium induced crystallisation to form a rear contact on a buried contact solar cell. Subsequent to this PhD research Linda entered the solar industry in early 2000 relocating to the USA to work with a University of Delaware spin off manufacturing solar cells and modules, Astropower. Early work at Astropower included research on solar cells and modules with a focus on screen printed solar cells. Linda has worked in the solar industry from early 2000 until present holding various roles including head of partnerships at Origin Energy, Head of Corporate Partnerships at EnergyLab, Director Strategic Development at UNSW Photovoltaics & Renewable Energy Engineering school, Director Strategic Sales for Meyer Burger/Roth & Rau, VP Business Development for BT Imaging, and Business Development Manager for Amonix Inc. Linda also holds an MBA from the AGSM and is a graduate of the Australian Institute for Company Directors. Linda is also currently Director of the APVI, on the board of advisors of Tractile P/L and Assurance Lab P/L and the Task 1 member for Australia on the IEA PVPS committee.



Jaideep Malaviya

Country: India

Year Started Research: 1995

Title of Research: Solar Photovoltaics market research and solar thermal technology research cu markets

University: The Energy Resources Institute / Solar Thermal Federation of India

Still Active in Research: Yes

Jaideep Malaviya started his research as Research Associate with The Energy Resources Institute (TERI) in the field of solar Photovoltaics in 1992 until 1996. Later he became an entrepreneur and associated with multiple institutions for undertaking market research on solar photovoltaics and offering training for installation and maintenance. Until now he has trained over 1,000 technicians and technical experts, several of them are successfully running their business and India has now a nett installed PV capacity of an impressive 35 GW. In the year 2000 he actively started research in solar thermal technology development by guiding entrepreneurs and industries to develop solar thermal technologies that will be self-sustaining. Through them Jaideep undertook over 50 awareness programmes on promoting solar water heating systems. During 2000 - 2010 India installed close to 4.5 million m² collector area. In 2010 he founded Solar Thermal Federation of India (STFI) world's first national solar thermal manufacturers body and is today the industry's voice on industry related issues and guiding government on policy framing. Jaideep subsequently started the world's first National Solar Energy Helpline in the same year until 2018 when the Federal Ministry took over. During this period, it handled almost 11 million voice calls guiding all categories of persons. In fact, the manufacturers have shared their testimonial that the voice Helpline was a vital tool for one to one interaction which best guided the caller and resulted in market development. During the period 2010 to 2019 the Indian market grew to 11.7 million m² installed area and with a cumulative of over 17 million m² installed area India was third best market globally after China and Turkey. It was during this year that several incentive measures suggested were implemented like property tax rebate for individual beneficiaries, accelerated 100% depreciation benefit resulting in income tax savings for commercial and industrial users, mandatory installation in new residential buildings, hotels, hospitals and student hostels that resulted in over 30 GW peak demand savings for electricity.



Markus Peter

Country: Germany

Year Started Research: 1993

Title of Research: Investigations on paraffin-based latent heat stores and development of a prototype

University: University of Applied Sciences, FH Aachen

Still Active in Research: Yes

Starting 1988 with freelance work on the thermal use of solar energy, since 1993 Markus Peter is involved in research projects and service work in the field of solar energy and other renewables. He is active in IEA Tasks, standardization and quality improvement in different areas of solar engineering. Since 2002 in parallel he runs an engineering office.



Gonzalo Piernavieja

Country: Spain

Year Started Research: 1991

Title of Research: Performance Comparison between fixed and tracking grid-connected PV arrays

University: Ludwigs-Maximilians University Munich

Still Active in Research: Yes

University (Germany): set-up of experimental grid-connected PV plant in Munich; development of a tracking system; test of inverters (1991-1992) Back in Spain: a) University of Las Palmas de Gran Canaria: European projects dealing with renewable energies and water desalination (1993-1996), b) Set-up of the Canary Islands Institute of Technology (www.itccanarias.org) (1996 on); research in: desalination powered by renewable energies; energy storage technologies; sustainable mobility; energy planning; integration of renewable energies and hydrogen technologies; waste to energy; circular economy; further areas: Solar radiation and solar resource assessment; wind resource assessment; prediction of solar and wind energy; solar thermal energy; solar photovoltaic energy; wind energy; distributed energy generation (incl. renewable energy storage); penetration of renewable energies in insular electricity grids; strategies for deployment of renewable energies in islands; wind-pumped hydro systems; insular 100% renewable energy models; hydrogen technologies (focus: electrolysis driven by renewable energies); technological cooperation with less developed countries in renewable energy and water projects, including technology transfer; development of circular economy models (especially for islands/isolated regions/remote areas).



João Pinho

Country: Brazil

Year Started Research: 1994

Title of Research: Study and Development of Energy Alternatives, mainly solar PV, wind, and hybrid systems for both on- and off-grid applications

University: Grupo de Estudos e Desenvolvimento de Alternativas Energéticas / Universidade Federal do Pará

Still Active in Research: Yes

João Tavares Pinho is Electrical Engineer by the Universidade Federal do Pará in 1977; Master in Electrical Engineering by the Pontifícia Universidade Católica do Rio de Janeiro in 1984; and Doctor in Electrical Engineering by the Rheinisch-Westfälische Technische Hochschule Aachen (Germany) in 1990. He was Assistant Professor at the Universidade Federal do Pará (UFPA) since 1978, and Full Professor from 1998 to 2018, when he officially retired on June 1st. He was Founder and Head of the Grupo de Estudos e Desenvolvimento de Alternativas Energéticas (GEDAE) from November 1st, 1994 to May 31, 2018; Head of the Instituto Nacional de Ciência e Tecnologia de Energias Renováveis e Eficiência Energética da Amazônia from 2008 to 2016; Technical Director of the Instituto para o Desenvolvimento de Energias Alternativas na América Latina from 2012 to 2018; Director of Science and Technology at the State Secretariat of the Government of Pará from January 2015 to May 2016; President of the Brazilian Microwave and Optoelectronics Society from 2004 to 2006; President of the Brazilian Section of the International Solar Energy Society from 2007 to 2011; President of the Brazilian Solar Energy Association from 2009 to 2011, and from 2017 to 2019; Member of the Board of Directors of the International Solar Energy Society from 2014 to 2015. His research work has been focused mainly on solar and wind energy, hybrid systems, and micro-grids, for both on- and off-grid, as well as for productive applications. He has both Brazilian and Portuguese nationalities, and besides Portuguese, he speaks English, German, and Spanish. Presently he works as senior researcher at GEDAE/UFPA and visiting researcher at the Institute of Energy and Environment of the University of São Paulo (IEE/USP), as well as consultant and member of several councils, financing institutions, and scientific societies.



Ricardo Rüter

Country: Brazil

Year Started Research: 1992

Title of Research: PhD Work on amorphous silicon PV (title unknown)

University: University of Western Australia

Still Active in Research: Yes

Ricardo Rüter is a Professor of Solar Energy at Universidade Federal de Santa Catarina (www.ufsc.br) in Florianópolis-Brazil, where he carries out R&D and academic activities in the field of solar photovoltaics, solar irradiation resource assessment, electrochemical storage and electromobility. He completed a BE with honours and a M.Sc. degree in Metallurgy and Materials Science at Universidade Federal do Rio Grande do Sul in Brazil, and obtained his Ph.D. from the University of Western Australia at the Department of Electrical & Electronic Engineering. He was an Alexander von Humboldt post-doctoral research fellow at the Fraunhofer Institute for Solar Energy Systems in Germany (from 1994), and was tenured at Universidade Federal de Santa Catarina in 2000, where he is the director of the Solar Energy Research Laboratory Fotovoltaica/UFSC (www.fotovoltaica.ufsc.br). Prof. Rüter was a member of the ISES Board of Directors in the 2005-2007 and 2008-2010 periods. He joined ISES in 1991, and became an ISES lifetime gold member in 2008. Ricardo Rüter not only has an excellent record list in research and teaching as a University Professor, he also contributes highly recognized to the promotion of RE in Brazil and world-wide.



Gerhard Stryi-Hipp

Country: Germany

Year Started Research: 2010 (industry 1994)

Title of Research: Fluid Flow Investigations of Bionic Absorbers Made From Aluminium and Steel

University: Fraunhofer ISE

Still Active in Research: Yes

Gerhard Stryi-Hipp is a physicist and an interdisciplinary expert on technologies, market development and policies in renewable energies and sustainable energy systems. From 1994 to 2008, he was managing director of the German Solar Industry Association BSW-Solar. He worked on market support policy for solar thermal and solar photovoltaic in Germany and Europe, on awareness campaigns, on quality assurance measures and technical innovations of the sector. He advocates for intensified research on renewable heating and cooling and was 2005 one of the initiators of the German and European Solar Thermal Technology Platforms. Since its foundation in 2008 found different data, he is president of the European Technology Platform on Renewable Heating and Cooling, which developed a vision, a research agenda and a roadmap for the sector. In 2009 he moved to the Fraunhofer Institute for Solar Energy Systems ISE as Head of Energy Policy and Group Leader Solar Thermal Systems. Since 2015, he is the head of the group »Smart Cities«, a research group that is developing modelling tools to identify and design cost-effective sustainable energy systems for cities and regions. Based on the modelling results, roadmaps for the transformation of urban energy systems towards sustainability are developed. In addition, they develop and coordinate Smart City lighthouse projects demonstrating and optimizing innovative technologies in energy, buildings, electric mobility and ICT. More on his research: https://beta.explore.openaire.eu/search/publication?articleId=dedup_wf_001::1286001626d22ca6f247aaa78c3cf051



Thorsten Trupke

Country: Australia

Year Started Research: 1994

Title of Research: PV related topics

University: University of New South Wales

Still Active in Research: Yes

Thorsten Trupke is a Professor at the School for Photovoltaic (PV) Renewable Energy Engineering at UNSW, where he leads a research team of approximately 15 staff, students and postdoctoral fellows. He is also co-founder and Chief Technical Officer of BT imaging, a Sydney based technology company providing high-end photoluminescence imaging systems to the Photovoltaic R&D community and to PV manufacturers. Thorsten started his career in PV research in 1994, at the University of Karlsruhe, Germany, with a thesis on the electroluminescence of silicon solar cells, performed under the supervision and guidance of Prof Peter Würfel. Thorsten has performed leading-edge and widely published research on numerous PV related topics across many different areas. As a postdoctoral Fellow he proposed, theoretically analysed and first demonstrated the concepts of combining solar cells with luminescence up- and/or down conversion. His work on the design and development of novel characterisation methods, including the invention and first demonstration of photoluminescence imaging in 2005, has revolutionized the measurement and characterization of silicon samples and devices. This work has had wide-ranging implications and benefits for PV research and development worldwide. The methods developed by Thorsten and his team, as well as the instruments commercialized by BT Imaging, have become standard tools across the world and are used on a daily basis, both in research labs and in high volume manufacturing. They continue to be crucial elements in the rapid improvement of silicon solar cell technology and associated cost reductions. Thorsten's impact and the quality and relevance of his work have been recognized by numerous awards, including the 2017 Engineers Australia Entrepreneur of the Year Award and most recently the prestigious 2019 Clunies Ross Innovation Award. Thorsten has been a Fellow of the Australian Academy of Technology and Engineering (ATSE) since 2016.



Klaus Vajen

Country: Germany

Year Started Research: 1991

Title of Research: Direct Coupling of PV system with a pump connected to uncovered collector field for heating a swimming pool.

University: University of Marburg (DE)

Still Active in Research: Yes

In July 1991 Prof. Ackermann, originally working on “traditional” solid state physics at the University of Marburg (DE), was awarded with his first grant for a research project in solar energy. He asked Klaus Vajen to be one of the two first PhD-students in the newly founded “Solar Energy Research Group” at the department of physics. The project dealt with the direct coupling of a 3 kWp PV-system with the pump for a 700 m² uncovered collector field for heating of a public swimming pool. The direct coupling didn’t deliver very promising results at the end, however both, the PV and the solar heating system were very large for the time being and they delivered a lot of interesting experimental and theoretical results. So, this project was the start of a fast-growing research group on solar energy at the University of Marburg and from 2001, continued at the University of Kassel (both in DE). By now, eight of the graduates became professors at different universities. The research in the “pioneer phase” included also the development of high-performance solar cookers. The oven reached more than 300°C with heat pipe vacuum tube collectors, the condenser was fixed in a boiling plate. But at that time the funding schemes in Germany were not as developed as today, so most of the projects were individual, we could seldom continue the research with a follow up project. Nevertheless, during that time solar researchers in Germany collected manifold experience in quite different fields like construction of components (collector, storage, ...) as well as monitoring, simulation and experimental investigations of complex heat supply systems which turned out to be very helpful later on.



Ruzhu Wang

Country: China

Year Started Research: 1993

Title of Research: Solar cooling with solar thermal and solar PV

University: Shanghai Jiao Tong University

Still Active in Research: Yes

Ruzhu WANG got his PhD in 1990 from Shanghai Jiao Tong University (SJTU), he became the director of the Institute of Refrigeration and Cryogenics of SJTU in 1993, and he was promoted to full professor in 1994. In 1993 he started to select solar cooling as his main research area, the first research project was solar adsorption refrigeration in which activated carbon-methanol was used as the working pair. As he was involved in solar thermal, thus he had a lot of collaborations with Chinese solar thermal industries like Himin, Lino, Sunrain and etc.. His research was developed with the growing market of Chinese solar water heaters and also solar heating/cooling and even solar medium temperature boilers for industry applications. He started solar PV powered cooling in 2006, and now he is also pioneered in solar PV driven air conditioning. Prof. Wang has published 4 books related to solar heating and cooling, such as *Advances in Solar Heating and Cooling*, Elsevier-Woodhead Publishing publications, 2016, ISBN: 978-0-08-100301-5; *Handbook of Energy Systems in Green Building*, Springer, 2018, ISBN: 978-3-662-49088-4; *Adsorption Refrigeration Technology: Theory and application*, John Wiley & Sons Singapore Pte. Ltd. 2014, ISBN: 978-1-118-19743-1; *Solar Refrigeration*, Chemical Industry Press (China), 2007, ISBN: 978-7-5025-9317-9. He has published a lot of research papers of solar cooling and presented a lot of keynote lectures in international conferences. Prof. Wang has published more than 500 SCI indexed papers with h index 69, and citations more than 17000 times. He was selected as Clarivate highly cited researcher in 2017 & 2018. He has won Chinese National Research Awards in 2010 and 2014 respectively. Prof. Wang received the J & E Hall International Gold Medal from the Institute of Refrigeration (UK) in 2013, Asia Refrigeration Academic Award in 2017, the Nukiyama Memorial Award from the Japanese Society of Heat Transfer in 2018, the IIR-Gustav Lorentzen Medal from the International Institute of Refrigeration in 2019.

9.9 Industry Pioneers 1990-1995



Dwipen Boruah

Country: India

Year joined industry: 1990

Company first worked for: Energy Science Centre, Assam Engineering College, Guwahati, India

Technology area: PV

Still active in the industry: Yes

Dwipen Boruah started his career in solar energy in 1990 as a Research Associate at Energy Science Centre, Department of Mechanical Engineering at Assam Engineering College during his first year of engagement after graduation from the same college. He designed and installed solar PV systems for mobile water pumping systems, a solar PV system to operate a fuel station and a standby power supply system. In 1992, he joined the Assam state nodal agency for the Ministry of New and Renewable Energy (MNRE), Government of India and worked for the agency for 13 years. During this period, Dwipen was responsible for the implementation of off-grid solar PV programmes of MNRE in the state of Assam. He was engaged in the electrification of 103 remote villages through off-grid PV systems and established a full-fledged facility for testing, monitoring and evaluation of off-grid solar PV lighting systems and components as a part of the programme. In 2007, he joined IT Power India, a reputed international renewable energy consultancy company as a Manager and was soon promoted to General Manager and Head of Renewable Energy Solutions. In 2012, Dwipen co-founded GSES India Sustainable Energy Pvt. Ltd. at New Delhi, India along with Geoff Stapleton. Since 2007, he has been providing professional consultancy and engineering services throughout several countries with clients from the corporate sector, governments, multilateral organisations and NGOs. Dwipen has worked and delivered more than 200 consultancy assignments across 21 countries and has a diverse portfolio of consultancy assignments that include renewable energy planning, project management, feasibility studies, detailed engineering design and due diligence services. Dwipen is a Master Trainer for GSES training programs conducted in India and abroad and has authored and co-authored books and training manuals on solar PV system design installation, maintenance and inspection. He is a Mechanical Engineer and completed his post-graduation in Renewable Energy from Oldenburg University, Germany.



Vaughan Boulwood

Country: Australia

Year joined industry: 1990

Company first worked for: Edwards Energy Systems Pty Ltd

Technology area: Solar Thermal

Still active in the industry: Yes

Vaughan Boulwood has been involved in the Education, Marketing and Sales of Solar Water Heaters both Domestic and Commercial since October 1990 and over this period of time he was a Pioneer in the establishment one of first Solar Thermal supply chains in Germany long before any of the local manufacturers established themselves as a major player. Over the past 30 years Vaughan Boulwood has been responsible for educating end users, Engineers and Governments on why Solar Thermal saves Energy, reduces Green House Gas Emissions in over 80 countries on 6 continents, from the Poorest nations like Madagascar and Zimbabwe to affluent Solar markets like Germany, France and Australia. Vaughan Boulwood started working in the Sales and Marketing of Domestic and Commercial solar thermal solutions for Edwards Energy Systems a reputable Australian water heater manufacturer who had been in the Solar Thermal business since 1962. He then moved on to a well reputed Solar Water heater manufacturer called Solahart Industries Pty Ltd in Australia who has been manufacturing Solar Water heaters since 1953. Major contracts have included the supply of Domestic solar water to large mines in Africa where several thousands of systems have been installed and saved countries like Botswana and South Africa from building additional power stations. Commercial solar thermal Water Heater Projects have been designed and implement throughout Africa, Middle East, Asia and the Pacific for Resorts, hotels, hospitals and food and beverage processing plants. In the past 30 years Vaughan Boulwood has spent more than 6 months a year flying hundreds of thousands of miles around the World on a mission to promote Solar Water Heating and he has several more years before he will consider retiring from the Global Challenge.



Victor de Sousa

Country: Australia

Year joined industry: 1995

Company first worked for: BP Solar Pty Ltd

Technology area: PV

Still active in the industry: No

Victor de Sousa joined BP Solar in 1995 as a Project Engineer in the Sales and Marketing Team in Sydney, Australia. He worked on numerous national and international projects, the highlight being the replacement of solar systems and batteries for Telstra in Cape York. He held various roles including Engineering Manager, Regional Sales Manager, Regional Commercial Manager and Global Performance and Planning Manager at BP Solar over a period of 17 years. Victor joined Solar Juice Pty Limited, the largest distributor of solar equipment in Australia, as General Manager for 4 years.



Renate Egan

Country: Australia

Year joined industry: 1994

Company first worked for: Pacific Solar Pty Ltd

Technology area: PV

Still active in the industry: Yes

Innovator, entrepreneur and academic, Renate Egan is passionate about using her skills to increase the uptake of solar and accelerate the energy transition. Recently described as one of Eight Great Women in the Business of Science and Solar by Renewable Energy World, she has led manufacturing and industrial technology development of energy technologies in Australia, Germany & China. Renate is currently, Chair of Solar Analytics, leads the UNSW activity in the Australian Centre for Advanced Photovoltaics and represents Australia on the IEA solar program PVPS. Renate started her Solar Pioneer journey with Pacific Solar Pty Ltd in 1994, in the first year of the company. Before joining Pacific Solar, Renate had been working in opto-electronics and optical fibre technologies. As a material scientist, Pacific Solar presented an opportunity to work in an emerging industry in Australia where she felt she could make a real & significant contribution. Renate worked with Pacific Solar to develop its thin film silicon on glass technology. Starting as a research scientist, Renate progressed to Pilot Line Manager. When the technology was ready to commercialise, Renate moved to Germany, with the team to set up CSG Solar AG, ultimately becoming CTO. CSG Solar built a 20 MW production line in 2005. This was big then! and the team delivered on the promise of 7% thin film modules, with a path to over 10%. Renate still has 1kW of CSG Solar panels powering her home. In 2007, Chinese module manufacturing had ramped up, bringing the beginnings of the vast manufacturing capability we all benefit from now. In 2009 CSG Solar the technology team came back to Australia and formed Suntech R&D Australia, under Renate's leadership as Managing Director. With a team of 15 Australian engineers, SRDA led long-term technology development for Suntech, then the world's largest module manufacturer. In 2014, Renate (i) joined the APVI as Chair, following Muriel Watt, (ii) co-founded Solar Analytics P/L, and, (iii) joined UNSW to run a research program with Prof Martin Green.



Hans-Josef Fell

Country: Germany

Year started promoting RE: early 1990s

Company first worked for: German Politician

Technology area: Policy

Still active in the industry: Yes

Hans-Josef Fell joined the Green Party in 1992 following years of interest in renewable energy and environmental protection. He was elected as a member of German Bundestag (parliament) in 1998 and remained a member to 2013. From 1999 to 2005, as spokesman of the Alliance 90/The Greens parliamentary group on the German Bundestag's research committee, Hans-Josef Fell helped to ensure an increase in funding for research into photovoltaics, concentrating solar power, geothermal energy, bioenergy, batteries for electric cars, bionics, nanotechnology and others. He served as a member of the Environmental Protection Committee, substitute member of the Committee on Economics and Technology and substitute member of the Defence Committee. Together with Hermann Scheer, he authored the 2000 draft of the Renewable Energy Sources Act, establishing the foundation for the technology developments in photovoltaic, biogas, wind power and geothermal energy in Germany. Fell is founder and president of the Energy Watch Group and an internationally renowned energy and climate change advisor, author and speaker. He has won many awards including: Solar Prize of the European Solar Energy Association(1994); Energy Globe Award (2000); Solar; German Solar Industry Prize (2002); Bonda Prize of (EPIA) (2006); Bavarian Order of Merit (2012) and The Order of Merit of the Federal Republic of Germany (2015).



Harish Hande

Country: India

Year joined industry: 1992

Company first worked for: SELCO

Technology area: PV

Still active in the industry: Yes

Harish Hande, the founder and Chief Executive of SELCO Foundation, is a renewable energy entrepreneur with over 25 years of grassroots experience in meeting the energy needs of underserved populations. He is also the co-founder (with Neville Williams) of SELCO India – a pioneering last mile rural energy enterprise based in India since the early nineties. SELCO sees the pressing need to develop a fertile environment to enhance sustainable energy access solutions for the poor. This energy access increases incomes, improves quality of life, and alleviates poverty, turning energy consumers into asset owners. Last mile energy solutions have clear commercial viability, and SELCO works to combine technical and non-technical aspects focused on alleviating poverty in a sustainable manner. Today, SELCO is an umbrella of organizations, each tasked to address gaps in the energy access ecosystem. SELCO India established in 1995 runs grassroots operations which sell, install, and service decentralized energy solutions like solar lights systems for households, institutions, digital education, livelihood appliances etc. financed by local financial institutions. SELCO Foundation established in 2010 is an open-source innovation research lab for replicable social innovations across areas: livelihoods, education, and health. SELCO's incubation program created in 2012 nurtures and catalyzes aspiring clean energy enterprises that deploy and maintain sustainable solutions for underserved communities. Finally, SELCO Fund registered in 2016 is an impact fund that seeks to deploy patient capital such as equity or debt to last mile energy access enterprises. SELCO operates at every level of the system and at every point in the supply chain, to build an ecosystem that increases accessibility, affordability, and appropriate renewable energy solutions for the poor. Collectively SELCO has so far impacted over 2 million people. Harish, a graduate from the Indian Institute of Technology, Kharagpur and a Masters and PhD from University of Massachusetts, US. In recognition of his vision and the efforts of SELCO, they have been awarded national and international awards including the reputed Zayed Future Energy Prize in 2018 and the Skoll Award for Social Entrepreneurship – 2018. In 2011, Harish was conferred the Ramon Magsaysay Award in recognition of his vision to catalyze development outcomes via sustainable energy.



Eric Hawkins

Country: United Kingdom

Year joined industry: 1991

Company first worked for: Quality Services Ltd

Technology area: Solar Thermal

Still active in the industry: Yes

After 10 years in the plumbing, heating and bathroom industry as his own boss, Eric Hawkins ventured into designing a new type of hot water tank, now called a Thermal Store. It was during a home installation that he looked at how to pre-heat the cold mains water to increase the efficiency through ST. This led to his first solar thermal collector design, which he later included in a container to Cyprus in 1993, where Eric then spent the next 5 years. During this time there, he educated himself about what was failing in ST and set up a new business importing evacuated tubes from China, as well as testing the SUNDA heat pipe collector. On his return to UK with a SUNDA UK agency, Eric set up a new business named Global Warming Solution Centre, followed by Powertech Solar Ltd. In 2001 he went to China to see how the SUNDA tubes were manufactured and to two other factories. In 2002, he was contacted by an Australian working in China, wanting to discuss a JV to establish an own brand, but he had no experience in this field. In 2003, the first samples arrived in UK for testing, which later were marketed as the Apricus brand. In 2008, Eric started a second JV, to produce his second evacuated tube heat pipe design named Suntech Solar, which he managed to export to his USA partner and to his UK Company. Then the banking crises happened and the company went into administration in 2009, as well as the loss of Suntech Solar China. Eric's current innovations are a new PVT solar panel on test in NSW, and an updated domestic Thermal Store up to 500L in UK, while his commercial flat pack thermal Stores produced in South Africa have reached 600.



Trevor Horman (Deceased)

Country: Australia

Year joined industry: 1990

Company first worked for: Power and Water

Technology area: PV

Still active in the industry: No

The late Trevor Horman AM was a long-serving Northern Territory engineer, public sector employee and a key driving force in laying the Territory's solar foundations. Over his career, he mentored many young engineers. Trevor commenced his career in 1968 with the Commonwealth Department of Construction in Melbourne. In 1971, he started with the Northern Territory's Electricity Supply Undertaking, now the Power and Water Corporation, as an electrical engineer. In a career spanning more than 50 years, Trevor held many senior roles including Chief Engineer, Manager Strategic Planning and Manager Sustainable Energy. Notably, Trevor worked to improve the safety of rooftop photovoltaic (PV) systems to establish them as a long-term, reliable energy source and was the author of Power and Water's first Roadmap to Renewables document. He oversaw the installation of the corporation's first diesel/solar/battery hybrid system for remote Aboriginal communities in Jilkmiggan as well as numerous landmark solar projects in the early 1990s and 2000s, including Australia's largest solar power station at the time, the 225kW PV station in Kings Canyon. He helped develop the first use of power purchase agreements for isolated power systems and was involved in advancing what was then Australia's largest tracking station, the 1MW Uterne solar PV tracking station in Alice Springs. Trevor was deeply engaged with policy development, researching demand management and load management options for urban and remote communities. He was also passionate about developing solar energy sources and supporting clean energy projects such as Alice Springs Solar City. Trevor commissioned wind resource mapping in the Northern Territory, trialled a mini-hydro project at Manton Dam and supported tidal power trials in the Territory's Clarence Strait. Trevor passed away in late 2019. His legacy continues to be honoured through a scholarship for undergraduate engineers at Charles Darwin University.



Arne Jacobson

Country: United States

Year joined industry: 1990

Company first worked for: Eclectic Electric (New Mexico-based electrical contractor and solar installer)

Technology area: PV

Still active in the industry: Yes

Dr. Arne Jacobson is Director of the Schatz Energy Research Center at Humboldt State University in California (USA). His involvement in the renewable energy sector dates back to 1990, when he began an apprenticeship in New Mexico with electrical contractor and solar designer/installer Bob Thatcher of Eclectic Electric. Since then, he has worked actively on renewable energy projects and research in over 20 countries in North America, South America, Africa, and Asia. He has degrees from Earlham College (bachelor's degree in physics), Humboldt State University (master's degree in environmental systems), and the University of California, Berkeley (Ph.D. in energy and resources). For the past decade, Dr. Jacobson has served as the technical lead for the World Bank Group's Lighting Global Quality Assurance program for off-grid solar products (the program was recently renamed VeraSol). As of December 2019, over 42 million off-grid solar products certified through the program have been sold globally. The large majority of these products are sold into markets in Africa and Asia for use by people without access to reliable electricity from the grid. Dr. Jacobson currently serves as co-chair of Joint Working Group 1 (JWG1) of IEC Technical Committee 82 (solar photovoltaics). JWG1 of IEC TC 82 manages test methods, standards, and guidance documents related to off-grid renewable energy systems. While much of Dr. Jacobson's work has focused on solar power systems and improved access to energy in off-grid and weak-grid areas, he has also worked on projects involving wind power, biomass energy, clean transportation, energy efficiency for appliances, and other related topics.



Gerhard Kleiss

Country: Germany

Year joined industry: 1991

Company first worked for: Fraunhofer ISE

Technology area: PV

Still active in the industry: Yes

Gerhard Kleiss received his Diplom in Physics in 1993 from Freiburg University, Germany, where he was writing his thesis at Fraunhofer ISE in Freiburg. The research at Fraunhofer ISE (which in fact started in 1991) was continued in combination with research at CEA Cadarache, St-Paul-lez-Durance, France, in a team what was then called the "Groupement Energétique de Cararache". Research was on outdoor performance of PV modules including a-Si:H products and was leading to his doctoral thesis. Gerhard received a title as Dr.-Ing. from the faculty of EE of TU Berlin. Gerhard worked from 1996 to 1998 for TNC Energie Consulting GmbH, directed by A. Goetzberger and Th. Nordmann, focused on early realizations of PV noise barrier installations as well as related EU projects. In 1998 Gerhard joined the newly forming team of Shell Solar in Hamburg. He initially covered project business and became later responsible for national direct sales and in particular for the sales center in Berlin, which he personally directed. In 2003 Gerhard changed again to a newly uprising solar company, namely SolarWorld in Bonn. Initially he directed Marketing and Product Management for SolarWorld. In 2006 SolarWorld took over former Shell Solar and Gerhard was responsible for managing the operational side of the merger and was later nominated MD for some former Shell Solar entities. Later he became Director for Product Engineering and Quality. He was in charge for the product of all manufacturing sites world-wide including toll manufacturers. Gerhard stayed with SolarWorld until 2017 and took a decision to continue working in the solar sector, first as a self-employed free-lancer. He also started in 2017 to work for iiDev, continuing renewables and solar projects in the development sector. In 2018 he started a new company, 8.2 Arp & Kleiss GmbH, focused on quality and reliability in PV, including the newly developing storage sector. Since 2012 Gerhard is teaching at UNI Hannover "Use of Solar Energy". Gerhard became ISES member in 1996 and is engaged in standardization of PV since 2007 in TC82.



Ulrich Leibfried

Country: Germany

Year joined industry: 1994

Company first worked for: Consolar

Technology area: Solar Thermal

Still active in the industry: Yes

Ulrich Leibfried had been involved with RE research since 1980 when in 1994 along with three other engineers founded the solar company Consolar GmbH in Lörrach and Frankfurt, Germany. Consolar developed, produced and offered in the first years stratified storage systems and regulations for solar thermal installations (heating and domestic hot water), later also evacuated tube collectors and solar heat pump systems with ice store. The most important product of the last years (with worldwide patent application) is the PVT heat pump collector SOLINK and systems with those panels as single heat source of a heat pump and covering its yearly electric consumption. His main involvement has been in R&D however he has been involved with business management along with overseeing of quality, purchase and production. His main concern is the transition of technologies, economies and society to a system respecting planetary boundaries and life. Currently Ulrich is engaged in a network which he initiated in autumn 2019, working for climate neutral communities.



Jaideep Malaviya

Country: India

Year joined industry: 1995

Company first worked for: Malaviya Solar Energy Consultancy

Technology area: PV

Still active in the industry: Yes

Since Jaideep Malaviya completed his three years as Research Scientist at TATA Energy Research Institute, New Delhi, he developed his skills for solar Photovoltaics (PV) Systems Designing and Engineering as well as domestic Solar Heating and started his own firm Malaviya Solar Energy Consultancy (www.malaviya.in). Jaideep associated with Industry associations and manufacturers of solar PV systems and published an Engineering handbook accredited by Department of Education. Since then he has conducted more than 500 training programmes with the objective of guiding the industries in considering the right size of Solar PV system and justifying the economics. Being a solar energy expert Jaideep did not discriminate within solar energy technologies hence equally was active in developing domestic, industrial and commercial solution for solar heating with the objective of conserving fuel oil as it was an import parity. Jaideep founded the Solar Thermal Federation of India (www.stfi.org.in) and aggressively took the task of accelerating the market by addressing the policy issues. Today India is amongst top five countries in solar energy development both PV and thermal. He continues to train technicians on Rooftop PV designing and also undertakes mass scale business development events in industries. The Government of India has announced its target of 300 GW of solar PV and 20 million sq. metre of solar thermal area as a future goal, so now Jaideep is devoting his activities in establishing an effortless mechanism for end of life management of the solar waste by inviting entrepreneurs to develop indigenous low cost portable recycling systems and set-up multiple collection centres all over India to ensure reuse of all discarded solar energy systems waste instead of land filling thus address climate change.



Hamisi Mikate

Country: Tanzania

Year joined industry: late 90's

Company first worked for: Ultimate Energy

Technology area: PV

Still active in the industry: Yes

Hamisi Mikate started working as Solar Technician with Ultimate Energy, a solar PV company based in Tanzania, under Harrold Burris. He worked with Ultimate Energy until 2001, when he co-founded Ensol Tanzania Limited, a solar energy company, where he worked as Technical Director till 2004 when he became the head of the Company as Managing Director. Mr. Hamisi Mikate is Electrical Engineer by professional, he is a founding member and Treasurer of Tanzania Renewable Energy Association (TAREA). He has participated in many projects and programs locally and regionally.

(Note from SWC50 Committee: Mark Hankins who provided information for the PV in Developing Countries sections of the booklet recommended that we should include Hamisi in the Pioneers . He started late 90's and hence technically did not meet the 1995 requirement. However it was decided that Hamisi, in addition to the others who meet the requirements such as Gaspar Makale and Daniel Kithokoi, provide a broader snapshot of the many Africans who were the entrepreneurs promoting the solar industry on the African continent last century)



Nigel Morris

Country: Australia

Year joined industry: 1992

Company first worked for: Rainbow Power Company

Technology area: PV

Still active in the industry: Yes

Nigel Morris has been involved in the solar since 1992 and is currently employed as the Head of Business Development at Solar Analytics. He has been involved in almost every aspect of the solar industry including manufacturing, installing, selling and designing solar, monitoring and storage systems around the world. His focus during his career has been the development of products, services, sales and marketing of solar in Australia. This led him to becoming a prolific speaker, passionate advocate and active lobbyist for the growth of a quality focused solar industry. In 2018 Nigel was awarded the Outstanding Contribution to Industry Award by the Clean Energy Council and was previously awarded the Smart Energy Council award for Industry Advocacy in 2011. Prior to joining Solar Analytics, he was Chief Executive Officer of RoofJuice, a premium solar retailer; Founder of Solar Business Services acting as a consultant, analyst, industry advisor and business coach; Senior manager at BP Solar for almost twelve years; and, Director, manufacturing manager, installer and salesperson at Rainbow Power Company. He sits on multiple industry advisory boards, is a prolific blogger and is a passionate electric motorcycle owner and pioneer. Nigel co-hosts the long running Solar Insiders Podcast focused on the ins and outs of Australian solar.



Kilian Reiche

Country: Germany

Year joined industry: 1992

Company first worked for: Fraunhofer ISE

Technology area: PV

Still active in the industry: Yes

Kilian Reiche received his Diplom in Physics in 1994 from the University of Frankfurt, Germany in 1994. He was starting to prepare his research work for the thesis at Fraunhofer ISE, Freiburg Germany, in 1992 in the sector of outdoor performance of solar PV modules. Kilian also holds also a Bachelor in Economics from Hagen University (Germany), and minor exams in Law and Computer Science from Frankfurt University (Germany). Kilian started his professional career from 1995 to 1998 working for TNC Energie Consulting GmbH, (Freiburg, Germany) directed by A. Goetzberger and Th. Nordmann, where he acted as –Responsible engineer for the design and construction of the three first integrated PV Noise Barriers worldwide. In 1999 he joined the World Bank, Washington D.C., (USA), first as a task manager, energy specialist, and co-task manager for a series of innovative and complex VRE projects in Argentina, Bolivia, Brazil, Nicaragua, Mexico across Africa. He has extensively contributed to World Bank research, including on RE topics, and early PCF projects. In 2003 he founded iiDev based in Frankfurt, Germany, which is committed to innovative infrastructure projects in development work, predominantly with a focus on PV solar and other sources of RE. Kilian Reiche is an internationally recognized VRE expert. During the last 20 years he has worked in or on more than 70 VRE projects in more than 30 countries, on all aspects of VRE scale-up, grid integration, and the design, funding, implementation, supervision and evaluation of innovative and complex RE funds and financing vehicles. He is also well versed in all aspects of structuring and supervising RE transactions on SPV and portfolio level — technical, financial, economic, legal, regulatory, managerial, and policy matters. Mr. Reiche has been published and has presented extensively, totalling >150 papers, proceedings and key notes on VRE since 1992.



Kathleen Ryan

Country: Australia

Year joined industry: 1995

Company first worked for: Pacific Solar

Technology area: PV

Still active in the industry: Yes

In Feb 1995 Kathleen Ryan commenced with Pacific Solar as PA to David Hogg, MD. The best part of her role was the Management Meeting Secretary where she took the minutes each Friday morning and obtained a research highlight of the week from Prof Martin Green to send to the staff. As the Company grew, she then joined the sales team under the direction of Dr Julio Braganolo. Plug&Power was the product that was created, and it was the sales team's role to sell that solar kit! Kathleen remembers making 9 sales visits in 1 day in the Blue Mountains region to prospective customers! (She still has Plug&Power on her roof at home!) Sadly Pacific Solar sales finished in 2002. Kathleen then went to work for BP Solar in 2003 in the Sales Team working for Nigel Morris where she began to attend solar conferences! This is when she became acquainted with all the Distributors and Dealers and where Kathleen truly excelled as she loved meeting all the fabulous installers and to this day, still has great relationships with so many of them. Sadly, BP Solar finished, and she left in 2011 moving on to assist Nigel Morris with his consultancy business, Solar Business Solutions. In 2012, she worked for Australia Wide Solar a dealer where she learnt how hard dealers worked! In 2013 Kathleen worked for WINAICO, a Taiwanese Solar Manufacturer with the Australian office headed by Blair Pester and the next 4 years saw her grow to understand the dealer network. In 2017, she joined Solar Analytics as the Relationship Manager. She has been groomed for this role since starting in the solar industry and has a great respect for the installers. She loves her solar life and feels very fortunate to have supported so many great people.



Mike Schach

Country: Australia

Year joined industry: 1990

Company first worked for: BP Solar

Technology area: PV

Still active in the industry: Yes

Mike Schach has been a major contributor to the industry throughout the years working on many pioneering solar projects, from the early days at BP Solar to now jointly running the successful small solar advisory firm, Coronium. Projects include: Solar Power Supplies for Telecom (Telstra) throughout Australia (1990-2000); Sydney 2000 Olympics Athletes Village - 650 grid connected solar systems (1998-2000); Shenzhen Green Gardens 1MW Rooftop (2005); 3MW Jindo project in Korea (2009); Moree Solar Farm (2009-2010); Business Development of 12 completed Utility Solar farms in Australia for large EPC company (2013-2017); Owners Engineer for Beryl 100MW Solar Farm.



Kersten Schmidt

Country: Australia

Year joined industry: 1991

Company first worked for: SMA

Technology area: PV

Still active in the industry: Yes

Kersten Schmidt has worked for some of the biggest as well as smaller, but most relevant businesses in the renewable energy sector over the last three decades, undertaking projects from Arnhem Land (remote tropical Australia) to Antarctica to Alice Springs to Alaska. In the late 80's, Kersten, had a vision of renewable energy becoming mainstream. He decided to study electrical engineering with renewables as a special focus. He undertook his first work as a student engineer testing the early generation of solar inverters at SMA. After he had finished his electrical engineering degree in Germany, Kersten moved to Australia in the 90's. Here he worked on innovation in energy efficiency, tidal power research and helped to establish the first few major wind farms in the late 90's and early 2000's. He engineered and project managed some of the landmark turnkey multi MW wind diesel hybrid power stations/microgrids around Australia and the globe, including in Antarctica. In the solar energy space, Kersten was a key driver in developing low cost concentrating solar PV dishes for Solar Systems. In the early 2010's, he was in charge of engineering some of the biggest solar PV farms in the country with BP Solar. He also worked on many commercial size solar systems and provided engineering and general support for all kind of residential and commercial grid connected and off-grid systems, including tracking solutions, free-field and roof top installations. He was the Technical Manager Australia for the Switzerland based solar inverter manufacturer Solarmax. In 2015 he founded Enesol, a professional and agile consulting company, empowering their clients on their journey to energy resilience, to lower energy costs and to decarbonisation, by providing independent, effective and relevant support and advice. Kersten Schmidt is proud of his life-long dedication to and his ongoing achievements in the renewable energy industry and is looking forward of many more to come.



Dipesh Shah

Country: United Kingdom

Year joined industry: 1991

Company first worked for: BP Solar

Technology area: PV

Still active in the industry: No

Dipesh Shah started at BP Oil in 1976 and in 1991 he became CEO of BP Solar International, a position he held until 1997. Over the next 6 years he took the company from a focus of professional systems in the developing world to one where 66% of its market was the growing grid connect market. While CEO of BP Solar International he was also chairman of Tata BP Solar Tata India. During that period, he was active with the EPIA and was chairman from 1992 to 1997. After 1997 he moved on with BP Solar . After leaving BP in 2002 he still maintained an interest in renewables through being: chairman of the board of IT Power Limited from 2002 to 2005 ; non-executive director of NAPS Systems Oy from 2003 to 2005; and chairman of HG Capital Renewable Power Partners LLP from 2003 to 2008.



Michelle Taylor (nee Guelden)

Country: Australia

Year joined industry: 1991

Company first worked for: UNSW Centre for Photovoltaic Devices and Systems

Technology area: PV

Still active in the industry: Yes

Michelle Taylor (nee Guelden) studied electrical engineering at UNSW and her final year thesis on Laser Grooved Buried Contact Solar Cells was under the supervision of Prof. Stuart Wenham - completed in mid-1991. Her experience in developing her thesis led to her working in the Solar Lab at the University of New South Wales from 1990, assisting in new technology transfer, providing external relation services for the Centre for Photovoltaic Devices and Systems, and working on application projects including the development of the Little Bay test facility. Michelle then began participating more broadly in the solar industry, speaking at ATRAA and SEIAA conferences as well as gaining RAPS (remote area power system) experience with a variety of industry professionals. She is a co-author of the book Speed of Light, documenting the 1996 World Solar Car Challenge and has continued a varied career revolving around the enablement of renewable energy, and in particular, solar photovoltaics. She spent 3 years in Alice Springs providing renewable energy solutions for remote aboriginal communities in Northern Territory, and then moved on to Queensland where she headed up the regional electricity distribution company's (Ergon Energy) stand-alone power system division. There she was involved in the design and engineering of hundreds of RAPS across Australia; from the islands of the Torres Straits to the Kimberley region of Western Australia. Michelle's passion for renewable energy has also been demonstrated through ongoing representation over 13 years in Standards Australia's EL42 renewable energy standards committee and more recently with the Queensland Electrical Safety Office, ensuring a safe future for new and emerging technologies. She was recently recognised as the 2019 National Professional Electrical Engineer of the Year by Engineers Australia's Electrical College for her work in industry, much of this work enabling renewable energy and developing the skills and passion of younger engineers in this area.



Thorsten Trupke

Country: Australia

Year joined industry: 1994

Company first worked for: BT Imaging

Technology area: PV

Still active in the industry: Yes

Thorsten Trupke is a Professor at the School for Photovoltaic (PV) Renewable Energy Engineering at UNSW, where he leads a research team of approximately 15 staff, students and postdoctoral fellows. He is also co-founder and Chief Technical Officer of BT imaging, a Sydney based technology company providing high-end photoluminescence imaging systems to the Photovoltaic R&D community and to PV manufacturers. Thorsten started his career in PV research in 1994, at the University of Karlsruhe, Germany, with a thesis on the electroluminescence of silicon solar cells, performed under the supervision and guidance of Prof Peter Würfel. Thorsten has performed leading-edge and widely published research on numerous PV related topics across many different areas. As a postdoctoral Fellow he proposed, theoretically analysed and first demonstrated the concepts of combining solar cells with luminescence up- and/or down conversion. His work on the design and development of novel characterisation methods, including the invention and first demonstration of photoluminescence imaging in 2005, has revolutionized the measurement and characterization of silicon samples and devices. This work has had wide-ranging implications and benefits for PV research and development worldwide. The methods developed by Thorsten and his team, as well as the instruments commercialized by BT Imaging, have become standard tools across the world and are used on a daily basis, both in research labs and in high volume manufacturing. They continue to be crucial elements in the rapid improvement of silicon solar cell technology and associated cost reductions. Thorsten's impact and the quality and relevance of his work have been recognized by numerous awards, including the 2017 Engineers Australia Entrepreneur of the Year Award and most recently the prestigious 2019 Clunies Ross Innovation Award. Thorsten has been a Fellow of the Australian Academy of Technology and Engineering (ATSE) since 2016.



Klaus Vajen

Country: Germany

Year joined industry: 1990

Company first worked for: Wagner Solartechnik

Technology area: Solar Thermal

Still active in the industry: Yes

In the late 1980s the solar thermal community discussed the “low-flow” concept as a promising new approach to decrease investment and backup heating demand of solar domestic hot water systems. In January 1990, Vajen started to develop a low-flow solar heating system for single family houses at the company Wagner Solartechnik, one of the largest and most innovative solar technology suppliers at the time. Low-flow meant more than just decreasing the flow rate through the collector field, we had to implement structural changes of collector and hydraulics. Another challenge was to reach distinguished stratification in the storage tank. The low-flow concept caused a nearly “holy” discussion in the early 1990s. Numerical evaluations put forward thermodynamic advantages of the low-flow concept, but unfortunately, this could not be validated with measured data to the same extend. At the end, practical problems prevailed: To avoid uneven flow distribution through collectors they needed to be connected in series. This led to rather high pressure losses and demanded special displacement pumps, which were noisy as well as expensive. Some devices to reach a good stratification in the storage tank were expensive, or didn't work, or even both. Furthermore, new highly efficient pumps decreased the potential savings of electricity. In total, the overall system concept was, other than expected, in practice slightly more expensive and at the same time slightly less efficient than systems with the traditional “high flow” operation. Today, “low-flow” technology doesn't play a perceptible role on the market of small SDHW-systems anymore, but it is still present in very large solar thermal systems, as here it can decrease cost of hydraulic parts significantly. Wagner Solartechnik is still present on the market as very experienced and innovative supplier of advanced solar technology. Vajen left industry after 1.5 years to start a PhD on another solar topic.



Gerhard Weinrebe

Country: Germany

Year joined industry: 1991

Company first worked for: Schlaich Bergermann und Partner (www.sbp.de)

Technology area: Solar Thermal

Still active in the industry: Yes

Gerhard Weinrebe undertook his diploma thesis in 1991-1992: Testing of Dish/Stirlings systems: Flux density measurements in focal area using self-developed hiflux . In 1994-1995 he worked at : German Aerospace Research Establishment (DLR) as their Program Manager 'Solar Measurement Technologies' at the European Solar Research Center 'Plataforma Solar de Almería'. Spain. In 1995-1996 he was Area Head 'Solar Thermal Central Receiver Systems' at 'Plataforma Solar de Almería', Spain. In 1997-2000 he undertook his PhD thesis on 'Technical, Economic and Ecological Assessment of Power Towers' Since then, techno-economic optimization of solar systems without neglecting the environmental impact is one of the specialties. From 1995 to -today: Testing and development of heliostats (incl. ASM150 & Stellio). From 2000 to 2015 involved with Design and optimization of solar updraft towers; projects in Spain, Australia and Chile. From 2000 totoday involved with Design and optimization of parabolic trough collectors for commercial plants (EuroTrough, HelioTrough, UltimateTrough). With team twice winner of the IEA SolarPACES technology innovation award (2013 & 2010 for troughs) 2012-today: Head of Research and Development at sbp sonne 2014 – 2016: Development of 'Stellio', a 48.5 m² high-performance low-cost heliostat, with efficient pentagonal collector structure and innovative axes arrangement Member of team that won the IEA SolarPACES technology innovation award for the Stellio heliostat in 2015 Strong involvement in marketing Stellio for Redstone project in South Africa and for projects in China. Stellio heliostat was selected for 50 MW molten salt power tower Hami, China. 2014-today: Root Cause Analyses for failures of parabolic trough collectors and PV trackers (not designed by sbp sonne) for owners and insurers Since 2012: Associate at sbp sonne, since 2020: Director Since 2018: Member of IEA SolarPACES industry advisory board



Kent Whitfield

Country: United States

Year joined industry: 1991

Company first worked for: Arizona State University

Technology area: PV

Still active in the industry: Yes

Kent Whitfield was a project leader for the development of a PV-powered car as an undergraduate at Arizona State University for the first ever GM Sun Race in Australia in 1991. Hired by ASU as a Laboratory Manager to establish the first ISO/IEC-accredited testing laboratory in the Americas for PV modules with Bob Hammond, Byard Wood and Chuck Baccus at Arizona State University (laboratory named the Photovoltaic Testing Laboratory - PTL). He was manager of a joint venture between Spire and BP Solar called Spire Solar Chicago from 1998-2002 that was the first organization to bring commercial PV systems to downtown Chicago museums and commercial facilities. As Research Manager at Underwriters Laboratories he assisted front-line certification staff in the development of certification services including technical requirements and business plans. Director of Reliability at MiaSole to develop reliability requirements and testing capability for large-scale CIGS module manufacturing. Kent was Sr. Director of Quality and Reliability at Solaria for development of a low-concentrating PV module and a supporting ISO9001/14001 and OHSAS 18001 Quality Management System. He was Director of Reliability, Solar Materials for SunEdison for deployment of a Design for Reliability within the Solar Materials business composed of both photovoltaic modules and microinverters and Sr. Director of module engineering for BeamReach Solar managing an organization responsible for the development of a unique PV module having integrated mounting and racking hardware, deploying unique materials, and featuring a lightweight construction. Kent is now VP of Quality at NEXTracker where he oversees global quality and durability.



Priyantha Wijesooriya

Country: Sri Lanka

Year joined industry: 1990

Company first worked for: SELCO Sri Lanka

Technology area: PV

Still active in the industry: Yes

Priyantha Wijesooriya was connected to Neville Williams of Solar Electric Light Fund (SELF) by Phil Covell of Enersol Associates, while he completed his Rotary Scholarship based solar masters in 1990 at University of Massachusetts (UMass). It was summer and he had just returned from an Enersol solar training session in Dominican Republic (DR) thanks to sponsorship from District Governor Edward C Hall of Rotary District 7910 of Central Massachusetts. In the DR project, former Westinghouse Engineer Richard Hansen literally brought in 'solar lighting' to a rural Dominican area, Bella Vista where only kerosene lamps were used. He went to DR to learn from Richard's work. Upon return to UMass, Priyantha's faculty Professors Jose Martin and John Duffy encouraged him to adopt similar operations in his country Sri Lanka. It is noteworthy that subsequently, Rotary District 7910 also sponsored his UMass colleague Harish Hande from India for a similar (Enersol) training stint in the DR that he took up as well. Meeting Neville was instrumental in determining his career and Priyantha and Neville soon met in Colombo and we planned a futuristic Sri Lanka strategy. Modest financing from SELF and Rotary D/7910, helped us install over 500 pilot-scale solar (lighting) systems in the outback. Neville being a great visionary, also contributed to convincing multi-laterals like the World Bank to explore financing renewable energy. He often leveraged on their local pioneer presence to persist his case, and often succeeded. About this time the Rio Earth summit happened; in 1993. The Post-Rio era provided an enabling climate for SELCO in Sri Lanka although obstacles remain today. He is still involved with solar today.



Shi Zhengrong

Country: China

Year joined industry: 1995

Company first worked for: Pacific Solar

Technology area: PV

Still active in the industry: Yes

Dr Shi Zhengrong completed his PhD at UNSW in the study of solar technology after his initial study in laser physics at the Shanghai Institute of Optics and Fine Mechanics. From UNSW he co-founded Australian solar start-up Pacific Solar, then later returning to his native China, as a dual-Australian citizen, where he established Suntech Power. Suntech would go on become the world's largest manufacturer of solar modules, and this in turn would lead to the mass production and falling costs of solar panels, making them an affordable reality for homes, business and industry across the globe. In 2007 Time Magazine honoured Dr Shi in its "Heroes of the Environment" list, and in 2009 he was the recipient of the prestigious Oslo Business for Peace Award in recognition of his contribution to "transformative and positive change through ethical business practices." Dr Shi has been a member of the Australian Academy of Technological Sciences and Engineering since 2009 and has addressed the World Economic Forum, is the inventor of more than a dozen patents in photovoltaic technology, and through the world-leading success of Suntech Power, was the world's first solar billionaire and philanthropist.

9.10 American Solar Energy Society Fellow

The following table lists all the American Solar Energy Society Fellows

First Name	Last name	First Name	Last name	First Name	Last name
Don	Aitken	Kenneth	Haggard	Frederick H.	Morse
Robert	Aresty	Bruce	Haglund	Michael H.	Nicklas
Jim	Augustyn	Denis A.	Hayes	Philip W.	Niles
J. Douglas	Balcomb	Elaine	Hebert	Paul C.	Notari
Marion	Barritt	Stephen	Heckeroth	Donald	Osborn
William A.	Beckman	John R.	Hickey	David	Panich
David L.	Block	Michael	Holtz	Richard	Perez
Dr Robert	Boehm	Bion	Howard	Alicia	Ravetto
Renate	Boer	Harold M.	Hubbard	Dave	Renne
Karl W.	Boer	Bruce D.	Hunn	John S.	Reynolds
G.Z. "Charlie"	Brown	Gina	Johnson	Stephen	Sargent
Marlene	Brown	Stephen	Kalland	Marc Eugene	Schiler
Harvey	Bryan	David	Kearney	Kenneth	Sheinkopf
Jay	Burch	Robert R.	Keller	Larry	Sherwood
Nancy	Carlisle	Edward C.	Kern	Larry	Shirley
Craig	Christensen	Sanford	Klein	Doug	Shoemaker
Jill	Cliburn	William H.	Klein	Walter	Shropshire
Gilbert	Cohen	Jan	Kleissl	William (Bill)	Spratley
David	Comis	Ralph	Knowles	Thomas	Starrs
Jeffrey	Cook	Richard	Komp*	Ronald	Stewart
Polly	Cooper	Frank F.	Kreith*	Steven	Strong
Jane	Davidson	Charles	Kutscher	Ron	Swenson
Francis	DeWinter	Alison	Kwok	Mark	Thornbloom
Christine T.	Donovan	Ronal	Larson	Mary	Tucker
Jack A.	Duffie*	Thomas	Lawand	Lorin	Vant Hull
John	Dunlop	Norbert	Lechner	Frank	Vignola
Anne	Dunning	George O. G.	Lof*	Gary	Vliet
Scotte	Elliott	Susan	Luster	Cecile	Warner
Helen	English	Gabriela	Martin	Jane	Weissman
Barbara	Farhar	Alison	Mason	Claudia	Wentworth
Wyldon	Fishman	Joseph	McCabe	John	Wiles
Randy	Gee	Margot	McDonald	C. Byron	Winn
D.Yogi	Goswami	Pamm	McFadden	Roland	Winston
Walter	Grondzik	Paulette	Middleton	Byard	Wood
Christian	Gueymard	Murray	Milne		

9.11 Individuals Involved with ISES National Sections

The following list of people were mentioned in *The Fifty-Year History of the International Solar Energy Society and its National Sections Volume 1 The First 25 Years, 1955 to 1980*. They provide a snapshot of the many individuals who have been involved with the various national sections of ISES in the early years. Not included within the list are those that are already included in the booklet either within the pioneers or the ISES Presidents.

American Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
David	Bainbridge	Ken	Haggard	Don	Prowler
Marian	Bert	Howard	Harrenstein	Jim	Rannels
	Bliss	Lloyd	Herwig	Paul	Rappaport
Barbara	Bradley	Everett	Howe	John	Reynolds
G.Z	Brown	Tim	Johnson	Gordon	Salmon
Jimmy	Carter	Robert	Jones	Walter	Shropshire
Bill	Cherry	George	Keck	William	Shurcliff
Mike	Corbett	Fred	Keck	Leonard	Spielvogel
Kinsell	Coulson	Doug	Kelbaugh	Wendell	Thomas
Albert	Dietz	Robert	Keller		Tybout
Peter	Dresser	John	Kincel	Omi	Walden
Fred	Dubin	John	Lyle	Tony	Ward
Anne	Dunnings	Edward	Mazria	Del	Ward
Jim	Eibling	Patty	McDaniel	Kurt	Wasserman
J.	Farber	Murray	Milne	Don	Watson
Pliny	Fisk	Fuller	Moore		Whillier
Freeman	Ford	Robert	Murray	Bruce	Wilcox
Ed	Fordyce	Loren	Neubauer	David	Wright
Harrison	Fraker	Phillip	Niles	Susan	Yanda
David	Freeman	Georges	Peri		
Drew	Gillett	Robert	Philips		

Argentinian Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Monica	Garcia	Alfredo	Rapallini	Jorge	Serrano
Jorge	Guerrero	Jorge	Rieznick	Ricardo	Serrano
Jaime	Moragues	Luis	Saravia		
Mauel	Neit	Walter	Scheuer		

Australia and New Zealand Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
D	Allen Williams	Terry	Hollands	Bill	Parker
David	Baggs	Wal	James	Steve	Phillips
John	Ballinger	Phil	Jennings	Trevor	Pryor
John	Barker	Peter	Jones	Graham	Reading
T E	Bowden	C. F.	Kettleborough	John	Riley
Ron	Brown	David	Langridge	Richard	Sale
Gareth	Cole	Bob	Lawrance	Sue	Saunders
Tom	Crawford	Michael	Leach	Rob	Shand
Angelo	Desante	Tevor	Lee	Norm	Sheriden
Bob	Dunkle	Peter	Little	Clarry	Small
Mahalath	Halperin	Keith	Lovegrove	Wes	Stein
Joan	Hamilton	John	Maitland	Brett	Stokes
Barbara	Hardy	Paul	McCormick	Bob	Sutton
John	Held	John	McNab	Zdenka	Underwood
Frank	Hogg	C.J.	Milner	Terry	Williamson

China Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Shi	Dinghuan	Mona	Shi	Meng	Xiangan

German Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Werner	Bloss	R.	Hezel	Thomas	Schmalschlager
Ulf	Bossel	Horst	Horster	Horst	Selzer
Albert	Derichsweiler	Wilhelm	Maier		
Pitter	Graff	Adolf	Remshardt		

Indian Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
V.	Bakthavatsalam	J.	Gururaja	R. K.	Pachauri
S.O	Gomkale	J.C.	Kapoor	A.	Ramachandran
Chaman Lal	Gupta	Anna	Mani	Anna	Mani

Israeli Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Joseph	Appelbaum	David	Govaer	Ari	Rabl
Abraham	Arbib	Gershon	Grossman	Arie	Rahamimov
Dov	Ashbell	Moshe	Hirsch	Tonny	Rigg
Jonathan	Ben-Dror	Ami	Katz	Nathan	Robinson
Joseph	Bourne	Yigal	Kimchi	Aharon	Roy
Guedi	Capeluto	Shimon	Klier	Ariela	Rozen
Philip	Carlson	Matti	Konnes	Shmuel	Sambursky
Israel	Dostrovsky	Eli	Korin	Yeshayahu	Segal
Dubi	Dvorjetski	Avi	Kribus	Edna	Shaviv
Michael	Epstein	Avraham	Kudish	Barbara	Shaw
Evyatar	Erell	Ruth	Lahav	Avraham	Shitzer
Yair	Etzion	Yehuda	Landau	Abraham	Tamir
David	Faiman	Moshe	Levy	Yeshayahu	Vardi
Daniel	Feuermann	Isaac	Meir	David	Wolf
Uri	Fisher	Emanuel	Menczel	Abraham	Yezioro
Baruch	Givoni	Ofer	Novick	Yair	Zarmi
Arnold	Goldman	Joseph	Nowarsky	Dan	Zaslavsky
Khaled	Gommed	Dov	Pasternak	Amos	Zemel
Jeffrey	Gordon	David	Pearlmutter	Yoram	Zvirin

ISES-ITALIA Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Luigi D'	Amelio	Maurizio	Cumo	Guglielmo	Righini
Carlo D'	Amelio	Alvaro	Donadio	Aurelio	Robotti
Arnaldo	Angelini	Mario	Dornig	Tito	Romagnoli
Vincenzo	Balzani	Giacomo	Elias	Giancarlo	Schileo
Gino	Bozza		Feltrinelli	Giuseppe	Sfligiotti
Ugo Lucio	Businaro	Giovanni	Francia	Mario	Silvestri
Vincenzo	Caglioti	Ambrogio	Locatelli	Vittorio	Silvestrini
Giancarlo	Chiesa	Giorgio	Nebbia		Somor
Mario	Columba	Luigi	Paris	Vittorio	Storelli
Corrado	Corvi	Mario	Pavese		

Japanese Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Y.	Hamakawa	Tetsuo	Noguchi		

Lebanese Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Rayan	Badro	Raja	Hajjar	Bassam	Ouaida
Kamal	Basilla	Bourhan	Kraitem	Fateh	Sakkal
Raja	Fawwaz	Naser	Mroueh	Fouad	Shuwairy

Mexican Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Juan Jose	Ambriz	Juan J.A.	Garcia	Oden	Rodriguez
Gustavo B.	Brown	Cluadio E.	Gasca	Rodolfo M.	Strevel
Hernando G.	Cazares	Ladislao	Gorczyński	Jorge H.	Villamar
Manuel M.	Fernandez	Ana M.	Martinez	Jose L. F	Zayas
Isaac	Figueroa	Eric	Mayer		
Alfredo S.	Flores	Enrique C.	Munoz		

Norwegian Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Rolf J.	Aaberg	Karl T.	Hetland	Harald	Rosvik
Øyvind	Aschehoug		Miljøplan	Fritjof	Salvesen
Ragnar	Evensen	Georg	Parmann		Sandvika

Pakistan

First Name	Last name	First Name	Last name	First Name	Last name
Agha H.	Abidi	Jamil A	Khan	Sohail	Qureshi
	Ajmal	M. Ikram	Khan	A.Qayyum	Qureshi
Parvez	Akhter	Nasim A	Khan		Sarhandsi
M. H. M.	Butt	Sarfraz	Khan	S. H.	Shah
Tajjamul	Hassan	Shehyar	Khan	T.	Sheikh
Iqbal	Hussain		Memon	I. H.	Usmani
Wajahat	Hussain	Atiq	Mufti	Z.I.	Zaidi
A. A.	Junejo	I	Qazi		

Portuguese Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Antonio	Adragao	Eduardo O.	Fernandes	Eduardo	Peres
Maria da Grace	Amado	Antonio	Forjo	Salgado	Prata

Onesimo	Barata	Manoel A.	Gomes	Lopes	Prates
Fernando	Carvalho	Franklin	Guerra	Antonio de Melo	Queiroz
Jorge C.	Costa	David	Loureiro	Manuel G.	Santos
Humberto D.	da Fonseca	Pedro	Numes	Ana	Solano
Eurico	da Fonseca	Sidonio	Paes	Antonio	Xavier
Armando V.	da Rocha	Manuel C.	Pereira		

Russian Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Zh. I.	Alferov	P. P.	Lasarev	L. S	Stilbans
V. M.	Andreev	Chizhevskiy Alexandr	Leonidovich	Dmitry	Strebkov
P. P.	Aparisy	N. S.	Lidorenko		Tarnizhevsky
	Arbuzov	Mikhail Vasilevich	Lomonosov	D. I.	Teplyakov
V. A.	Baum	G. I.	Markov	V. A.	Tsesarskii
P. P.	Bezrukik	Yu. P.	Maslakovets		Tveryanovich
	Chirkov	V. A.	Mikhelson		Tyukhov
D.S.	Strebkov	D. I.	Nasledov	Andreev	V. M
V. M.	Evdokimov	D. N.	Nasledov	Evdokimov	V. M.
	Generalov		Nikitin	Kondratyuk Jury	Vasil'evich
Abram Fedorovich	Ioffe	V. B.	Petukhov	A. M.	Vasilev
M. V.	Kagan	V. D.	Rumyantsev	V. S.	Vavilov
	Kargiev	C. M.	Ryvkin	V. B.	Veinberg
M. M.	Koltun		Shpilrain		Zadde
G. M.	Krzhizhanovsky		Sokolskii		
A. P.	Landsman		Starshiov		

Singapore

First Name	Last name	First Name	Last name	First Name	Last name
T.T	Chandratilleke	J.C.	Ho	Tay Siang	Lee
Tan Seng	Chee	Tan Chuan	Jin		Rajaratnam
Tang Beng	Cheok	Chew Hock	Kee	N.E.	Wijeyesundera
M.N.A	Hawlder	T.H	Kho		
Teng Chong	Heng	Chng Teck	Lam		

Solar Energy Society of South Africa

First Name	Last name	First Name	Last name	First Name	Last name
Duard	Barnard	G.	James	Mike	Rycroft
Wayne	Beb	D.	Johnston	Brian	Schaller
Sandra	Bezuidenhout	Iain	Johnston	Bernard	Scheffler
Sandra	Bird	Uwe	Klingenberg	Martin van	Schoor
Bill	Birrer	J.	Kok	Noel	Smith
Derrick	Botha	P.	Kruger	Stefan	Smoleniec
Petrus	Brits	Peter	Lee		Stander
Petrus	Britz	Doyle	Liebenberg	Deon	Stassen
Will	Cawood	Ken	Long	Danie	Steyn
D. N. W.	Chinnery	Louise	Luttig	B.	Thornton
T.	Cooper	Chris	Malan	Neville	Tully
Leon	Drotsche	Lyon van der	Merwe	Richard	Turner
Andrew J.	Drummond	Willem van der	Merwe	Trevor van der	Vyfer
Dick	Dutkiewicz	F.	Mohr	Patrick	Walker
Irene	Field	Glynn	Morris.	Marlett	Wentzel
Jack	Gledhill	Anton-Louis	Olivier	Van der	Westhuizen
	Grober	Benny du	Plooy	Austin	Whillier
Hazel	Hall	Erica du	Preez	Mary	Whillier
Jim	Hickey	Deon	Raubenheimer	Marius	Willemse
Dieter	Holm	S. J.	Richards	Janet	Wolhuter
Everitt	Howe	Gertrud	Riemerschmid	J. Van	Wyk

Solar Energy Association of Sweden

First Name	Last name	First Name	Last name	First Name	Last name
Anders Jonas	Ångström	Svenska	Fläktfabriken	Peter	Margen
Emeritus Enno	Abel	Ivar	Franzén	Rolf	Mårtensson
Hans E. B.	Andersson	Valdis	Girido	Esko	Niemi
Lars	Andrén	Claes-Göran	Granqvist	Christer	Nordström
Knut Johan	Ångström	Jonas	Hedström	Bengt	Perers
Lars	Åstrand	Bengt	Hidemark	Folke	Pettersson
Lars	Åstrand	Jan	Högberg		Pleijel
Per	Bergqvist	Ingemar	Hoglund	Ulf	Rengholt
Willem	Boeke	K.	Honda	Dr. Ewa	Wäckelgård
Arne	Boysen	Göran	Hultmark	Bengt	Warne

Gösta	Brown	Eric	Ingelstam	Peter	Weissglas
Hans	Eek	Lars	Jäderberg	Gunnar	Wilson
Lars	Engstrom	Björn	Karlsson	Heimo	Zinko
John	Ericsson	Vagn	Korsgaard		
Ralph	Erskine	B. I.	Lindström		

Turkey Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Mehmet	Akyurt	Suheyl	Elbir	Yusuf	Korucu
Kemal	Altinisik	Suleyman	Eraslan	Sener	Oktik
Necdet	Altuntop	Ibrahim	Ezinc	Galip	Oturanc
U. D.	Arinc	Turkan	Goksal	Necdet	Ozbalta
O. Ercan	Ataer	Cetin	Goksu	Aksel	Ozturk
Gurbuz	Atagunduz	Mustafa	Gunes	Kazım	Pıhtılı
Kemal G.	Bayraktar	Ali	Güngör	M. Kudret	Selçuk
Ali	Beba	Siddik	Icli	Ersoy	Tasdemiroglu
Orhan	Buyukalaca	Osman	Ilhan	Mustafa	Tiris
Metin	Colak	Demir	Inan	I. Engin	Ture
F. Nur	Demirbilek	Figen	Kadirgan	M. Ozcan	Ultanir
Riza	Durdu	Abdurrahman	Kilic	Mazhar	Unsal
Ahmet	Ecevit	Gul	Koclar	Kemal	Uzonboy
Nilufer	Egrican	Kemal	Koman	Tuncay	Yilmaz

UK Section of the International Solar Energy Society

First Name	Last name	First Name	Last name	First Name	Last name
Mary	Archer	Leslie	Jesch	George	Porter
Brian	Brinkworth	Barry	Justin	Alan	Puford
Harry	Brown	Julian	Keable	Dickie	Richards
Derek	Bryce-Smith	Peter	Landsberg	Jean	Rosenfold
Peter	Dunn	Cleland	McVeigh	Ali	Sayigh
David	Gerassi	Dominic	Michaelis	Albert	Strub
Toby	Harrison	Emslie	Morgan	Roy	Swayne
Harold	Haywood	June	Morton	Phil	Woodcock
Mick	Hutchins	Roger	Mytton		
Ted	Jefferies	Ken	Page		

9.12 SWC50 Platinum Partner: GSES



The History of GSES

Global Sustainable Energy Solutions Pty Ltd was founded in Australia in September 1998 by four founding partners: Mr Geoff Stapleton, Ms Susan Neill, Mr Stephen Garrett and Mr Kim Aitkinson

At the time of formation, each of the four directors had over 10 years experience in the sustainable energy industry and in particular, operating their own companies within Australia. Each of the four companies were involved in designing, selling and installing off grid (stand-alone) power systems. When GSES started, Geoff Stapleton was consulting for a local electricity utility, Integral Energy, which was offering power with or without “poles and wires”. Integral Energy had joined the USA based Utility Photovoltaic Group after a number of Integral staff (including Geoff) had undertaken a study of the US in 1995. This led to Geoff travelling yearly to the USA for the combined SEIA/UPVG conference.

During the 1997 conference that was held in Washington D.C. Geoff met 3 people who became important in the early days of GSES. These included the late Mark Fitzgerald (Institute for Sustainable Power) , Bernard McNelis (IT Power) and Lalith Gunaratne (consultant from Sri Lanka who had started a solar company with 2 friends in the 80's).

While in Washington, Bernard had introduced Geoff to a number of World Bank staff working on solar home system projects, including Mac Cosgrove Davies, which was to become instrumental for GSES in the years to come. As a result of attending these conferences and meetings, Geoff identified an opportunity to take the skills of designing/installing systems and conducting small businesses overseas. Hence the original intention was to identify existing small businesses in Asia and Africa and see if we could partner with them and help them grow. However, to survive in the early days GSES would undertake general RE consultancy within Australia. GSES first Australian consultancy was being part of a consortium which undertook the study of the size of the off-grid power systems market in Australia, which led to the Australian Remote Renewable Power Generation Program (2000-2008).

Geoff proposed the GSES consultancy idea to Lalith Gunaratne who was very supportive, which led to Geoff meeting Pradip Jayewardene (Solar Power and Light, Sri Lanka) at Village Power 1998. In February and May 1999, Geoff visited Sri Lanka and helped Pradip with a new business plan. However, at the time Geoff was president of the NSW Chapter of the Solar Energy Industry Association of Australia, while Susan Neill was also the national president. Both had been very active within the establishment of the Australian Technician accreditation program in 1992/93 and also training and the development of standards. When this was discussed with Pradip he basically asked could we help the new Sri Lanka Solar Industry Association. The end result was that GSES changed its focus to capacity building and, when Shell purchased Solar Power and Light for it to become Shell Solar Sri Lanka in 1999, GSES conducted a technical training course and operating business course for Pradip's dealers.

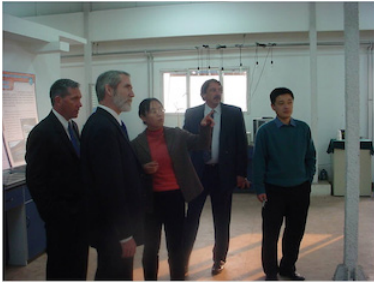
During 1999 Bernard McNelis had been successful in having IEA PVPS approve what was known as Task 9-PV in Developing countries. The first meeting was held in 1999 in Utrecht, The Netherlands. Geoff joined this Task, first as an observer and then as the Australian representative and stayed a member until it finished around 2017. Being a member of this group gave GSES the opportunity to meet many people from around the world and help GSES grow over the years



Sri Lanka was the first country GSES worked in and following the initial training with Pradip's dealers GSES won the contract to work with the Sri Lanka Industry association in providing technical training for the World Bank funded Energy Services Delivery project. GSES undertook many trips to Sri Lanka between 2000 and about 2006 and undertook projects supported by World Bank, Australian Aid and GTZ. In 2016 GSES was back in Sri Lanka conducting grid connect training courses.

[GSES First Training course in Sri Lanka 1999](#)

At the end of 2000 Geoff finished his consulting contract with Integral and started running GSES full time. The other partners would then join as consultants within particular projects.



Geoff Stapleton, Mark Fitzgerald and Stephen Garret in China for Auditor Training in Dec 2002

After meeting Mark Fitzgerald in 1997 Geoff had kept in touch with him. Geoff believed in what Mark was doing with ISP, that is establishing a framework for accreditation renewable energy technician competency-based training courses. Geoff became an ISP Master Trainer and also joined the board of ISP in 2000. Until Mark's early passing in 2005, GSES worked closely with ISP in many projects with the aim of establishing the ISP framework in the Asia Pacific region. Through the work with ISP, GSES travelled extensively through Asia in the early 2000's leading to many projects. It also led to major projects in India and China in the late 2000's.

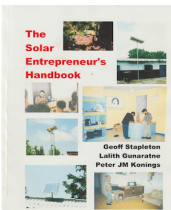
In June 2000 Geoff went to Ghana , with Geoff and Stephen Garret returning in October 2000. During these visits we met Mr Frede Bosteen from Deng Ltd. The end result was that GSES worked with Frede who then established the Deng Solar Training Centre (DSTC). GSES conducted many training courses in Ghana between 2004 and 2010 and still maintains a relationship with the training centres .



Geoff at first Ghana Training Course (2003) - Frede Bosteen and Geoff



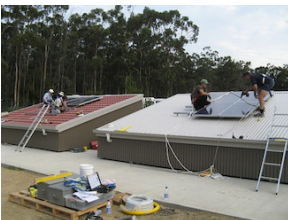
Frede Bosteen and Geoff



Based on the business training courses that GSES had been conducting and along with the years of experience in operating small businesses GSES published their first book in 2000 titled: *The Solar Entrepreneurs Handbook*.

From 2008 onwards GSES became a major publisher of technical training books that are regularly updated. Versions have been developed for Australia, USA and global editions to cover the requirements of different technical standards.

In 2006, GSES won a UNDP contract to develop a grid connect training course for Malaysia including the manual , conduct training and train the trainers. Basically, helping Malaysia establish their grid connect training centres. After returning from finishing the first part of the Malaysia project in 2007 Geoff found that there was still no technical college in the state of New South Wales offering training in solar, particularly Grid connect. GSES then proceeded to plan to become a Registered Training Organisation (RTO). GSES hired their first staff person (Belinda Thorne) outside of the founding partners. GSES established online training and developed the Australian version of the grid connect book that had been developed for Malaysia. Stephen Garrett, through his own company Pyramid Power, built the training centre in Pambula which GSES rented from him. The training centre opened in 2008.



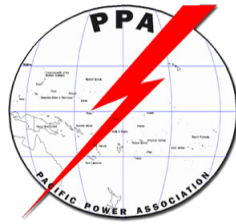
GSES First Australian Training Centre

Like many countries around the world, the mid to late 2000's marked the boom of PV and for Australia it was 2007 onwards. As a result, opening the RTO was the start of GSES's growth. GSES hired their second full time person in 2008 and then Susan Neill one of the partners sold her company to Conergy (from Germany) and she joined GSES full time early 2009 to manage the office in Sydney while Geoff maintained growing the international business.

In 2012, GSES started a joint venture with Dwipen Boruah with GSES India opening in New Delhi. That company also has over 20 staff in the office.

Since 2008, GSES has grown substantially and there are currently 26 staff in the Sydney office. In 2014 GSES hired Chris Martell, who became manager at the Sydney office at the end of 2016 after Susan Neill retired. GSES is still an RTO, publisher of training manuals, developing numerous short training courses and involved with OS projects. Within Australia it is involved in engineering design and undertaking inspections of systems.

9.13 SWC50 Supporter- Pacific Power Association



The PPA is an inter-governmental agency and member of the Council of Regional Organizations in the Pacific (CROP) to promote the direct cooperation of the Pacific island power utilities in technical training, exchange of information, sharing of senior management and engineering expertise and other activities of benefit to the members.

The PPA's objective is to improve the quality of power in the region through a cooperative effort among the utilities, private sector and regional aid donors. The PPA's members pool their resources and expertise for their common benefit, gain international representation and improve access to international power sector assistance programmes.

The PPA provides direct links between the private sector and member utilities to improve private sector services and thus make their presence in the region more productive. We have a password protected area in the Back office and Tenders for all members which includes full active member details and equipment installed, current tenders and many other useful features.

Pacific Power Association (PPA) is an association of electricity utilities, organisations, and individuals who have an interest in the operations and development of the power industry in the Pacific Island Countries. PPA is an inter-governmental regional organisation founded by the electricity utilities operating in the Pacific Islands Countries (PICs).

The PPA was established in 1992 and has a Secretariat Office located in Suva, Fiji. Currently it has a membership of 25 electricity utilities operating in 22 Pacific Island Countries and 91 Allied Members world-wide with interest in the development of the power industry in the Pacific region.

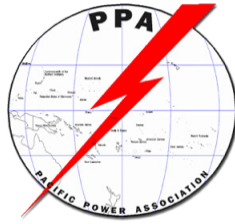
The main objective of PPA is to create an environment of "co-operative partnership" with the private sector, funding institutions, and others with interest in the development of the power industry and to enhance the role of the power sector in the Pacific Island Countries. PPA is directly funded through annual subscriptions from the members.

There are three categories of membership – Active Membership, Allied Membership and Affiliate Membership. Active membership is limited to power utilities operating in the Pacific islands region whilst Allied membership is open to all other power utilities, organisations, and individuals with interest in the regions power industry.

An Affiliate Member shall be any organisation whether incorporated or unincorporated that will not seek to gain a financial benefit from the PPA and would include multilateral and bilateral agencies, non-utility government entities and various international standards associations. An Affiliate Member is not a financial member of the PPA.

The Activities of the Association are directed by a Board of Directors which is comprised of the Chief Executive Officers of Active members and a Representative elected from the Allied members. The day to day affairs of the Association is managed through a Secretariat headed by an Executive Director with a total staff of five (5).

The idea for an Association came about in the course of 3 years of discussion among the region's power utilities, governments, aid donors, private sector companies and others with interest in the Pacific islands power industry. These meetings brought to light many problems that Pacific island utilities and the power sector market face in common, which could be dealt with effectively through direct cooperation.



Through the PPA, Active members pool their resources and expertise for their common benefit and gain international representation and improved access to international power sector assistance programmes. In addition, the direct links that the PPA provides between the private sector and utility members are designed to improve private sector services to member utilities and make the private sector members' presence in a geographically difficult marketing region more productive. Allied members presently include Australian, American, Canadian, European, Japanese, New Zealand, Singapore, and Pacific based companies marketing generation, transmission and distribution plant, tools and equipment; cables; transformers; electrical control equipment and other power industry related products as well as engineering and business services.

The PPA is thus designed to improve the access of all members to the considerable resources and the expertise that exists in the region and around the world for the development of the Pacific islands power sector, and to take on the administrative responsibility of ensuring that all members are adequately served.



The PPA 28th Annual Conference, 2019, held in Cook Islands.

For further information visit www.ppa.org.fj

9.14 ISES Institute Members: Politecnico Di Torino

20+ YEARS OF RESEARCH ON THE SUN AT DEPT. OF ENERGY-POLITECNICO DI TORINO

The experimental research regarding solar energy at Politecnico di Torino has a long history, more than 20 years in two different Departments, in the past, Department of Electrical Engineering and Department of Energetics, and now after merging of them (2012) in the Department of Energy (Director: Prof. M. Perino).

For what concerns the solar photovoltaic (PV) technology supervised by Prof. F. Spertino, who collected the heritage of Prof. A. Abete, pioneer in the research on PV generators and systems, a pilot plant was installed in 2000 on a rooftop of the former Department of Energetics. The Italian Agency for the Energy and Environment (ENEA) managed the investment. This PV plant started its operation after that in 1999 a new Italian regulation made possible, for a commercial or residential user, to exchange power with the national electric grid; in particular, this regulation fixed an adequate price for the electricity injected into the grid, while in the past no monetary amount was paid. This pilot PV plant, equipped with 18 PV modules in monocrystalline silicon with 13% of conversion efficiency (at that time a remarkable value) is still operating after 21 years and is connected to the single-phase grid (230 V/50 Hz). The performance was monitored in the first years to check the correct operation of the PV array with rated power of 1.5 kW and of the centralized inverter in terms of conversion efficiency and quality of the current and voltage AC waveforms.

The second PV plant was installed in 2003 in the former Department of Electrical Engineering on a terrace with surrounding buildings that create shading problems. For that reason, the configuration of the DC-AC conversion was the Module Integrated Converter (MIC) or AC module, in which each of ten PV modules in monocrystalline silicon supplies a MPPT-integrated inverter able to create a stable grid connection with anti-islanding protection. The power electronics is characterized by high-frequency commutation under resonance with low weight and is inserted into a rugged and sealed enclosure. The PV plant with rated power of 1.1 kW is still operating and each AC module has different duration of operation according to the daily evolution of the shading pattern.

The third PV plant was installed in 2010 and it is the first building integrated PV system on the rooftop of the Politecnico's startup company incubator (I3P): the special PV modules have double glaze with high thermal insulation for winter season and are equipped with highly-efficient monocrystalline silicon (efficiency of 19% with rated power of about 30 kW); they supply two inverters with three-phase grid connection (400 V/50 Hz). The orientation of the skylight in the two-pitch roof is east-west and so the first PV generator produces the majority of energy in the morning, while the other one has the opposite behavior, producing mainly in the afternoon.

In the last five years up to now, other three PV systems with global rated power near 900 kW have been installed on the roof of different Politecnico's buildings (Departments and classrooms) and connected to the three phase grid with ability to exchange power in the framework of the so-called Italian "Scambio sul Posto" (translated in English as "onsite power exchange"). The energy production from the PV systems is able to meet about 10% of the total university consumption. The most important one, with rated power of 600 kW, is placed on the saw-tooth (shed) rooftop of a former factory, now, after renovation, block of classrooms of Politecnico. In general, the vision of Politecnico is to gradually shift towards the concept of nearly Zero Energy Buildings (n-ZEB) for its real estate assets by using the photovoltaic generation to produce the needed electricity.

Developing sustainable technologies is essential and highly desirable for mitigating the anthropogenic impact on environment. In this context, the research of Prof.s P. Asinari and E. Chiavazzo, with their group, investigates the use of solar energy to address and mitigate the problem of the water scarcity, especially in far-away regions without access to the electricity grid as Sub-Saharan Africa, Central Asia, Southern Asia, Eastern Asia and South-Eastern Asia. Recently, they have developed low-cost and low-carbon renewable energy (thermal solar) driven desalination technology to reduce the carbon footprint in drinkable water production. To this purpose, they have focused our attention on: i) optimizing the solar light harvesting process to enhance the solar to vapour generation efficiency and ii) improving the use of the harvested energy flux through an efficient condensation passive process with multiple re-uses of the heat of condensation (a lab-scale prototype is reported on the left-hand side of the figure below). Thus, they have designed and realized a standalone compact desalination unit based on a multi-effect distillation process able to produce fresh water.

This device is completely passive, which means that it does not need pumps, active components and power supply for operation; it simply uses the solar energy to purify water. In addition, this process is efficiently operated by a thermal power density of less than 1 kW m^{-2} (non-concentrated solar power) and at a maximum temperature of 65°C . However, future developments may involve the use of concentrated solar power (e.g. by means of the two-axis solar concentrator installed at internal lab, which could be beneficial for improving the performance and industrial scalability of this passive desalination device.

The engineering complexity and geographical requirements of desalination techniques make their deployment difficult in certain regions of the world, such as desert climates, countries with no direct access to brackish or seawater. The atmosphere contains around $13,000 \text{ km}^3$ of freshwater, which is an order of magnitude higher than rivers (primary fresh water source) and this water is also a widely accessible resource in all regions around the world. Prof.s G. Fracastoro and M. Simonetti, with their group, are studying solar-driven atmospheric water harvesting systems based on adsorption techniques, introducing an innovative iso-thermal process (patented) and a new hygroscopic bio-compatible material (patent pending). The activity is carried on in partnership with Princeton University (NJ, US) both on the research and technology transfer grounds, through the spin-off company Aquaseek. They used sorption technologies also to study open-loop solar cooling systems. The NAC-wall, one-of-a-kind machine, demonstrated a desiccant-evaporative cooling cycle, based on the use of SAPO-34 zeolite, regenerated by solar thermal energy, activated by full buoyancy-driven ventilation. It can perform also in hybrid ventilation mode, achieving an electrical COP of 26, and a thermal COP of 0.75.

Tubular receivers in central tower systems suffer the high mechanical stresses caused by the temperature gradient typically established along the tube and across its circumference due to the one-side heating. Prof. L. Savoldi and her group design, test and analyze new solutions for the removal of high heat fluxes from absorber tubes, moving in the two parallel directions of enhancing the heat transfer by tailored turbulence promoters and metal porous media/foams.

The specific focus of the tests, typically performed at the Plataforma Solar de Almeria within the EU SFERA projects using pressurized air as a Heat Transfer Fluid (HTF), is the assessment of the role of turbulence promoters/porous media in reducing the peak wall temperature when a strong one-side heating is present, contributing to the reduction of the thermal gradients between the irradiated and the non-irradiated (back) side of the receiver. Suitable Computational Fluid Dynamic (CFD) 3D models are developed and validated against experimental data, and further used to perform the enhancement of the heat transfer to the HTF.



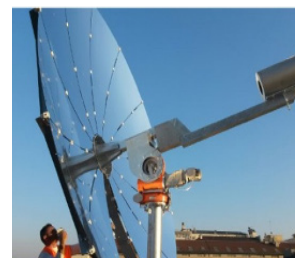
Internal view of PV systems
@13P (about 30-kw)



The oldest PV plant with
rated power of 1.5 kW



Lab scale prototype of destination



Two-axis solar concentrator

10. 2000-2009

10.1 ISES 2000-2009

2000

- The Millennium Solar Forum was organised by ISES in Mexico City.
- ISES and UNEP organised a highly successful *Seminar on Rural Energy Provision in Africa (SEREPRO)*, part of the second phase of the ISES Utilities for Africa initiative.



Figure 72: The Staff at ISES Headquarters in June 2001, at the time of Burkhard Holder's resignation due to ill health. Rian van Staden, fourth from the right, would become Executive Director and Christine Hornstein, 9th from the right, the Deputy Executive Director.

2001

- Rian van Staden became ISES Executive Director.
- The 2001 Solar World Congress was in Adelaide, Australia

2002

- Dr. Karl Böer agreed to serve as editor of the proposed book, *The Early Years of ISES* which was to become the 50 Year History of ISES and its National Sections.
- The first woman elected as President. Prof. Anne Grete Hestnes takes office on 01.01.2002.
- Anne Grete Hestnes and Rian van Staden ensured ISES was part of the World Summit on Sustainable Development in Johannesburg.
- Prof. Yogi Goswami becomes Editor-in-Chief of Solar Energy journal.

2003

- ISREE-9 was held in conjunction with the Solar World Congress in Göteborg, June 2003.
- ISES White Paper, *Transitioning to a Sustainable Energy Future*, by Dr. Donald Aitkin, outlining the rationale for effective governmental renewable energy policies world-wide, was released.
- The *European Solar Cities Initiative* workshop organised by ISES led to the International Solar Cities Initiative (ISCI).



Figure 73: Karl Böer speaking after receiving the Farrington Daniels Award (2003)

- Professor D Yogi Goswami (USA) was elected President in 2003.

2004

- The first ISCI Congress was held in Daegu, Korea.
- ISES made a strong showing at the *Renewables 2004* conference in Bonn in early June.
- Through involvement on the International Steering Committee and the International Advisory Group, ISES became recognized as an NGO with strong science and technology credentials.
- Two new Sections, Brazil and Lebanon, were accepted.
- ISES, together with the World Wind Energy Association (WWEA) and the International Hydropower Association (IHA), became a founding member of the International Renewable Energy Alliance (later renamed to Ren-Alliance) during the Bonn International Renewable Energy Conference. In 2007 the International Geothermal Association joined and 2009 the World Bioenergy joined. The goal of the REN-Alliance is to advance policies that favour the increased deployment and use of all renewable energy technologies.
- November 2004: ISES organises the 1st International Solar Cities Congress, held within the framework of a Memorandum of Understanding between ISES and the city of Daegu, Korea.



Figure 74: Anna Grete Hestnes at Solar Cities in Daegu

2005

- August 2005: ISES, together with its U.S. Section the American Solar Energy Society, celebrates its Golden Jubilee at the Solar World Congress in Orlando/Florida, USA. The ISES publication “The Fifty-Year History of the International Solar Energy Society and its National Sections” is released during the Congress.
- ISES launches the Pocket Reference Books with the release of the first book “Solar Energy Pocket Reference”.
- ISES releases the second White Paper “Rapid Transition to a Renewable Energy World”, by Prof. Dieter Holm, presenting a rationale for effective policies to advance renewable energies in the developing world.



Figure 75: ISES Board Meeting in Florida 2005

- Torben Esbensen from Denmark is elected ISES President for 2006-2007
- At the ISES Board Meeting held in conjunction with the Orlando Congress Rian van Staden steps down as Executive Director of ISES after 4 years in the role. He had worked at ISES HQ since it moved to Freiberg in 1995. Christine Hornstein was named the new Executive Director.



Figure 76: Christine Hornstein and Monica Oliphant

2006

- In April ISES helps to organise the 2nd International Solar Cities Congress, being held within the framework of a Memorandum of Understanding between ISES and the city of Oxford.
- First Young ISES members' meeting held during Eurosun 2006 in Glasgow, Scotland.
- ISES participates in the UN Commission on Sustainable Development (CSD) 14th session and hosts a side-event focusing on renewable energy in developing countries.
- the new ISES vision statement is launched: **Rapid Transition to a Renewable Energy World.**

2007

- ISES inaugurates the Solar Carport at the Headquarters Office, Villa Tannheim in Freiburg.
- ISES hosts a side-event focusing on 100% renewable energy in Asia and Africa at the UN Commission on Sustainable Development (CSD) 15 session held in New York April/May 2007.
- The SWC2007 was held in Beijing, China, co-hosted by the ISES Section, the Chinese Renewable Energy Society.
- The name of the Löf/Duffie Best Paper Award for papers in Solar Energy journal is changed to Solar Energy Journal Best Paper Awards. It is presented every second year at the SWCs to authors of papers that demonstrate significant pioneering contributions to the solar energy literature, for innovative concepts or approaches, and whose quality and presentation have a lasting impact.
- Larry Kazmerski received the Karl Boer Solar Energy Medal of Merit for 2007 and gave an honorary speech at SWC 2007.
- Monica Oliphant from Australia is elected ISES President for 2008-2009 becoming only the second female president of ISES.

2008

- During the year the following ISES supported conferences were held and attended by the ISESPresident:February - International Solar Cities Congress, Adelaide Australia, October – Eurosun Lisbon, Portugal, November - Latin American Regional Conference, Florianopolis, Brazil, November – Asia Pacific Regional Congress, Sydney, Australia.
- June – ISES President Monica Oliphant, Vice President Dave Renné, and Executive Director Christine Hornstein represented ISES at WIREC in Washington, DC.At a meeting of the International Renewable Energy Alliance (IREA), the name of the organizations was changed to: the Renewable Energy Alliance, or REN-Alliance, to avoid confusion with the newly established IRENA.Peter Rae was the Chair of the REN-Alliance.
- The gas heating system is replaced with a wood pellet heater at the ISES Headquarters - another step towards making the ISES offices CO2 neutral.
- ISES releases the second in the series of pocket books, the Wind Energy Pocket Reference

2009

- During the year the following ISES supported Congresses were held and attended by the ISES President:June-IHA Congress (REN Alliance) – Iceland, September – Iberoamerica RE Summit, Guadalajara Mexico, October – SWC2009, Johannesburg South Africa.
- Christine Hornstein represented ISES at the Founding Conference of IRENA in Bonn on 29 January 2009. At the conference it was announced that the Interim Director General of IRENA would be Ms. Helene Pelosse.
- Ms. Pelosse met with Christine Hornstein and Monica Oliphant (on Skype) in April 2009.A meeting with Ms. Pelosse was also arranged with REN Alliance representatives in Stockholm on 15 September 2009. Jan-Olof Dalenbäck and Christine Hornstein participated for ISES. IRENA and the REN Alliance agreed on fields of co-operation to work together (via an MOU) in order to speed up the utilisation of RE sources worldwide. Fields of co-operation at the time were:
 - Carbon funds for renewables;
 - Sustainability assessment;
 - Potentials for renewables;and
 - Renewable energy scenarios.
- Monica Oliphant presents the Karl Boer Solar Energy Medal of Merit to Hermann Scheer at a ceremony hosted by the University of Delaware and the Boer family, USA.
- ISES releases the Passive Solar Architecture Pocket Reference book.
- August – Elsevier gives ISES 6 months notice that in March 2010 Renewable Energy Focus will no longer be the official magazine of ISES. End of 10 year contract started in 2000.
- In December:The first cooperation between IRENA and ISES involved an IRENA&REN-Alliance Side Event at UNFCCC COP15 in Copenhagen, Denmark in December 2009.
- Also at COP-15 Ms. Helen Pelosse, the Interim Director of IRENA, met with ISES and other representatives of the REN-Alliance.
- NZ leaves ANZSES which then becomes AuSES.
- The Solar World Congress 2009 is held in Johannesburg, South Africa, the second time the SWC was held on the African continent.
- Dave Renné from the U.S. is elected ISES President for 2010-2011.



Figure 77: Four ISES Past Presidents Monica Oliphant, Anne Greta Hestnes, D Yogi Goswami and Dave Renne

Table 20: Officers of ISES 2001-2009

Years	President	Vice Presidents	Secretary or Secretary / Treasurer	Officer/ Director
2001-2002	Anne Grete Hestnes	D. Yogi Goswami Hyun Chai Jung	Torben Esbensen	Rian van Staden
2004-2005	D. Yogi Goswami	Monica Oliphant Renate Böer Jan-Olof Dalenbäck Venkatrama Bakthavatsalam	Torben Esbensen	Rian van Staden
2006-2007	Torben Esbensen	Prof. Klaus Vajen Prof. Sadasuke Ito Ms. Monica Oliphant Mr. Isao Ike Yukawa Prof. Yogi Goswami	Prof. Dieter Holm (Secretary) Prof. Jan-Olof Dalenbäck (Treasurer)	Christine Hornstein
2008-2009	Monica Oliphant	Prof. Jan-Olof Dalenbäck Dr. Dave Renné Ms. Mahalath Halperin Mr. Ming Huang	Dr. Eduardo A. Rincón Mejía (Secretary) Mr. Torben Esbensen (Treasurer)	Christine Hornstein

Table 21: Conferences and Meetings 2001-2009

Year	Location	Overview
2001	Adelaide Australia	Theme: <i>Bringing Solar Down to Earth</i> 600 participants (57 countries) Conference Chair: Professor Wasim Saman Farrington Daniels Award: Prof. Roland Winston (USA) Christopher Weeks Achievement Award: Bernard McNeilis, IT Power (UK) Karl W Böer Award: Dr Allen M Barnett (USA)
2003	Göteborg Sweden	Theme: <i>Solar Energy for the Built Environment</i> 700 participants (70 countries) Chair of Organising Committee: Farrington Daniels Award: Prof. Karl W. Böer (USA) Christopher Weeks Achievement Award: Dr. Werner Weiß, AEE, Gleisdorf (Austria) Karl W Böer Award: Prof. Martin A Green (Australia) ISES Special Services Award: Donald Aitkin (USA)
2005	Orlando USA	Theme: <i>Solar Energy: Bringing Water to the World and The History of Solar Energy and ISES</i> Farrington Daniels Award: Christopher Weeks Achievement Award: Prof. Zhiqiang Tin, Tsinghua University, Beijing (China) Karl W Böer Award: Prof Yoshihiro Hamakawa (Japan) ISES Special Services Award: Torben Esbensen (Denmark) and Joachim Luther (Germany)
2007	Beijing China	Theme: <i>Solar Energy and Human Settlement</i> Farrington Daniels Award: Prof. D. Yogi Goswami (USA) Christopher Weeks Achievement Award: Prof. Andrew Blakers & Dr Klaus Weber, Centre for Sustainable Energy Systems, ANU Canberra (Australia) Karl W Böer Award: Dr Lawrence Kazmerski (USA) ISES Special Services Award: Dieter Holm (South Africa)
2009	Johannesburg South Africa	Theme: <i>Renewable Energy Shaping our Future</i> Farrington Daniels Award: Dr Manuel Romero Álvarez (Spain) Christopher Weeks Achievement Award: Prof. Joachim Luther, Solar Research Institute of Singapore Karl W Böer Award: Dr Hermann Scheer (Germany) ISES Special Services Award: Jan-Olof Dalenbäck (Sweden)

10.2 ISES Presidents 2000-2009



Figure 78: Anne Grete Hestnes,
President 2002 – 2003

Anne Grete Hestnes

Anne Grete Hestnes (Norway) is an architect educated at M.I.T and UC Berkeley, and Professor Emeritus at the Norwegian University of Science and Technology. Her main scientific focus is in the areas of energy conservation and the use of solar energy in buildings.

In 2005, she was awarded an honorary doctorate by Chalmers University for her work within the field of sustainable development, and in 2011 she received the Farrington Daniels Award for her contribution to the advancement and knowledge of solar energy in the built environment. During its first three years of operation (2009-2012) she was director of the National Centre for Environment-friendly Energy Research – Zero Emission Buildings. Her areas of specialization are energy conservation and the use of solar energy systems in buildings, as well as optimization and integration of systems. She has been Full Professor of Building Technology at the Faculty of Architecture and Fine Art at the Norwegian University of Science and Technology since 1985. Hestnes is presently Dean of the Faculty of Architecture and Fine Art at NTNU. In Norway, she is frequently consulted by the Ministry of Petroleum and Energy and by the Research Council of Norway both on scientific and on policy issues.



Figure 79: Professor Yogi Goswami,
President 2003 – 2005

D.Yogi Goswami

Professor D. Yogi Goswami (USA) did his undergraduate degree in Mechanical Engineering at the University of Delhi, India, followed by an MSc and PhD at Auburn University in Alabama. A Professorship followed at North Carolina A&T State University, and in 1990, he became a Professor of Mechanical Engineering and the Foundation Professor and Director of the Solar Energy & Energy Conversion Laboratory, Department of Mechanical and Aerospace Engineering at the University of Florida.

He is internationally known for his research in fundamental and applied areas of renewable energy and also holds five US patents and one world-wide patent. He is a Co-author of the revised textbook *Principles of Solar Engineering* and has been Editor-in-Chief of *Solar Energy Journal*. He also has chaired a number of task forces to advise the U.S. Congress and the federal administration on energy policy.



**Figure 80: Torben Esbensen,
President 2006 – 2007**

Torben Esbensen

Torben Esbensen (Denmark) is Director at Esbensen Consulting Engineers A/S since 1979, a company working internationally in the field of solar energy and energy design of buildings. Esbensen was Member of the ISES Board from 1990-96, representing the four Scandinavian countries and again from 1998 representing the small sections of ISES. Esbensen was Vice-President 1999-2001, secretary 2002-2005, and treasurer from 2007-2017. He was Organizing Chairman of the ISES Solar World Congress 2007 and EuroSun 2000; and International Chairman of the ISES Solar World Congress 2003. He started his career in solar in 1973 as an employee at the Technical University of Denmark. In 1979 he left the university to implement research results into the practical building designs.



**Figure 81: Monica Oliphant,
President 2008 – 2009**

Monica Oliphant

Monica Oliphant (Australia) played a very active role in ANZSES and AUSES. She joined the ISES Board in 1997 and is still a member. She first became interested in renewable energy, and in particular solar energy, when she worked at Flinders University on solar thermal energy research from 1977 to 1981.

As a Senior Research Scientist with the Electricity Trust of South Australia (ETSA) from 1981 to 2000, she undertook ground-breaking research into the role of renewable energy, energy efficiency and consumer behaviour in demand management for power networks. She was a pioneer in building-integrated photovoltaics in Australia, through ETSA managed research, development and demonstration projects. Oliphant began her scientific career with a Master's Degree in Physics from the University of London and worked as an Energy Research Scientist for the Electricity Trust of South Australia for almost 20 years. Since 2000 Monica has been an independent consultant specialising in residential energy efficiency and renewable energy. She is an Adjunct Associate Professor at the University of South Australia. Currently, she is working to develop community-owned solar and energy efficiency projects together with local governments.

10.3 PV 2000-2009

The new decade started with the feed-in tariff (FIT) through the "EEC" renewable energy law being introduced in Germany, one of the programs that increased the use of PV particularly in Germany. For 2004 to 2007 and in 2009 more than 50% of the PV installed each year globally was installed in Germany (highest being 66% in 2006). Spain was over 50% in 2008 because they introduced a FIT. Over the decade more countries introduced feed-in tariffs and various other incentive programs were introduced. China introduced the Renewable Energy Law in 2005 that saw the number of Chinese manufactures increase which was the start of the future Chinese domination of the market. The price of solar modules fell dramatically in the later part of the decade. By about 2003 more 3-5MW systems were installed and these kept on growing as the decade progressed. During this decade the PV manufacturing base moved from being focussed in Japan, USA and Europe to China and some other Asian countries. MW replaces kW when quoting PV installation capacity.

For the two decades of this century, the historic highlights include some of the early solar farms and breakthroughs in cell efficiencies etc. However, the focus is on providing the data that displays the growth

of installations, the top 10 manufacturers each year and the changes in countries where manufacturing was being undertaken.

In accordance with the IEA Trend Reports during the 2000's:

- Annual installations grew from 195MW in 2000 to almost 7,000MW(7GW) in 2009.
- Cumulative installed capacity grew from approximately 700MW in 2000 to approximately 23GW in 2009.
- In 2000 off grid systems represented 16% of the annual installations and by 2009 this had decreased to 1%.
- In 2000 off grid systems represented 39% of the cumulative installed capacity and by 2009 this had decreased to 4%.
- In 2000 grid connected centralised systems represented 0.8% of the annual installations and by 2009 this had grown to 60%. (Note the 2009 Trends report did not have a breakdown)
- In 2000 grid connected centralised systems represented 5% of the cumulative installed capacity and by 2009 this had grown to 33%.

Note: Traditionally the IEA Trends Reports only covered IEA member countries which during the 90's were the main manufacturers and deployers of solar though some systems were not being installed in member countries. During the 2000's many systems started to be installed in non-member countries and the IEA then started using other databases, in addition to member countries data, in preparing their installation tables. While preparing these graphs some minor differences in figures were observed however the numbers shown in this document are indicative of how the market has grown. China joined the IEA in 2010 so there were no figures provided in the annual reports prior to 2010 however in the 2018 report China's figures had been back dated to 2000 and the following charts use a combination of the various trend reports.

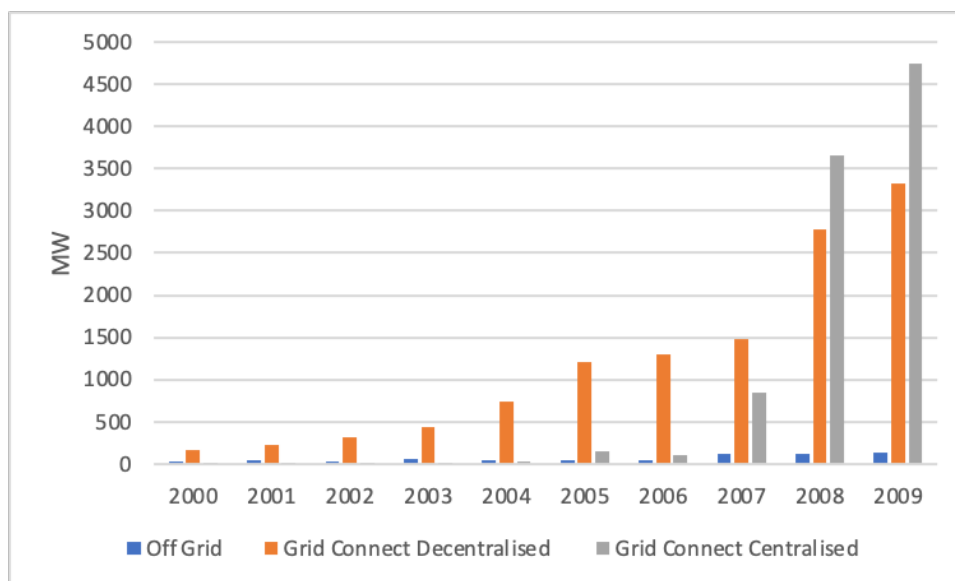


Figure 82: Annual Installed Capacity

Source: IEA PVPS Annual Trend Reports (2000 to 2009 and 2018)

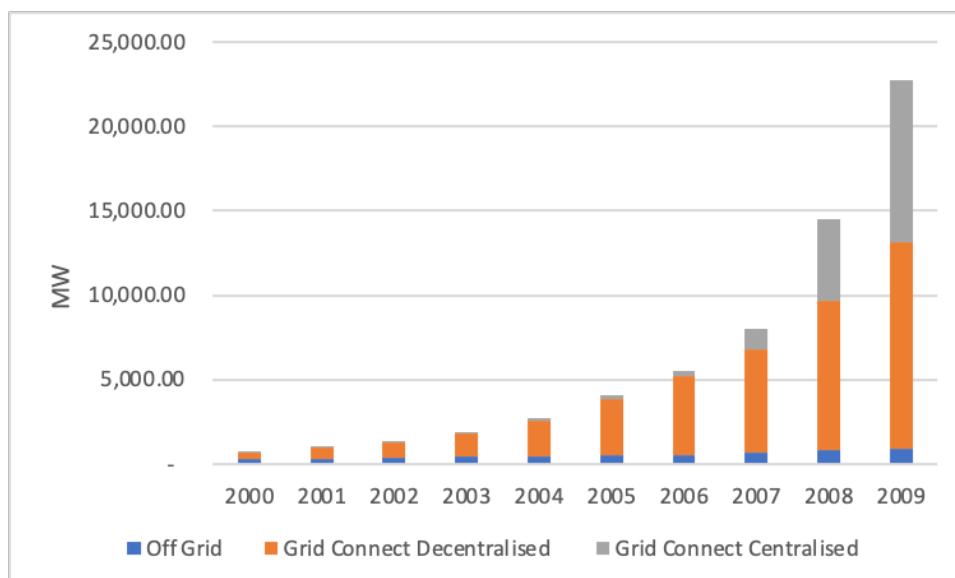


Figure 83: Cumulative PV Installed Capacity

Source: IEA PVPS Annual Trend Reports ((2000 to 2009 and 2018)

Table 22: Top 10 PV Manufacturers by Year (2000-2004)

2000		2001		2002		2003		2004	
252MW _p		352.9MW _p		504.9MW _p		675.3MW _p		1049.8MW _p	
Kyocera	17%	Sharp Solar	20%	Sharp Solar	25%	Sharp Solar	29%	Sharp Solar	29%
BP Solar	17%	BP Solar	15%	BP Solar	13%	BP Solar	11%	Kyocera	10%
Sharp Solar	14%	Kyocera	15%	Kyocera	12%	Kyocera	11%	BP Solar	8%
Shell Solar	14%	Shell Solar	13%	Shell Solar	9%	Shell Solar	8%	Shell Solar	7%
Astropower	7%	Astropower	7%	RWE /Schott	6%	RWE /Schott	7%	Q Cells	7%
RWE /Schott	6%	RWE /Schott	7%	Astropower	6%	Mitsubishi Electric	5%	Schott Solar	6%
Photowatt	5%	Isofoton	5%	Isofoton	5%	Sanyo	5%	Sanyo	6%
Isofoton	4%	Photowatt	4%	Mitsubishi Electric	4%	Isofoton	5%	Mitsubishi Electric	5%
Sanyo	3%	Sanyo	4%	Sanyo	4%	Q Cells	4%	Isofoton	4%
Mitsubishi	1%	Kaneka	1%	Photowatt	3%	Photowatt	3%		
Other	12%	Other	10%	Other	13%	Other	12%	Other	18%

Source: Renewable Energy World

Table 23: Top 10 PV Manufacturers by Year (2005-2009)

2005		2006		2007		2008		2009	
1407.7MW _p		1984.6MW _p		3073MW _p		5491.8MW _p		7913.3MW _p	
Sharp Solar	27%	Sharp Solar	22%	Sharp Solar	12%	Q Cells	10%	First Solar	13%
Kyocera	10%	Q Cells	12%	Q Cells	11%	Suntech	9%	Suntech	9%
Q Cells	9%	Kyocera	9%	Suntech	10%	Sharp Solar	8%	Sharp Solar	7%
Schott Solar	7%	Suntech	8%	Kyocera	7%	First Solar	8%	Yingli	7%
BP Solar	6%	Sanyo	6%	First Solar	6%	Kyocera	5%	Q Cells	7%
Mitsubishi Electric	6%	Mitsubishi Electric	5%	Motech	6%	Motech	5%	JA Solar	7%
Sanyo	6%	Schott Solar	5%	Sanyo	5%	Sanyo	4%	Trina	5%
Shell Solar	4%	Motech	5%	SolarWorld	4%	SunPower	4%	SunPower	4%
Motech	3%	BP Solar	4%	Mitsubishi Electric	4%	JA Solar	4%	Kyocera	4%
Isofoton	3%	SunPower	3%	SunPower	3%	BP Solar	3%	Motech	4%
Others	19%	Others	21%	Other	32%	Other	40%	Other	33%

Source: Renewable Energy World

Table 24: PV Module Manufacturing by Regions

	USA	Japan	Europe	Other
2000	23%	57%	17%	3%
2001	23%	57%	18%	2%
2002	17%	54%	28%	2%
2003	11%	60%	27%	2%
2004	12%	51%	36%	1%
2005	13%	50%	34%	3%
2006	12%	39%	45%	4%
2007	6%	15%	39%	40%
2008				
2009				

Source: IEA PVPS Annual Trends Reports

Note: China joined IEA PVPS in 2010 hence it was difficult estimating the figures for 2008 and 2009 with the growth of the Chinese Manufacturers

Table 25: Annual Installed PV (%) by Country (2000-2009)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Australia	0.1%	1.3%	1.3%	1.3%	0.5%	0.6%	0.6%	0.4%	0.5%	1.0%
Austria	0.2%	0.4%	1.1%	1.4%	0.4%	0.2%	0.1%	0.1%	0.1%	0.2%
Belgium	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	1.3%	6.8%
Canada	0.2%	0.7%	0.3%	0.4%	0.2%	0.2%	0.2%	0.2%	0.1%	0.8%
China	1.6%	1.7%	4.6%	2.1%	0.9%	0.6%	0.7%	0.8%	0.6%	2.0%
Denmark	0.1%	0.3%	0.4%	0.4%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%
Finland	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
France	0.3%	1.0%	0.8%	0.8%	0.3%	0.1%	0.8%	1.5%	1.6%	2.3%
Germany	2.9%	39.2%	29.7%	23.6%	60.5%	66.2%	56.6%	51.0%	29.5%	54.5%
Great Britain	0.1%	0.3%	0.4%	0.4%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%
Israel	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
Italy	0.1%	0.3%	0.5%	0.8%	0.5%	0.4%	0.9%	2.0%	6.0%	9.6%
Japan	17.5%	40.9%	46.7%	47.3%	24.6%	20.2%	19.2%	8.5%	3.4%	5.9%
South Korea	0.1%	0.3%	0.2%	0.1%	0.2%	0.3%	1.5%	1.8%	4.2%	1.0%
Malaysia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.1%	0.0%	0.0%
Mexico	0.2%	0.3%	0.3%	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
Netherlands	0.1%	2.3%	1.5%	3.8%	0.3%	0.1%	0.2%	0.0%	0.1%	0.1%
Norway	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Portugal	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.6%	0.8%	0.4%
Spain	0.1%	0.0%	0.5%	0.0%	0.7%	1.1%	7.4%	22.6%	45.2%	0.6%
Sweden	0.1%	0.0%	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Switzerland	0.2%	1.0%	0.3%	0.4%	0.2%	0.3%	0.2%	0.2%	0.2%	0.3%
Thailand	0.0%	0.0%	0.0%	0.0%	0.0%	1.7%	0.4%	0.1%	0.0%	0.1%
Turkey	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
USA	3.1%	9.6%	11.3%	13.4%	9.1%	7.2%	9.7%	8.3%	5.1%	5.8%
Total IEA Countries	99.9%	99.7%	99.5%	97.2%	98.9%	99.7%	99.7%	99.6%	98.7%	92.2%
Total Non IEA Countries	0.1%	0.3%	0.5%	2.8%	1.1%	0.3%	0.3%	0.4%	1.3%	7.8%

Source: IEA PVPS 2010 and 2018 Annual Trend Reports

2000

- **First Solar** began production in Perrysburg, Ohio, being the world's largest photovoltaic manufacturing plant at that time. The plant had the capability of producing enough solar panels each year to generate 100 megawatts of power.
- At the **International Space Station**, astronauts begin installing solar panels on what will be the largest solar power array deployed in space. Each "wing" of the array consists of 32,800 solar cells.
- Two new thin-film solar modules, developed by **BP Solarex**, broke previous performance records. The company's 0.5-square-meter module achieved 10.8 % conversion efficiency - the highest in the world for thin-film modules at that time. Its 0.9-square-meter module achieved 10.6% conversion efficiency and a power output of 91.5 watts.
- Herman Scheer and Hans Josef Fell through the Renewable Energy Act (Erneuerbare Energien Gesetz, or EEG) established the Feed in Tariff (FIT) that would be supportive for PV in Germany (The Feed In Tariff Law of 1991 promoted wind and the Tariff for PV was too little). The EEG led to the rapid expansion of the PV Industry.

2001

- NASA's solar-powered aircraft, **Helios**, sets a new world record for non-rocket powered aircraft: 96,863 feet, more than 18 miles high.
- The **National Space Development Agency** of Japan, or NASDA, announced plans to develop a satellite-based solar power system that would beam energy back to Earth. A satellite carrying large solar panels would use a laser to transmit the power to an airship at an altitude of about 12 miles, which would then transmit the power to Earth. It never proceeded.
- **TerraSun LLC** developed a unique method of using holographic films to concentrate sunlight onto a solar cell. Concentrating solar cells typically use Fresnel lenses or mirrors to concentrate sunlight. TerraSun claims that the use of holographic optics allows more selective use of the sunlight, allowing light not needed for power production to pass through the transparent modules. This capability allows the modules to be integrated into buildings as skylights
- **PowerLight Corporation** connected to the grid in Hawaii the world's largest hybrid system that combines the power from both wind and solar energy. The grid connected system is unusual in that its solar energy capacity (175 kilowatts) is actually larger than its wind energy capacity of 50 kilowatts. Such hybrid power systems combine the strengths of both energy systems to maximize the available power.
- **Powerlight Corporation** installed the largest rooftop solar power system in the United States - a 1.18 megawatt system - at the Santa Rita Jail in Dublin, California.

2002

- **NASA** successfully conducted two tests of a solar-powered, remote-controlled aircraft called **Pathfinder Plus**. In the first test in July, researchers demonstrated the aircraft's use as a high-altitude platform for telecommunications technologies. Then, in September, a test demonstrated its use as an aerial imaging system for coffee growers.
- **ATS Automation Tooling Systems** Inc. in Canada commercialised an innovative method of producing solar cells, called Spherical Solar technology. The technology based on tiny silicon beads bonded between two sheets of aluminium foil promised lower costs due to its greatly reduced use of silicon relative to conventional multi-crystalline silicon solar cells. However, the technology was not new. It had been championed by Texas Instruments (TI) in the early 1990s. But despite U.S. Department of Energy (DOE) funding, TI dropped the initiative.

2003

- On April 29th 2003, the world's largest photovoltaic plant at that time was connected to the public grid in Hemau near Regensburg (Bavaria), Germany. The peak power of the "Solarpark Hemau" plant was 4 MW.

2004

- California Governor Arnold Schwarzenegger proposed Solar Roofs Initiative for one million solar roofs in California by 2017.
- Due to the "EEC" renewable energy law many other large systems of up to 5 MW were built in Germany in 2004. Some of these are Geiseltalsee, Leipzig, Bürstadt, Göttelborn solar parks.
- 1GW of solar modules are shipped for the first time.

2005

- Annual installation reaches 1GW.
- China's Renewable Energy Law was introduced. The Law imposed a national renewable energy requirement with the objective to boost the use of renewable energy capacity up to 10 percent by the year 2020.

2006

- Polysilicon use in photovoltaics exceeded all other silicon use for the first time.

2007

- University of Delaware claims to achieve new world record in Solar Cell Technology without independent confirmation (42.8% efficiency).

2008

- Scientists at the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) set a world record in solar cell efficiency with a photovoltaic device that converted 40.8% of the light that hit it into electricity. However, it was only under the concentrated energy of 326 suns that this was achieved. The inverted metamorphic triple-junction solar cell was designed, fabricated and independently measured at NREL.

10.4 Solar Thermal 2000-2009

From 2000's onwards concerns about climate change growing so many government subsidy programs lead to large increases in the market across the 2000's.

Key points from the IEA SHC data:

- IEA SHC collected data from Australia, Austria, Brazil, Canada, Cape Verde, China, Germany, India, Lebanon, The Netherlands, Sweden, Turkey, and USA.
- The total recorded annual installed capacity increased from 9 million m² in 2000 to 49.5 million m² in 2009. This is shown in Figure 84.
- China dominance of the market grew from being 71.5% of the total recorded annual installed capacity in 2000 to 84.9% in 2009.
- In 2000 ETC's represented 58% of the recorded annual installed capacity and this grew to 82% in 2009.
- The dominance of ETC's is due to the China market where in 2000 80% of the annual installed capacity were ETC's growing to 95.2% in 2009. In the ROW ETC represented only 4% growing to 9% in 2009.
- Air collector heater data was being collected by the IEA SHC however prior to 2000 data was only for USA while for 2000 to 2010 data was collected for USA and Canada. Canada was the larger of the two markets representing 85.8% in 2000 and 95.8% in 2009. Figure 85 shows the annual installed capacity of air collector heater panels for USA and Canada.

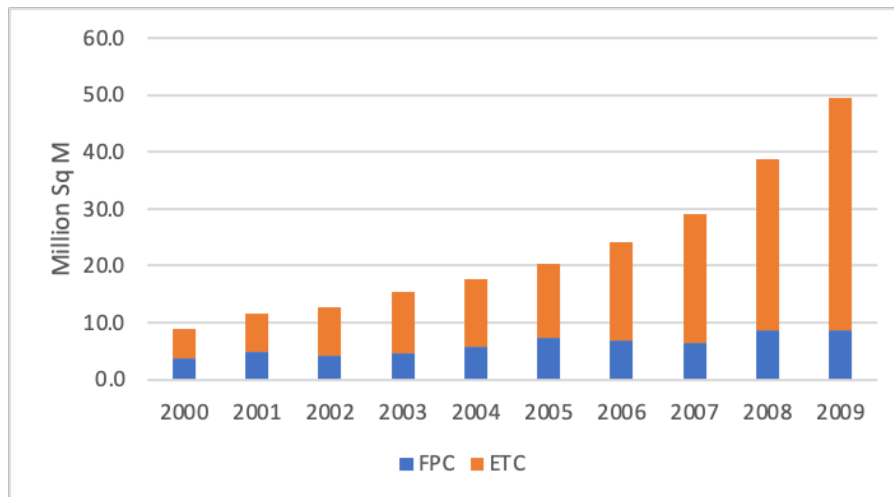


Figure 84: Annual recorded installed solar water panel capacity 2000-2009 broken down into ETC and FPC
Source: IEA SHC

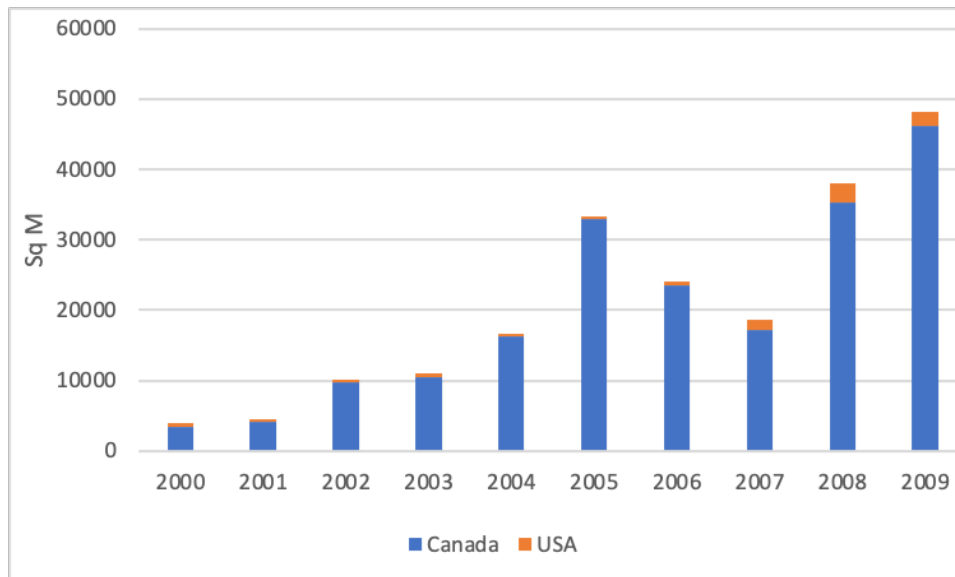


Figure 85: Annual recorded installed air heating panel capacity 2000-2009 for Canada and USA
Source: IEA SHC

2000

- Start of 'Solar Keymark' project by European Solar Industry Federation (ESIF) supported by the European Commission, under its ALTENER programme.

2001

- European standards EN 12975 for solar collectors, EN 12976 for factory made systems and EN 12977 for custom built systems were introduced.

2002

- The European Solar Thermal Industry Federation (ESTIF) is created by the merger of ESIF (European Solar Industry Federation) and ASTIG (Association of Solar Thermal Industry Groups).
- First edition of the "Tag der Sonne" in Austria, organised by **Austria Solar**. This initiative developed later into the origin of the European Solar Days, which reached its pinnacle in the 2013 edition, with more than half a million European citizens involved in 6,000 local events spread over 20 countries.

2003

- Solar Keymark Scheme rules are formulated by the European Solar Thermal Industry and major testing institutes, as a unified and simple solution in order to get solar thermal products recognised all over Europe. As a result, the first Solar Keymark license was issued that same year.

2004

- At an international meeting in Gleisdorf Austria in September 2004 it was agreed upon the conversion factor of 0.7 kWth/m² in order to convert collector area to thermal power capacity. Since then, the factor was quickly adopted and recognised, and it is now used worldwide.

2005

- The state of Victoria, Australia requires new houses to have sustainability measures to save energy and water. Approximately 70% of new houses now have solar water heaters.
- Estimated 3% of Energy in Israel comes from solar water heaters.
- Establishment of the "European Solar Thermal Technology Platform" (ESTTP) . This was Initiated by Werner Weiss, Gerhard Stryi-Hipp, Harald Drück et. al.

2006

- Establishment of the "Solar Keymark Network" (SKN) managed by Jan Erik Nielsen with Harald Drück as Chairman.

2007

- Solar Keymark obligatory in Germany and the majority of all collectors sold in EU show Solar Keymark
- ESTIF launches the Solar Thermal Action Plan for Europe, projecting 1m²/habitant by 2020
- Drake Landing Solar Community is a Canadian solar district heating system with seasonal thermal storage. The demonstration project, designed to achieve over 90% solar fraction, was commissioned in the summer of 2007.
- The first SolNet-course for PhD-students in the solar heating sector took place in Borlänge (SE). Meanwhile, 16 PhD courses have been conducted with more than 300 participants from all over the world. Additionally, nine SolNet-courses for Master students took place in connection with Eurosun-conferences since 2000 in Copenhagen (DK). Over that time almost 200 students have participated in the courses that are organised by the University of Kassel (DE) in close cooperation with local partners.

2008

- The European: Solar thermal market has its historical record sales year, reaching 3,3 GWth of new capacity, equivalent to 4,75 mil m² of collector area.
- Solarthermalworld.org initiated by the European Copper Institute (ECI) with the aim of providing stakeholders from research, public and private sector all around the globe with first-class information about solar heating and cooling.
- Creation of the European Technology Platform on Renewable Heating and Cooling.
- China SAC TC 402, the mirror committee of ISO TC 180 in China in charge of standardization in the field of solar collectors, solar thermal components, solar water heating system, solar cooker, solar passive house.
- Publication of the ground breaking "Potential study for solar thermal in Europe", modelling the potential contribution solar thermal in the European Union up to 2050, based on three main scenarios.

2009

- BURJ KHALIFA tower, Dubai, UAE -tallest building of the world installs, 1.020m² flat plate collectors with 80m³ heat store.
- SOLTRAIN - Southern African Solar Thermal Training and Demonstration Initiative is a regional program of capacity building and demonstration of solar thermal systems in the SADC region. It is funded by the Austrian Development Agency and OFID. The implementing agency of SOLTRAIN is AEE INTEC, an Austrian institute for applied research. In 2020 it is in its fourth phase of cooperation with Botswana, Lesotho, Mozambique, Namibia, South Africa and Zimbabwe

10.5 CSP 2000-2009

2003

- Work on the Eurotrough was completed.

2004

- Ausra completed a 1 MWth CSP plant using Fresnel technology to supplement the 2000 MW coal-fired Liddell Power Station, subsequently increased up to 9 MWth by 2008. This was the world's first solar thermal power collector system for coal-fired power augmentation. In December 2010, Novatec Solar was awarded the contract to expand the facility with another 9.3 MWth. This phase was completed by October 2012.

2005

- The U.S. Congress established the Loan Guarantee program at DOE which provided long term low interest debt and States enacted renewable portfolio standards which created a market demand for CSP.

2006

- Solargenix built the 1 MW Saguaro CSP trough demonstration plant in Arizona.

2007

- The Royal Decree in Spain set a feed-in tariff for CSP that attracted the attention of project developers. This led to a major expansion of CSP development in Spain.
- PS 10, a 10 MW steam power tower, began operation in Spain.
- Nevada Solar One, a 64 MW trough plant in Nevada, built by Solargenix and then sold to Acciona, began operation.

2008

- Andasol 1, the first commercial 50 MW trough plant with 7.5 hours of molten salt thermal energy storage began operation in Spain.
- A US 30% investment tax credit became available for CSP plants and States increased their RPS targets, which opened a market opportunity for CSP plants in the US.

10.6 Solar Architecture Buildings 2000-2009

2002

- The U.S. Department of Energy launches the Solar Decathlon. Today, the 10 contests that are the foundation of the Solar Decathlon inspire student teams to design and build highly efficient buildings powered by renewables, while also taking into consideration affordability, resilience, and occupant health.

2003

- On 1st January 2003 The Australian Building Codes Board introduced energy efficiency measures for houses into the Building Code of Australia (BCA). It has been adopted by all Australian states and territories which did not already have an equivalent system in place. Various states have since adopted requirements for new houses to be either 5- or 6-star standard. The 6-star standard requires the building fabric to have a 6-star energy rating along requirements to either have rainwater tank for flushing the toilet or a solar hot water system.

2004

- German Architect Rolf Disch designs and builds The Sun Ship (Das Sonnenschiff) which is a small community in Freiburg Germany that is run entirely by solar energy.

2005

- A private company launched the world's first standardised passive house in Ireland, this concept makes the design and construction of passive house a standardised process.

2006

- In December, the UK government announced that by 2016 all new homes in England will be zero energy buildings.
- The Masdar City (United Arab Emirates) planned solar and renewable city south east of Abu Dhabi is initiated with construction starting in 2008. IRENA's headquarters is located in Masdar City.

2007

- In October, the Malaysian Energy Centre (PTM) successfully completed the development and construction of the PTM Zero Energy Office (ZEO) Building.
- The Building Technologies Program of the US Department of Energy has set the strategic goal to achieve "marketable zero energy homes in 2020 and commercial zero energy buildings in 2025". On a state level, California has committed to making all new commercial buildings and 50% of existing commercial buildings net-zero by 2030.

2009

- The 71 story zero energy office buildings the Pearl River Tower, opens in Guangzhou China.
- Singapore's first zero-energy building was launched in October at the inaugural Singapore Green Building Week. The retrofitted building was on the campus of the Building Construction Authority (BCA) Academy.

10.7 PV in Developing Countries 2000-2009

Donor driven projects increase, and more international organisations are formed with the focus on supporting the growth of solar home systems being deployed in developing countries. More companies start and close as the solar home market tries to get established in many countries globally. This decade sees a number of manufacturers established with the focus on plug and play small solar home systems (SHS) that allows the end-users to self-install. A number of these are the companies that transformed the SHS market into the vibrant commodity market that exists today. Near the end of the decade a new World Bank Group Initiative, Lighting Africa will lead the way in the use of quality plug and play systems that helps initiate the new commodity market for SHS. The grid connected PV market is growing substantially however a number of industry people are unaware of, or interested in, the need for solar energy solutions in the developing world. This led to a new industry association, Alliance for Rural Electrification being formed to focus on this market from the industry perspective.

- In 2000 1.36 billion people in the world did not have access to electricity representing 22.3% of the total population. This had decreased to 1.17 billion by 2009 representing 16.8% of the population

Table 26: Percentage of Population without access to Electricity 2000-2009

2000	22.3%
2001	22.7%
2002	21.2%
2003	20.5%
2004	20.3%
2005	19.6%
2006	18.8%
2007	18.3%
2008	17.7%
2009	16.8%

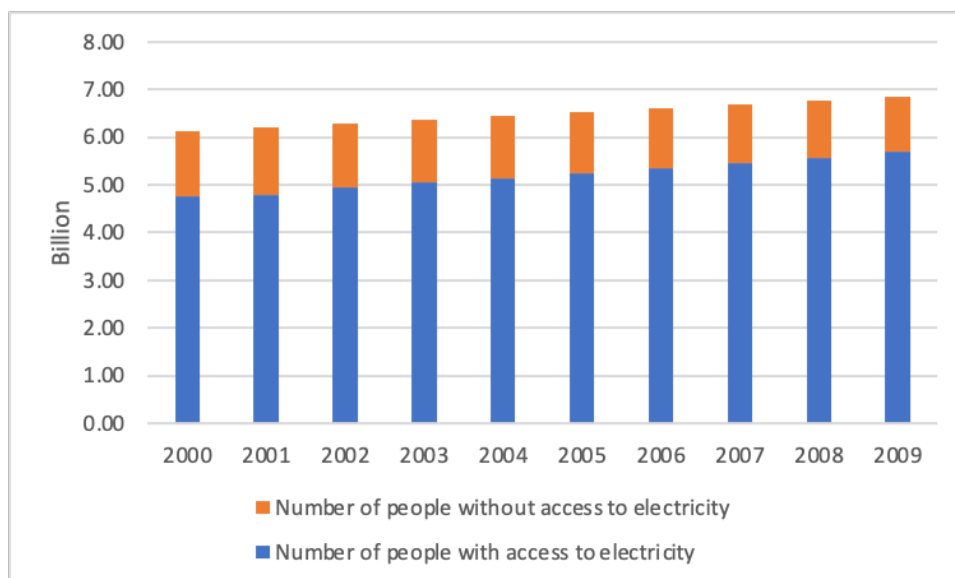


Figure 86: Access to Electricity 2000-2009

Table 27: Access to Electricity by Regions 2000 and 2009

Region	2000		2009	
	Number of People without access (million)	% of Total Population	Number of People without access (million)	% of Total Population
East Asia and Pacific	188.6	9.2%	109.9	5%
Latin America and Caribbean	43.5	8.3%	26.2	4.4%
Middle east and North Africa	26.6	8.4%	16.3	4.3%
South Asia	594.6	42.9%	417.6	26.0%
Sub Saharan Africa	510.1	74.1%	576.6	67.5%

Source for above data: <https://ourworldindata.org/energy-access>

2000

- Peter Aldemann founded **Phocos AG**, a German company manufacturing of equipment for solar home systems. He remained CEO until 2008 and the company is still operating.
- **SELCO** buys out **RESCO** in Sri Lanka and it transforms into **SELCO-Sri Lanka**.

2002

- The Renewable Energy and Efficiency Partnership (**REEEP**) was launched by the government of the United Kingdom, along with other partners, at the Johannesburg World Summit on Sustainable Development (WSSD) in August 2002. **REEEP** is based in Vienna and has the objective of advancing markets for renewable energy and energy efficiency particularly within the emerging markets and developing countries. Its primary focus is in de-risking and scaling up clean energy business models.

2004

- Harald Schützeichel founded the **Stiftung Solarenergie - Solar Energy Foundation** (Freiburg, Germany) an organisation committed to economic development and poverty reduction through the sustainable supply of solar energy. The holistic approach includes training, installation, maintenance/service, end-customer financing and promotion of local SMEs. The aim is to initiate a self-sustaining solar trade in the partner countries. The **Stiftung Solarenergie** is active in Ethiopia, Kenya, Uganda and the Philippines.

2005

- Stewart Crane and Harry Andrews founded **Barefoot Power** in Australia which is one of the pioneers of the pico solar products including its well-known Firefly Solar Lamp.

2006

- In 2004 Peace Corps volunteer Sam Goldman's neighbour was badly burned in a kerosene accident in Benin, Africa. Sam knew there had to be better, safer ways to power homes and businesses in the developing world. After returning to North America he met Ned Tozun. In 2006, Ned and Sam founded **d.light**, developing the initial prototype solar lantern and an ambitious plan to bring safe, bright, clean lighting and power to people around the globe. **d.light**'s first commercial solar product made its debut in the marketplace in 2008.

2007

- **Lighting Africa** is launched in September 2007. The initiative is jointly managed by the World Bank and the International Finance Corporation (IFC), leveraging the comparative advantage of both organizations to support the rapid scale-up and delivery of modern off-grid lighting to Sub-Saharan Africa. **Lighting Africa** builds upon the pioneering work of the Lighting the Bottom of the Pyramid (LBOP) program, which was created by IFC. The objective is to develop a Quality Assurance Program for the plug and play solar home systems.
- The then **European PV Industry Association (EPIA)** created the **Alliance for Rural Electrification (ARE)**. The Alliance for Rural Electrification (ARE) was created in response to the need for access to sustainable electricity in the developing world and to facilitate the involvement of ARE members in emerging rural energy markets. Initial members mainly came from Europe, however, it soon expanded to become an international business association (over 170 members) that promotes a sustainable decentralised renewable energy industry for the 21st century, activating markets for affordable energy services and creating local jobs and inclusive economies.

2009

- **Greenlight Planet** is founded in 2009 and produces a range of Sun King plug and play products.
- The **International Renewable Energy Agency (IRENA)** was officially founded in Bonn, Germany, on 26 January 2009. Abu Dhabi was selected as the location for the headquarters with the Innovation and Technology Centre located in Bonn, Germany. There are currently 161 member countries. IRENA has taken a lead role in supporting governments to develop renewable energy plans and targets.

Table 28: World Bank Group Solar Projects in Developing Countries: Approved 2000-2009

Country	Project	Systems	PV Capacity (kWp)	Total Project Costs # (\$ millions)	Year Approved
World Bank Projects					
Ecuador	Power and Communications Sectors Modernization and Rural Services Project (PROMECS)	2200	110	1.5	2001
Bangladesh	Rural Electrification & Renewable Energy Development	198000	9900	91.4	2002
Sri Lanka	Renewable Energy for Rural Economic Development	85000	3400	28.3	2002
Bolivia	Decentralized Energy, ICT for Rural Transformation	60000	2600	38.6	2003
Nicaragua	Off-grid Rural Electrification *	7500	2100	23.0	2003
Mali	Household Energy and Universal Access Project *	10000	420	5.0	2003
Mozambique	Energy Reform and Access Project	9600	1012	12.5	2003
Mozambique	PV for Schools and Health Clinics	200	84.5	1.0	2003
Cambodia	Rural Electrification and Transmission	10000	400	4.0	2003
Philippines	Rural Power	135000	9000	107.0	2003
Burkina Faso	Energy Sector Reform *	8000	300	3.0	2004
Senegal	Electricity Services for Rural Areas *	10000	420	5.0	2004
China	Renewable Energy Development	400000	10000	144.9	2005
Papua New Guinea	Solar Lighting Kits for Teachers	2500	100	2.2	2005
Peru	Rural Electrification	7500	8000	5.3	2006
Mongolia	Renewable Energy and Rural Access	50000	520	5.2	2006
Tanzania	Energy Development and Access	16200	810	12.2	2007
Bangladesh	Grameen Shakti Solar Home Systems - Carbon Finance	1000000	50000	320.0	2007
Pacific Islands	Regional Sustainable Energy Finance	21000	630	16.5	2007
Sri Lanka	Renewable Energy for Rural Economic Development - Additional Financing	50000	2500	25.0	2007
Argentina	Permer Renewable Energy Additional Financing	16130	3042	36.5	2008
Ethiopia	Second Electricity Access Rural Expansion	40200	407	20.5	2008
Ghana	Solar PV Systems to Increase Access to Electricity Services (GPOBA)	15000	750	15.0	2008
Zambia	Increased Access to Electricity Services	10250	410	6.2	2008

Mexico	Renewable Energy for Agriculture *	1000	700	5.0	2009
Uganda	Energy for Rural Transformation (APL)	90000	6300	67.7	2009
Bangladesh	IDCOL Solar Home Systems - Carbon Finance	250000	12500	80.0	2010
International Finance Corporation (IFC) Global Programs					
PV Manufacturing	China, India and Russian Federation			202.0	Unknown
Joint World Bank/ IFC	Lighting Africa Program	500			2009
	TOTAL	2,505,780	126,415	1,284	

Source Anil Cabraal: World Bank (retired)

The above has been provided as a sample of the type of projects and the level of funding. Other multi-lateral and bi-lateral organisations were also funding programs around the world. It shows that the number of systems installed through World Bank group projects has grown from 120,000 in the 1990s to over 2.5 million between 2001 and 2010. The value of the projects increased from \$100 million in the 90s to \$1.28 billion in the 2001-2010 decade.

10.8 SWC50 Gold Partner: Smart Energy



We are one of Europe's leading integrated solar power companies with presence in Solar IPP, Solar EPC and PV module manufacturing. Headquartered in İstanbul, Turkey, we offer the complete solar solutions - from setting up solar power plants to providing innovative solar products for both commercial and retail users.

Established in the year 2009, we have an extensive presence in South East Europe with over 460+ employees, 1 manufacturing facility, 7 Offices located in Turkey, Romania, Greece, Bulgaria, Germany, Switzerland and Ukraine.

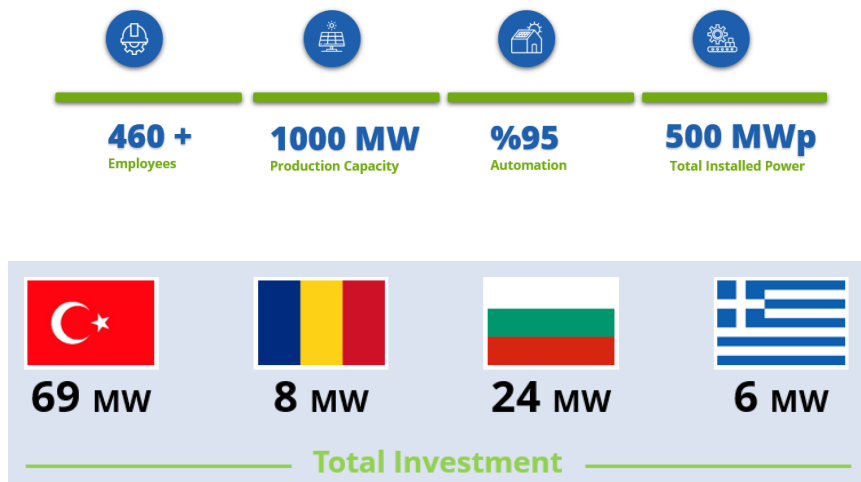
We manufacture highly efficient solar PV modules based on crystalline silicon technology for use in on-grid & off-grid solar power plants, commercial rooftop and land based solar power projects. With 23.500m² indoor space and our state-of-the-art automated production lines to ensure highest quality standards in producing both standard and dual glass modules using the latest PERC, Half Cut Cell and Bi-Facial solar module technologies up to 12 Busbars totaling to an 800MW yearly capacity.

Smart Energy currently owns and operates solar IPP sites in Turkey, Romania, Greece and Bulgaria with a total capacity over +100 MW, with another +60MW under construction.

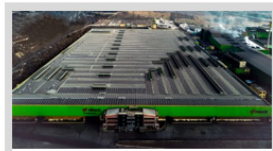
With a portfolio of more than 500+ MW in utility scale & rooftop solar EPC projects, we possess years of expertise in constructing utility-scale and rooftop solar power plants of all sizes.

Our Principles

- We Value Our Business Partners
- We Take Responsibility
- We Have an Innovative Perspective
- We Work with the Desire to Develop and Learn
- Believe in Being a Team; We Work With Experts in the Field
- We Adopt the Highest Standards in All Processes
- We Are Solution Oriented
- We Are Confident
- We Produce Value with Our Value Engineering Approach
- We Act With the Awareness That All of Our Steps Are Steps of Kindness



Engineering References



Osmaniye

Turkey

9.924,17 kWp



Kayseri

Turkey

2.290,56 kWp



Slobidka

Ukraine

11.000,00 kWp



Karaman

Turkey



Aksaray

Turkey



Artuklu Mardin

Turkey

PV Module References



Manisa Salihli

Turkey

8.164,80 kWp



Transdanubia Spedition GmbH

Germany

500,00 kWp



Sägewerk Johann Offenthaler

Austria

200,00 kWp



Konya MT Dođal

Turkey

12.100,50 kWp



Konya Yaysun

Turkey

12.100,50 kWp



Edikli Niđe

Turkey

15.237,12 kWp

10.9 SWC50 Supporter: ARE



The Alliance for Rural Electrification (ARE) was established in 2006.

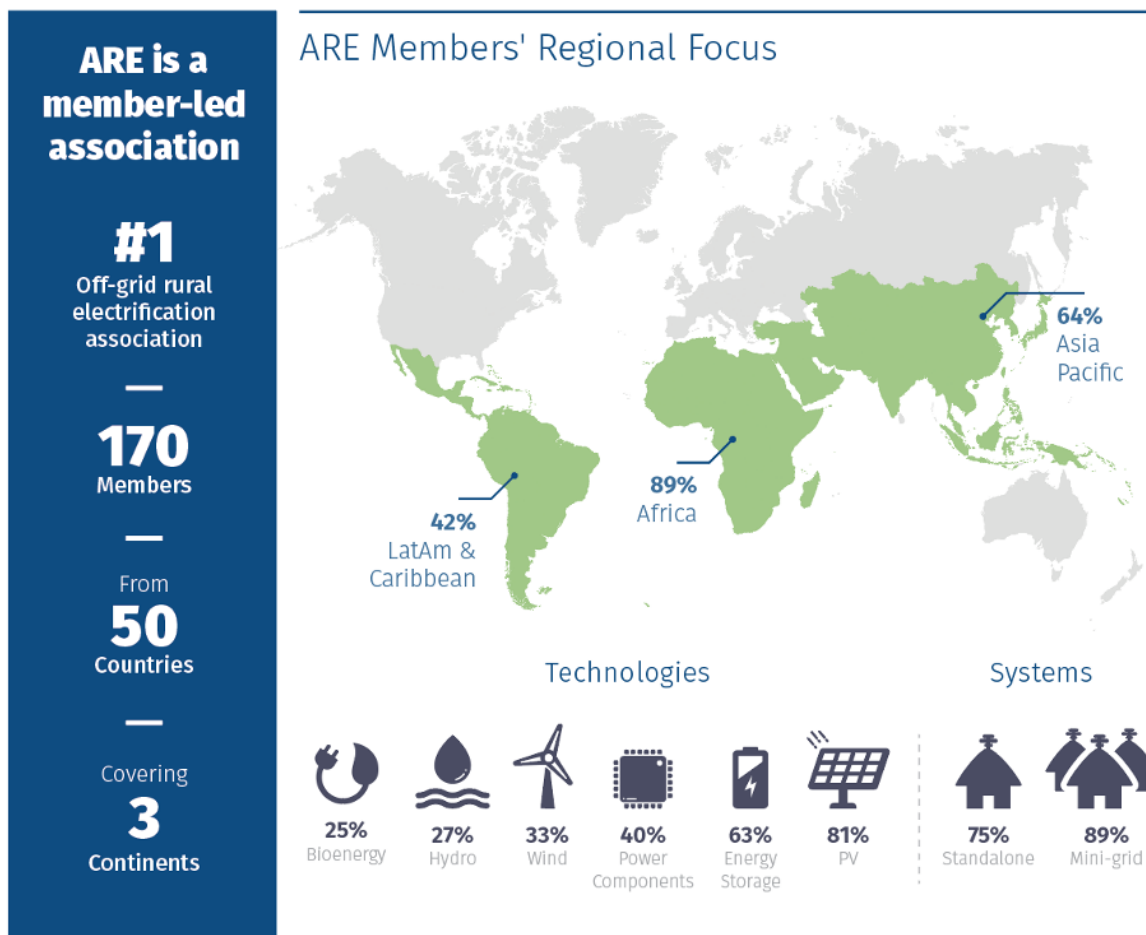
ARE is the only global business association that represents the whole decentralised renewable energy sector for integrating rural electrification in developing and emerging countries.

ARE Vision

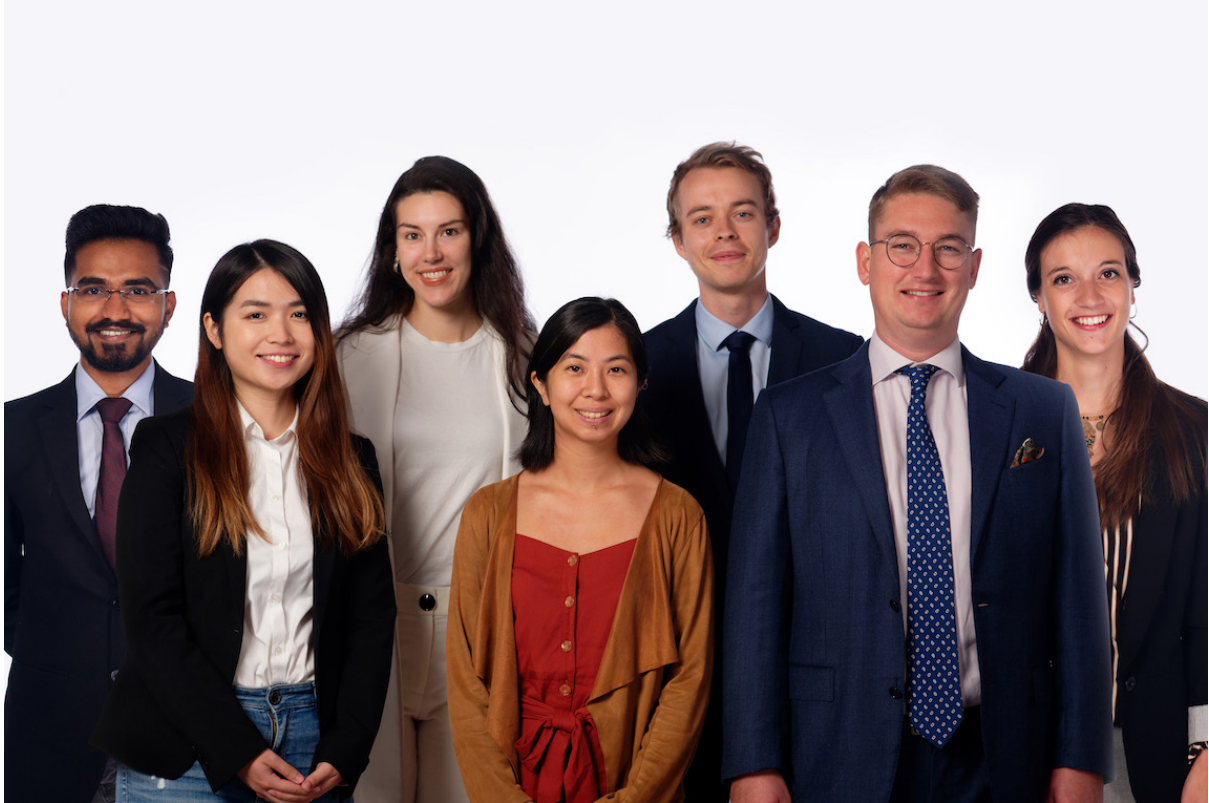
It is the vision of ARE that by 2030 everyone in the world and in particular all rural people in low-and medium income countries should have access to affordable, secure and clean energy and energy services.

ARE Mission

ARE aims to promote a sustainable decentralised renewable energy industry for the 21st century, activating markets for affordable energy services, and creating local jobs and inclusive economies.



ARE enables improved energy access through business development support for its Membership along the whole value chain for off-grid technologies.



L-R: Deepak Mohapatra, Amanda Soler, Jens Jaeger, Ines Van Oldeneel,
Ida Leung, Ling Ng, David Lecoque (CEO)

The ARE Secretariat

10.10 SWC50 Supporter: APVI



APVI supports the development and uptake of photovoltaics with research, analysis and information.

The Australian Photovoltaics (PV) Institute was formed in 2014 from the previous Australian PV Association (APVA), which in turn was formed in 2008 from the Australian PVPS Consortium. The latter had been operating since 1993 to coordinate Australia's input to the International Energy Agency PV Power Systems Programme. The current Chair of the APVI is Dr Chris Fell, CSIRO. Past Chairs have been Prof. Renate Egan, UNSW & Solar Analytics, and Dr Muriel Watt, ITP Renewables (& UNSW at the time).

The APVI carries out a range of solar research projects, produces detailed technical and market publications, hosts seminars, workshops and member events, prepares submissions on key solar issues and promotes solar energy in the media.

Over the years, the APVI has provided information and analysis to support the technical and policy debates in Australia and internationally around topics including solar feed-in tariff design, safety and standards for PV systems, managing high penetrations of PV, and developing distributed energy markets.

Activity – IEA Implementing Agreements

A key component of the APVI's work is the collation of data on manufacturing, end-use applications, research & development and policy support for contribution to two IEA Implementing Agreements:

The Photovoltaic Power Systems Programme (PVPS): Australia is currently represented on the Executive Committee by Renate Egan (UNSW) and Olivia Coldrey (Sustainable Energy for All).

PV information is compiled by APVI into an annual *PV in Australia* report, the first of which was published in 1996. APVI also coordinates Australian contributions to the various PVPS international collaborative research Tasks. It is currently participating in Tasks on High Penetration of PV in Electricity Grids; PV Sustainability and Life-Cycle Assessment; and Off-Grid and Edge of Grid PV Systems.

Solar Heating & Cooling (SHC): Australia is represented on the Executive Committee by Ken Guthrie (Sustainable Energy Transformation) and Stephen White (CSIRO).

This Implementing Agreement has been operating since 1974 and a range of Australian companies and researchers have been involved in the various tasks since that time. APVI contributes to an annual market report entitled *Solar Heat Worldwide* and currently participates in Tasks on Solar Energy in Industrial Water and Wastewater Management, Integrated Solutions for Daylighting & Electric Lighting, and Application of PVT Collectors and Solutions in HVAC Systems.



Clip from the *PV in Australia* report

Activity – Asia-Pacific Solar Research Conference

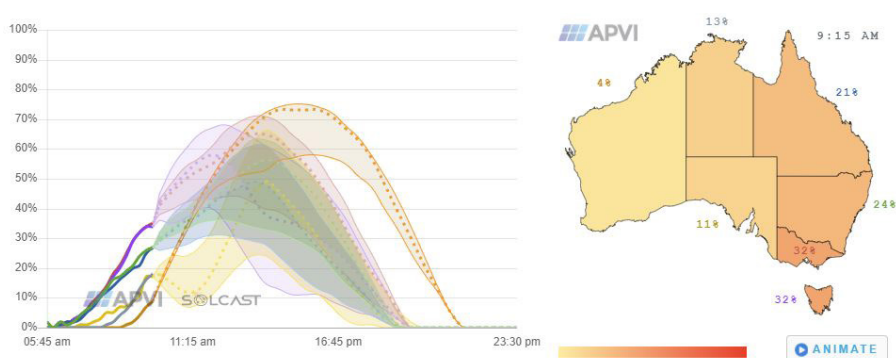
APVI organises an annual solar research conference for the region which is typically attended by 200-400 people. The Conference is held in partnership with the Australian Centre for Advanced Photovoltaics, the Australian Institute of Refrigeration, Air Conditioning & Heating and the Australian Solar Thermal Research Institute. Papers are presented in 6 streams: PV Devices; Solar Electricity Deployment & Integration; Solar Buildings and Solar Heating & Cooling; Concentrating Solar Thermal; Solar Fuels & Chemistry; and Off-Grid & Fringe of Grid Systems. This is the only conference in the region where peer reviewed papers can be presented and hence plays a key role in the development of the next generation of solar energy researchers and practitioners.



Delegates at APVI's annual Solar Research Conference

Activity – Solar Map

APVI hosts the Australian Solar Map, which includes live PV generation data by State and postcode, including estimates of rooftop PV contribution to State electricity loads; PV performance by region; PV installed capacity by postcode, State and electorate; Analysis of the development of the PV market; and SunSPoT, a rooftop solar mapping tool which provides detailed maps for estimating PV potential on local rooftops.



Screenshot of a page from the APVI solar map website

Membership

APVI membership comprises businesses, researchers and individuals with an interest in PV. Over the years, membership has included Government agencies, utilities, PV manufacturers and installers, universities, research groups, individual researchers and interested individuals.

APVI welcomes new members! If you are passionate about solar energy and photovoltaics in particular, download the Membership application form [here](#) and get involved!

10.11 SWC50 Supporter: WWEA



The World Wind Energy Association WWEA

WWEA was founded in 2001 and works for a transformation of the world energy system towards 100 % renewable energy, with wind energy as one cornerstone. A special focus lies on decentralised solutions and on citizens centered approaches, e.g. in form of community energy.

WWEA advises national governments and international organisations, WWEA is a communication platform for its members and WWEA enhances technology transfer.

WWEA Members and Structure

Currently WWEA has more than 600 direct members and represents the wind sector from over 100 countries on all continents. The WWEA members include national wind energy associations as well as companies, scientific institutions and public bodies. WWEA's member association have more than 50'000 members.

WWEA is governed by board comprising members from all continents. The President is Hon. Peter Rae AO (Australia), he daily management is done by the Secretary General Stefan Gsänger, the WWEA Head Office is based in Bonn (Germany).

WWEA is co-founder of the International Renewable Energy Alliance, of the Global 100% Renewable Energy Platform as well as of REN21 and has Special Consultative Status at the United Nations.

WWEA Events

WWEA organises annual World Wind Energy Conferences gathering hundreds of leading wind energy experts from around the world, held so far in Australia, Brazil, Canada, China, Cuba, Egypt, Germany, India, Pakistan, South Africa, South Korea, Sweden, and Turkey. The WWEC2021 will take place in New Delhi.

WWEA has a special focus on community energy and has accordingly, together with partners, launched a series of World Community Power Conferences. The first WCPC taking place in Fukushima in 2016, the second WCPC2018 in Bamako (Mali), and the WCPC2020 to be held as online meeting, with the theme "Women in Community Energy". More information: www.conference.community

In light of the Corona pandemic, WWEA started a series of regular webinars presenting first hand information about the latest developments in wind power from experts from around the world. The #WWEAwebinars cover a broad range of topics, from market updates up to technical issues or training and education.

#WWEAwebinar programmes and recordings

28 October: [Wind Power Markets Around the World – Half-year Review \(3\): The Americas](#)

15 October: [Wind Power Markets Around the World – Half-year Review \(2\): Europe, MENA and Africa](#)

8 October: [Wind Power Markets Around the World – Half-year Review \(1\): Asia and Australia](#)

28 September: [Education and training for wind power and renewable energy](#)

9 September: [Renewable Transportation: Aviation and Shipping](#)

26 August: [The Role of Hydrogen in a Renewable Economy](#)

2 July: [Grid Integration](#)

24 June: [Community Power Partnerships for Developing Countries](#)

- 28 May: [Achieving energy self-sufficiency with a small wind turbine](#)
14 May: [Wind power and renewable energy policies: What is best to reach 100% RE](#)
30 April: [Why Community Power Matters in Times of Crisis: Community Power in Industrialised countries](#)
16 April: [Wind Power Markets Around the World](#)



Information hub

WWEA publishes annual statistics on wind power and small wind and numerous other studies and reports analysing wind power deployment around the world. Policy studies have been done on several wind power markets, including Germany, Pakistan or Russia. WWEA is also active on social media, including on Facebook, LinkedIn or Twitter. Many resources are available on the WWEA website:

www.wwindea.org

Join WWEA

Become part of the worldwide network of wind power, renewable energy, community energy actors and join WWEA! Together and united we will achieve a global 100 % renewable energy supply!

Membership application: <https://directory.wwindea.org/membership/>

WWEA Head Office

Charles-de-Gaulle-Str. 5

53113 Bonn, Germany

Fon +49 228 24269 800



WWEC2019 in Brazil.

11. 2010-2019

11.1 ISES 2010-2019

2010

- In January, 2010, in line with the new relationship with IRENA ISES attends the inaugural World Future Energy Summit (WFES) in Abu Dhabi. ISES was represented by ISES President Dave Renné. Since then ISES has regularly participated in the annual WFES as well as the IRENA General Assemblies, held immediately prior to the WFES.
- ISES held a special side event and D. Renné presents an invited keynote address at GRE2010, Yokohama, Japan, June 28-July 2, 2010. He also attended meetings of the Japan Renewable Energy Society and ISES-Japan.
- ISES helps organize and participates in Solar Cities Conference, Dezhou, China, 13-17 September
- Euroun 2010 is held in Graz, Austria.
- ISES and the REN-Alliance held their first side event at COP16, Cancun, Mexico, December 6.
- In December, 2010 Christine Hornstein stepped down as ISES Executive Director. Jennifer McIntosh is appointed as Head of Secretariat.



Figure 87: Jennifer McIntosh

2012

- ISES participates in the second JREF international event, known as REVision 2012, and a REN21 Steering Committee meeting, Tokyo, March 8-10.
- D. Renné gives an invited keynote speech and attends other events at AsiaSolar 2012, Shanghai, March 20-22.
- D. Renné and Prof. Shi Donghuan, President of the Chinese Renewable Energy Society (CRES), sign an ISES/CRES MoU, March 23. Monica Oliphant was also in attendance. Following this, D. Renné attended the Korean Solar Energy Society Spring Annual Meeting in Daegu, March 29-30.
- D. Renné represents ISES at the Asia Clean Energy Forum in Manila, organised by the Asian Development Bank, June 5-8.
- Several ISES Board members participated in the World Wind Energy Association's Annual Conference in Bonn, July 2-4. The REN-Alliance held an event, and we were all treated to free passes to a Bob Dylan conference held close by.
- ISES initiates a free monthly webinar series, providing high-quality renewable energy technical presentations on a monthly basis. The first webinar, on Solar Thermal Electricity, and led by Prof. Manuel Romero, was held on 4 September 2012.
- President D. Renné presents an invited keynote address at the ABENS Latin America Regional Conference in Brazil, 19 September.
- EuroSun 2012 is held in Croatia, 18-23 September.
- D. Renné gave an invited speech at the ANES Annual Conference, Cuernavaca, Mexico.
- The REN-Alliance held a Side Event at COP-18, Doha, Qatar, December 4.

2013

- ISES formerly becomes a member of the REN-21 Steering Committee and participated in the first steering committee meeting in Abu Dhabi on 17 January, and the second at the UNFCCC COP-19, Warsaw on 17 November.

- At the COP-19 ISES and the REN-Alliance held a side event focusing on 100% Renewable Energy.
- As part of ISES' role with REN 21 we were invited to lead a panel discussion on the future of solar PV as part of the activities of the Abu Dhabi International Renewable Energy Week (in conjunction with the WFES in January).
- ISES members provided technical input on solar technologies to REN 21's 2013 Global Status Report.
- Besides REN21, ISES formed partnering relationships with key international organizations such as IRENA (where ISES provided inputs to the IRENA Renewable Energy Learning Platform and the Global Solar and Wind Atlas); the IEA's Renewable Energy Working Party, the UN's Sustainable Energy for All Program, the UN Foundation's Practitioner Network, the UNFCCC, ACORE and LAC-CORE.
- D. Renné attended the International Hydropower Association Conference in Kuching, Malaysia and participated in a REN-Alliance side event, May 22-25.
- The ISES SWC2013 was held in Cancun, Mexico on 3-7 November, hosted by the ISES local Section ANES.

2014

- ISES is represented at the 4th IRENA General Assembly and at side events at the WFES, Abu Dhabi, January 18-22.
- D. Renné represents ISES and gives an invited talk at the International Forum on Renewable Energy, organised by the Government of Mexico and held at the Riviera Maya, near Cancun, Mexico, May 22-24.
- D. Renné represents ISES at a Student Energy event in Mexico City, June 18-20.
- D. Renné gave an invited keynote address at GRE2015, Tokyo, where a special ISES track was held, July 28 – August 1, 2014. He also participated in meetings with the Japan Renewable Energy Society and ISES-Japan.
- President D. Renné represents ISES and gives a keynote address at WREC XIII, London, August 4-6.
- ISES EuroSun was held in France (NOTE: Need dates and location).
- EuroSun 2014: International Conference on Solar Energy and Buildings, takes place 16 - 19 September 2014, in Aix-les-Bains, France.

2015

- D Renné meets with a Student ISES group at the University of South Florida, organised by Prof. Yogi Goswami, April 23.
- ISES launches its Conference Proceedings Database of proceedings from Solar World Congresses, EuroSun conferences and section events. The website provides a searchable open access platform for the conference proceedings.
- D. Renné attends WREC XIV and gives a keynote address in Budapest, June 8-9, and, then attends several ISES related events with HQ staff in Munich at Intersolar Europe, June 10-12.
- ISES played a key role in developing portions of the South Africa International Renewable Energy Conference (SAIREC) program in Cape Town on 5-7 October 2015 including contributing to an issue paper on PV, organising two side-events and presenting a keynote address by ISES President D. Renné.
- At the annual REN 21 Steering Committee meeting, held on 7 October immediately following SAIREC ISES was re-elected as a member of the REN-21 Steering Committee for another 3-year term.
- ISES provides annual support in the review of the annual Global Status Reports (GSRs), and annually invites the Executive Director, Christine Lins to give a webinar presentation shortly after the annual GSR has been released.
- ISES becomes a Founding Member of the GO100% Renewable Energy Campaign led by the World Future Council.
- ISES organised a panel discussion on 100% renewables at Intersolar North America in San Francisco on 15 July 2015.
- ISES SWC2015 was held in Daegu, S. Korea, November 8-13, hosted by the ISES local Section Korean Solar Energy Society.
- The REN-Alliance (ISES, WWEA, IGA, WBA, and IHA) organised a side event at the UNFCCC COP21 in Paris, December 7.
- ISES becomes a founding member as well as member of the Board of the Directors of the Global Solar Council, launched in conjunction with UNFCCC COP-21, Paris, December 10.
- ISES becomes a sponsor of the International Energy Agency's Solar Heating and Cooling Technology Cooperation Programme, and becomes a member of the Executive Committee.
- ISES celebrates 20 years of ISES headquarters in Freiburg with an open-house event with special guest Prof. Joachim Luther.

2016

- ISES participates in the 6th IRENA General Assembly and WFES in Abu Dhabi, January 16-20, and officially joins the IRENA Coalition for Action. Prep meetings for SWC 2017 were held with representatives of the Masdar Institute.
- ISES, as a member of the board, attends the Global Solar Council Board Meeting, and also participates in a Now/Turkey side event during Intersolar Europe, Munich, 22-24 June.
- D. Renné attends WREC XVI in Jakarta, Indonesia, and gives a keynote address, September 19-20.
- The Karl Boer Solar Energy Medal of Werit was awarded to Yogi Goswami during a ceremony at the University of Delaware, September 23.
- ISES EuroSun 2016 held in Palma de Mallorca, Spain (11-14 October 2016)
- Solar Energy Journal increases to 18 issues per year (up from 12 per year) and introduces Subject Area Editors.
- D. Renné, at the invitation of the ISES Section in South Africa, gives a plenary speech at the Southern Africa Solar Energy Conference on November 2.
- D. Renné and J. Costello (ISES HQ) attend COP-22 in Marrakech, Morocco, and participate in a REN-Alliance side event, November 14-16.

2017

- ISES representatives President Dave Renné, Vice President Eicke Weber, attend the 7th IRENA General Assembly and the Coalition for Action Strategy Meeting in Abu Dhabi, 15-18 January. The first meeting of the Go 100% Renewable Energy Platform Executive Committee, of which ISES is a member, was also held.
- The first ELSEVIER-ISES Renewable Transformation Challenge (RTC) is launched. The objective of the Renewable Transformation Challenge is to recognize and honour outstanding work encouraging progress towards a world powered by renewable energy and with accessible energy for all. The first winner of the RTC, Dr. Sebastian Groh of ME SolShare was announced during the awards banquet at SWC 2017, Abu Dhabi.
- ISES President D. Renné participates in the Student Energy Summit, Merida, Mexico, 14-15 June.
- ISREE-12, was held at the Strömstad Academy in Sweden, and attended by a number of ISES representatives, June 19-21. This was the first ISREE since 2005, and a commitment was made to have future ISREE's be held in conjunction with ISES Solar World Congresses, as had been done up through 2005.
- ISES is re-elected to the Board of the Global Solar Council, June 28.
- ISES and its U.S. Section ASES organize a day-long side event on 100% Renewable Energy at Intersolar North America, San Francisco, July 10.
- ISES introduces a new award, ISES Fellows, to recognise people who have given many years of distinguished service to ISES and have advanced the use of solar and renewable energy through research, education, communication and deployment.
- ISES SWC2017 is held in Abu Dhabi on 29 October – 2 November, hosted by the Masdar Institute. For the first time the Congress was held together with the IEA SHC Conference on Solar Heating and Cooling for Buildings and Industry.

2018

- D. Renné and M. Oliphant participate in the 8th IRENA General Assembly and Coalition for Action Strategy Meeting, January 13-17. D. Renné also attended a GSC Board meeting, and there were side meetings with the REN-Alliance and the GO 100% RE Campaign. A working relationship with the International Solar Alliance, new intergovernmental organisation led by India with the goal of promoting rapid growth of solar energy, especially in tropical and subtropical regions, was established with ISES and D. Renné participated in an ISA side event during this week.
- ISES participated in the REN 21 Steering Committee meeting and the Berlin Energy Transition Dialogue, March 16-18.
- D. Renné gives an invited speech at SNEC 2018, Shanghai and attends a GSC Board Meeting, May 27-30.
- D. Renné gives keynote address and ISES has special track at GRE2018, Yokohama, June 18-20, 2018.
- D. Renné gives an invited speech and attends the WREN Council meeting at WREC XVII in Kingston (London), England, July 30 – August 2.
- ISES EuroSun 2018 was held in Rapperswil, Switzerland on 10-13 September. D. Renné participated in the closing ceremony.
- The GSC held its Board Meeting and a Side Event at Solar Power International, Anaheim, California, September 24-27.
- ISES launches a new infographics publication and published the first instalment titled “Dispelling “Dispelling the Myths-Renewables in the Grid”. The infographic addresses myths about renewable energy grid integration, storage, load management and energy transmission.

2019

- D. Renné, M. Oliphant, and E. Weber participated in the 9th IRENA General Assembly in Abu Dhabi, January 12-15. They also attended the Public-Private Dialogue, where the first White Paper of the Coalition for Actions “Towards 100% Renewable Energy Working Group” was rolled out by ISES member Rainer Hinrichs-Rahlwes, the Chair of the group. Both Dave and Monica played key roles in developing the White Paper. They all attended the Coalition for Action Strategy Meeting, and Dave participated in a GSC Board meeting. For the remainder of 2019 Dave served as a co-Chair with Rainer in the Working Group as they developed a second White Paper for release in early 2020.
- D. Renné and E. Weber participated in the Berlin Energy Transition Dialogue as well as the REN 21 Korean International Renewable Energy Conference planning meeting, April 8-10.
- D. Renné gave an invited speech at SNEC 2019, Shanghai, and attended a GSC Board Meeting, June 3-6.
- D. Renné represented ISES at Intersolar South America in Sao Paolo, Brazil on August 27-29 and participated in several panel discussions. He also participated in a meeting of ABENS.
- D. Renné was invited by REN21 to attend the KIREC 2019 in Seoul, South Korea, October 21 – 25, and participated in several panel discussions, as well as a meeting of the REN 21 Steering Committee. ISES was re-elected for another 3-year term on the SC.
- The ISES SWC2019 was held in Santiago, Chile, November 3-7, and hosted by SERC/Chile. As with SWC2017 the Congress was held together with the IEA SHC Conference. This was the first SWC held in South America.
- The second winner ELSEVIER-ISES Renewable Transformation Challenge is presented. The winner, “Sunspot Solar Electric Cooking” by Team SUNSPOT was presented the award at the awards banquet at SWC2019, Santiago, Chile.
- The second instalment of Infographics were launched at the SWC2019 in Chile. This second instalment proactively highlights existing and highly successful applications of solar thermal energy. Three different examples of solar thermal applications were highlighted:
 1. Solar thermal process heat for brewing beer in a German brewery.
 2. Solar thermal process heat for the mining of copper needed for electronics in a Chilean mining site.
 3. Solar thermal process heat for generating steam used in the production of pharmaceuticals in Jordan.
- Klaus Vajen of Germany is elected president for the term starting 01 January 2020.
- In December 2019 D. Renné completes his final term as ISES President. His ten years is the longest term of any President in the 65 years history of ISES. His legacy is that ISES has a high profile and excellent working relationships with the many other organisations that have formed over the last 10 to 20 years such as REN21, IRENA , Global Solar Council etc.

ISES Staff 2020

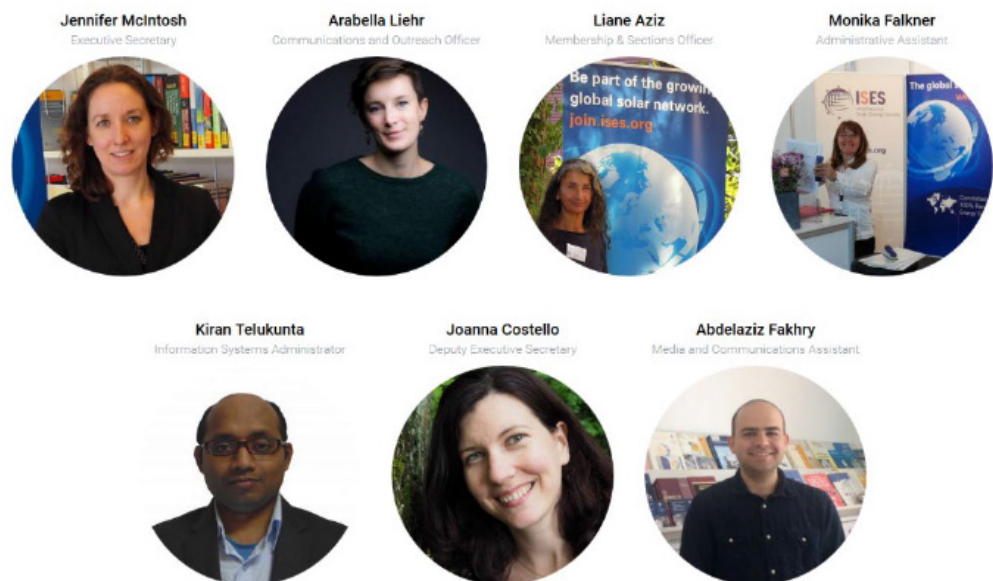


Figure 88: ISES Headquarters Staff as of 2020

Table 29: Officers of ISES 2010-2019

Years	President	Vice President	Secretary /Treasurer	Officer
2010-2011	Dave Renné.	Ajay Prakesh Shrivistava Roberto Román Dieter Holm Mahalath Halperin Huang Ming	Pete Gorton (Secretary), Torben Esbensen (Treasurer)	Christine Hornstein (2010) Executive Director Jennifer McIntosh (Head of Secretariat)
2012-2013	Dave Renne	Paulette Middleton	Torben Esbensen (Treasurer/Secretary)	Jennifer McIntosh (Executive Secretary)
2014-2015	Dave Renne	Manuel Romero	Dr. Elimar Frank (Secretary) Torben Esbensen (Treasurer)	Jennifer McIntosh (Executive Secretary)
2016-2017	Dave Renne	Eicke Weber	Paulette Middleton (Secretary) Torben Esbensen (Treasurer)	Jennifer McIntosh (Executive Secretary)
2018-2019	Dave Renne	Eicke Weber	Paulette Middleton (Secretary) Geoff Stapleton (Treasurer)	Jennifer McIntosh (Executive Secretary)
2020-2021	Klaus Vajen	Kemal Gani Bayraktar	Viktoria Martin (Secretary) Geoff Stapleton (Treasurer)	Jennifer McIntosh (Executive Secretary)

Table 30: Solar World Congresses, 2011 - 2019

Year	Location	Overview
2011	Kassel Germany	Theme: Rapid Transition to a Renewable Energy World 720 participants (66 countries) Conference Chair: Prof. Klaus Vajen Farrington Daniels Award – Prof. Anne Grete Hestnes, Norway ISES Global Leadership Award in Advancing Solar Energy Policy: In Honor of Hermann Scheer – Dr. Wolfgang Palz, Germany Karl Böer Award – Richard M. Swanson, USA ISES Special Service Award: Yogi Goswami (USA)
2013	Gancun Mexico	Theme: Renewables Working Together for All 750 participants (66 countries) Conference Chair: Dave Renné and Alvaro Lentz Farrington Daniels Award - Dr. Aldo Steinfeld, Switzerland Achievement through Action Award - Dr. Lawrence Kazmerski, USA ISES Special Service Award – Prof Klaus Vajen, Germany and Isao Yukawa, Japan ISES Global Leadership Award in Advancing Solar Energy Policy: In Honor of Hermann Scheer - Mr Michael Eckhart, USA Karl Boer Award – Prof Hores Alferov and Prof Slava Andreev, Russia Special Service Award – Prof Klaus Vajen, Germany and Isao Yukawa, Japan

2015	South Korea	<p>Theme: Achieving the Renewable Energy Transformation 450 participants (66 countries) Conference Chair: Dave Renné and Prof. Kwang Hwan Choi</p> <p>Farrington Daniels Award – Prof. Richard Perez USA</p> <p>Achievement through Action Award - Prof. Klaus Vajen and research group at the Institute of Thermal Energy Engineering, University of Kassel, Germany and Isao Yukawa, Japan</p>
2017	Abdu Dhabi UAE	<p>Theme: Innovation for the 100% Renewable Energy Transformation 500 participants (58 countries) Conference Chair: Dave Renné, Ken Guthries and Steven Griffiths</p> <p>Farrington Daniels Award. Recipient: Professor Robert Pitz-Paal Achievement through Action Award - In memory of Christopher A. Weeks. Recipient: Professor Aldo Steinfeld of the ETH Zurich in Switzerland</p> <p>ISES Global Leadership Award in Advancing Solar Energy Policy - in honour of Hermann Scheer. Recipient: Mika Obhayashi ISES Special Service Award. Recipient: Dr. Elimar Frank, Switzerland ISES Fellow. Recipient: Torben V. Esbensen Renewable Transformation Challenge: Dr. Sebastian Groh of ME SolShare</p>
2019	Santiago Chile	<p>Theme: Innovation in Transforming Energy Systems and Markets to 100% Renewable Energy 422 participants (48 countries) Conference Chair: Dave Renné, Daniel Mugnier, Roberto Román</p> <p>Farrington Daniels Award. Recipient: Prof. Lawrence Kazmerski, USA Achievement through Action Award - In memory of Christopher A. Weeks. Recipient: Prof. Ricardo Rüther, Brazil ISES Global Leadership Award in Advancing Solar Energy Policy - in honour of Hermann Scheer. Recipient: Hans-Josef Fell, Germany Renewable Transformation Challenge: “Sunspot Solar Electric Cooking” by Team SUNSPOT, USA</p>

11.2 ISES Presidents 2010-2019



Figure 89: Dave Renné , President 2010 – 2019

David Renné

Dave Renné (USA) was ISES president for ten-years, the longest term of by any president. Renné has worked in renewable energy R&D programs for over 40 years. After graduating from Colorado State University with a Masters in Atmospheric Sciences and a PhD in Earth Resources in 1975, he started his renewable energy career at the U.S. Pacific Northwest National Laboratory in 1977. He worked primarily on wind resource assessment programs, both in the U.S. and internationally. He was one of the early program area leaders to support the U.S. Department of Energy's Wind Characteristics Program Element. He focused on wind resource assessments, wind monitoring programs, and wind turbine wake studies.

He moved to the U.S. National Renewable Energy Laboratory (Golden, Colorado USA) in 1991 to manage NREL's solar resource assessment activities and to work on a number of international renewable energy programs. He managed the development of the National Solar Radiation Database, first produced in the mid-1990's, and subsequently updated several times. He introduced the use of satellite-derived solar resource estimates into the NSRDB as well as other solar resource programs at NREL. Following his retirement in 2012, he continues to remain engaged in renewable energy programs through his consultancy, Dave Renné Renewables. He is currently a Senior Consultant to Clean Power Research and has consulted with the World Bank, the International Renewable Energy Agency (IRENA), the Asian Development Bank, and several private-sector organizations. He was involved in the early development of the World Bank's Global Solar Atlas as well as the IRENA Global Atlas. He served as Treasurer on the Board of the American Solar Energy Society for many years. From 2010 – 2019 he was President of the International Solar Energy Society and continues to serve on the ISES Board. He has been an Associate Editor of the Solar Energy Journal for the past 15 years.

11.3 ISES President 2020-2021



Figure 90: Klaus Vajen President 2020-2021

Klaus Vajen

Professor Klaus Vajen (Germany) is Director of the Institute of Thermal Engineering at the University of Kassel, Germany, where he is the Chair of Solar- and Systems Engineering, and furthermore Distinguished Professor of the Technical University of Kyrgyzstan in Bishkek. He holds a PhD in Applied Physics and is (co-)author of 300+ publications about (solar) thermal engineering, university education and energy policy.

He is founder and Director of the MSc-programme "Renewable Energies and Energy Efficiency" at the University of Kassel, as well as the founder and Head of the council "University Educations on Renewable Energies" with 120+ professors from German-speaking countries. He developed and coordinates the Europe-wide PhD-education on solar thermal technology, together with Professor U. Jordan. Klaus was a member of the ISES Board of Directors from 2003-2011 and is a member again since 2018. He was Vice-president of ISES 2006-2007, founder of Young ISES (together with ISES Executive Secretary J. McIntosh) and Chair of the Solar World Congress 2011 in Kassel. In 2019, Prof. Vajen was elected ISES President and started his term in January 2020.

11.4 PV 2010-2019

The decade where the very large solar farms and the term GW became common!

The global PV industry grew at an average compound annual rate greater than 35%. The Chinese Renewable Energy Law of 2005 and the investments by the Chinese Government in Renewables during this decade had the result that in 2018, 73% of the world's PV manufacturing is by Chinese companies and 42.5% of modules installed in 2018 is in China. In technology the Passivated Emitter and Rear Cell (PERC) and ½-cell modules are introduced to increase the performance and modules are fast approaching 500W in size. Solar farms kept increasing in size with the largest being 2.04GW installed in India in 2019. No summary points are provided for this decade, the following facts and figures is the story of PV for this decade.

In accordance with the IEA Trend reports during the 2010's

- Annual installations grew from 17GW in 2010 to almost 103GW in 2018.
- Cumulative installed capacity grew from 39GW in 2010 to approximately 512GW in 2018.
- In 2010 off grid systems represented 1% of the annual installations and by 2018 this had decreased to 0.2%.
- In 2010 off grid systems represented 2.8% of the cumulative installed capacity and by 2018 this had decreased to 0.4%.
- In 2010 Grid connected centralised systems represented 38% (down from 60% a few years earlier) of the annual installations and by 2018 and it was 58.9%.
- In 2010 Grid connected centralised systems represented 37% of the cumulative installed capacity and by 2018 this had grown to 57%.

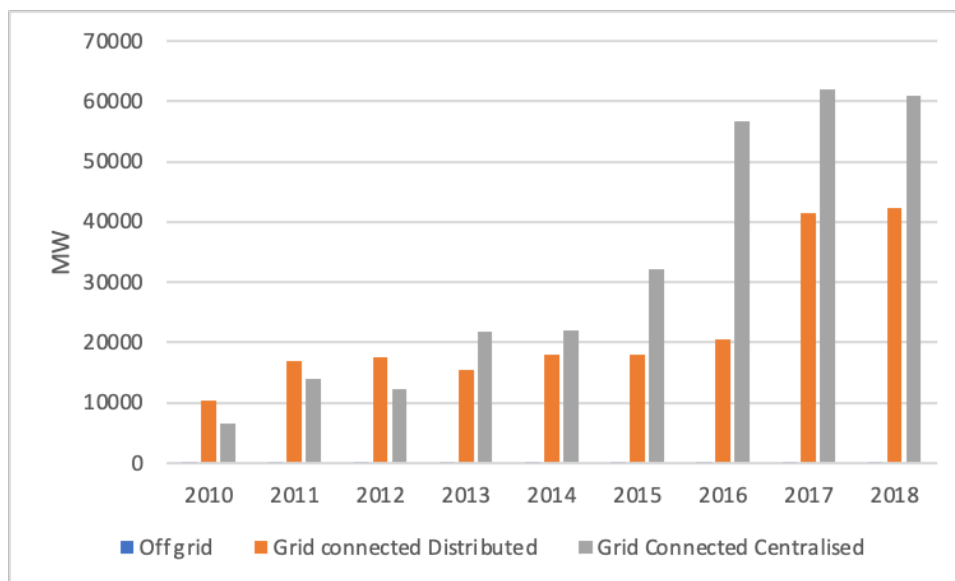


Figure 91: : Annual Installed PV Capacity

Source: IEA PVPS 2018 Trends Reports

Note: Off Grid was estimated in the 100-200MW per year and hence why it is not seen on the above graph

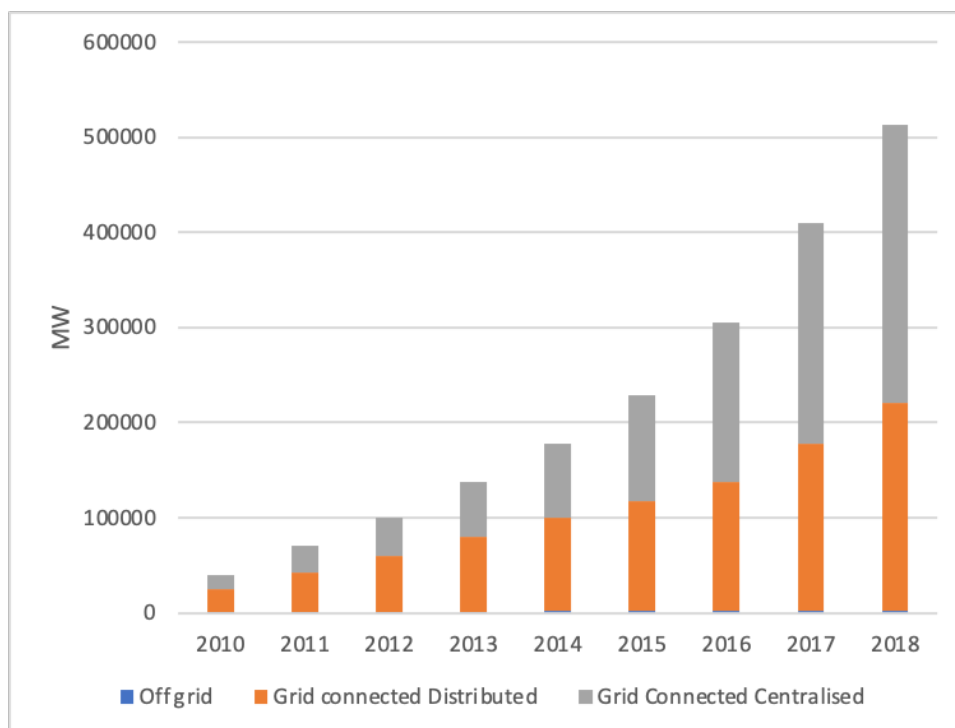


Figure 92: Cumulative Installed PV Capacity
Source: IEA PVPS 2018 Trends Report

Table 31: PV Module Manufacturing by Country (2010-2018)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
China	49%	62%	63%	65%	66%	69%	69%	72%	73%
Germany	12%	9%	6%	4%	2%	4%			
Europe							4%	2%	3%
Japan	11%	7%	8%	9%	8%	5%	4%	2%	1%
USA	6%	4%	3%	25	2%	2%	2%	1%	1%
South Korea	5%	5%	5%	3%	7%	5%	7%	7%	6%
Spain	3%								
Canada	1%	1%	1%	2%	2%				
Italy	1%	1%	1%	1%					
Mexico	1%								
Sweden	1%								
Austria	1%	1%							
Malaysia		6%	5%	6%	6%	6%	7%	6%	5%
Singapore				2%	2%	2%	2%	1%	
Taiwan					1%	2%	2%	1%	1%
India									2%
Other	9%	4%	8%	6%	2%	5%	3%	8%	8%

Source: IEA PVPS Trends Reports

Table 32: : Top 10 PV Manufacturers by Year (2010-2014)

2010 ¹		2011 ¹		2012 ¹		2013 ¹		2014 ²	
17402.3MW _p		23579.3 MW _p		26061.8MW _p		33421.8MW _p		GW _p	
Suntech	9%	Suntech	9%	Yingli	9%	Yingli	10%	Trina	3.6
JA Solar	8%	JA Solar	8%	First Solar	7%	Trina	8%	Yingli	3.3
First Solar	8%	First Solar	7%	JA Solar	6%	JA Solar	6%	JinkoSolar	2.9 - 3.2
Yingli	6%	Yingli	7%	Trina	6%	Canadian Solar	5%	Canadian Solar	2.73 - 2.78
Q Cells	6%	Gintech	6%	Canadian Solar	6%	ReneSola	5%	JA Solar	2.4 - 2.5
Sharp Solar	5%	Trina	5%	Suntech	6%	Motech	5%	ReneSola	2.3 - 2.5
Trina	5%	Canadian Solar	4%	Motech	5%	Jinko Solar	5%	Sharp Solar	1.9 - 2
Motech	5%	Motech	4%	Gintech	4%	Neoslar	4%	First Solar	1.8 - 1.9
Gintech	5%	Sharp Solar	4%	Sharp Solar	4%	First Solar	4%	Hanwha Solar One	1.43 - 1.46
Kyocera	4%	Jinko Solar	4%	NeoSolar	3%	Hareon	4%	Wuxi Suntech	1.3 - 1.5
Other	39%	Other	43%	Other	44%	Other	44%		

Source: 1. Renewable Energy World
2. PV Tech

Table 33: : Top 10 PV Manufacturers by Year (2015-2019)

2015 (GW) ¹		2016 (GW) ²		2017 (GW) ²		2018 (GW) ¹		2019 (GW) ¹	
Trina	5.74	Jinko Solar	5.28	Jinko Solar	6.55	Jinko Solar	11.4	Jinko Solar	14.2
Canadian Solar	4.7	Trina Solar	5.19	Trina Solar	6.4	JA Solar	8.8	JA Solar	10.3
Jinko Solar	4.51	Canadian Solar	4.28	Canadian Solar	6.03	Trina Solar	8.1	Trina Solar	9.7
JA solar	3.93	Hanwha Q Cells	4.21	Hanwha Q Cells	5.6	LONGi Solar	7.2	LONGi Solar	9
Hanwha Q Cells	3.3	JA Solar	4.5	JA Solar	5.4	Canadian Solar	7.1	Canadian Solar	8.5
First Solar	2.8	GCL System Integration	3.48	LONGi Green Energy Technology	4.8	Hanwha Q cells	5.5	Hanwha Q cells	7.3
ReneSola	2.69	Yingli Green energy	2.08	GCL System Integration	4.6	Risen Energy	4.8	Risen Energy	7
Yingli Solar	2.4	LONGi Green Energy Technology	1.85	Risen Energy	3.43	First Solar	2.7	First Solar	5.5
Shunfeng International Clean Energy Limited (SFCE)	2.28	Risen Energy	1.61	Yingli Green energy	3.43	GCL System Integration	4.1	GCL System Integration	4.8
Risen	1.24			Talesun Solar	3.05	SFCE	3.3	SFCE	4

Source:1. https://en.wikipedia.org/wiki/List_of_photovoltaics_companies
2. HIS Markit

In 2018 Seven of the top ten manufacturers all are Chinese companies except for Q Cells (South Korea), Canadian Solar (Canada) and First Solar (USA). But all of the above manufacture some or all of their panels in China with the exception First Solar (Malaysia, USA and Vietnam).

Table 34: Annual Installed PV (%) by Country (2010-2018)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Australia	2.3%	2.8%	3.5%	2.1%	2.1%	1.8%	1.1%	1.2%	3.7%
Austria	0.3%	0.3%	0.3%	1.0%	0.4%	0.3%	0.2%	0.2%	0.2%
Belgium	2.5%	3.4%	2.4%	0.7%	0.3%	0.2%	0.3%	0.3%	0.4%
Canada	1.1%	0.9%	0.8%	1.1%	1.6%	1.3%	0.2%	0.3%	0.2%
Chile	0.0%	0.0%	0.0%	0.0%	0.5%	0.7%	0.7%	0.6%	0.6%
China	2.9%	8.7%	11.9%	28.6%	26.6%	30.2%	44.8%	51.2%	42.9%
Denmark	0.0%	0.0%	1.3%	0.4%	0.1%	0.3%	0.1%	0.0%	0.1%
Finland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
France	4.9%	5.7%	3.7%	1.8%	2.4%	1.8%	0.8%	0.9%	0.8%
Germany	43.7%	25.4%	27.2%	7.1%	3.0%	2.6%	1.9%	1.7%	2.9%
Israel	0.3%	0.4%	0.3%	0.3%	0.5%	0.4%	0.1%	0.1%	0.4%
Italy	13.7%	30.7%	12.2%	3.8%	1.0%	0.6%	0.5%	0.4%	0.4%
Japan	5.8%	4.2%	5.7%	18.7%	24.4%	21.5%	10.2%	7.2%	6.5%
South Korea	0.7%	0.3%	1.0%	1.4%	2.3%	2.3%	1.1%	1.3%	2.2%
Malaysia	0.0%	0.0%	0.1%	0.3%	0.2%	0.1%	0.1%	0.0%	0.5%
Mexico	0.0%	0.0%	0.0%	0.2%	0.2%	0.1%	0.1%	0.2%	3.5%
Netherlands	0.1%	0.2%	0.5%	1.0%	0.9%	1.0%	0.8%	0.7%	1.5%
Norway	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Portugal	0.1%	0.1%	0.2%	0.1%	0.3%	0.1%	0.1%	0.1%	0.1%
South Africa	0.0%	0.0%	0.0%	0.8%	2.7%	0.2%	1.0%	0.1%	0.1%
Spain	2.9%	1.5%	1.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.3%
Sweden	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%
Switzerland	0.2%	0.3%	0.8%	0.9%	0.8%	0.7%	0.3%	0.2%	0.3%
Thailand	0.0%	0.6%	0.5%	1.2%	1.2%	0.2%	1.3%	0.6%	0.4%
Turkey	0.0%	0.0%	0.0%	0.1%	0.1%	0.6%	1.1%	2.9%	2.9%
USA	4.9%	6.2%	10.6%	13.3%	15.6%	14.9%	19.6%	10.5%	10.3%
Total IEA Countries	86.5%	91.7%	84.2%	84.9%	87.2%	82.4%	86.7%	80.9%	81.0%
Total Non-IEA Countries	13.5%	8.3%	15.8%	15.1%	12.8%	17.6%	13.3%	19.1%	19.0%

Source: IEA PVPS 2018 Annual Trend Report

11.5 Solar Thermal 2010-2020

Key points from the IEA SHC data:

- IEA SHC collected data from 63 countries and estimated that all other countries represented 5% total annual installed capacity.
- The total annual installed capacity was 62.5 million m² in 2010, peaked at 77.5 million m² in 2013 and had decreased to 46.7 million m² in 2018. This is shown in Figure 93.
- China dominance of the market represented 78.3% of the total annual installed capacity in 2010 and represented 82% in 2018.
- In 2010 ETC's represented 79.6% of the recorded annual installed capacity and this decreased to 72.8% in 2018.
- This decrease was a result of the decrease in the China market where in 2010 94% of the annual installed capacity were ETC's decreasing to 78% in 2018. In the ROW ETC represented 28% in 2010 growing to 37% in 2018.
- Calculations were undertaken of the total cumulative installed capacity allowing for systems being removed after a specified number of years. This showed that cumulative capacity grew from 333 million m² in 2010 to 666 million m² in 2018. This is shown in Figure 94.
- Air collector heater data was collected from 19 countries with an estimate for the other countries. However, 6 of the countries only had data for 1 year and 4 others only 3 years. The 10 countries which had data collected for most of the nine years included: Australia, Austria, Brazil, Canada, Hungary, India Japan, UK and USA. Figure 106 shows the annual installed capacity of air collector heater panels from 2010 to 2018 for the data collected (and estimated). Note: 1 of the dominant , the USA, did not have figures for 2010.
- The two dominant markets for the installation of air collectors in 2018 were: Canada (37.9%) and USA(23.1%) .

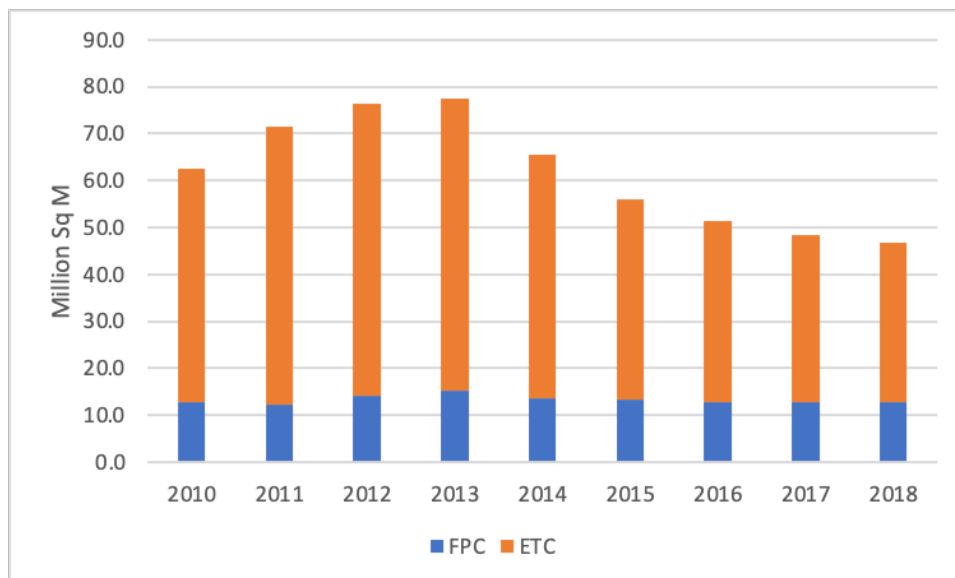


Figure 93: Annual installed solar water panel capacity 2010-2018 broken down into ETC and FPC
Source: IEA SHC

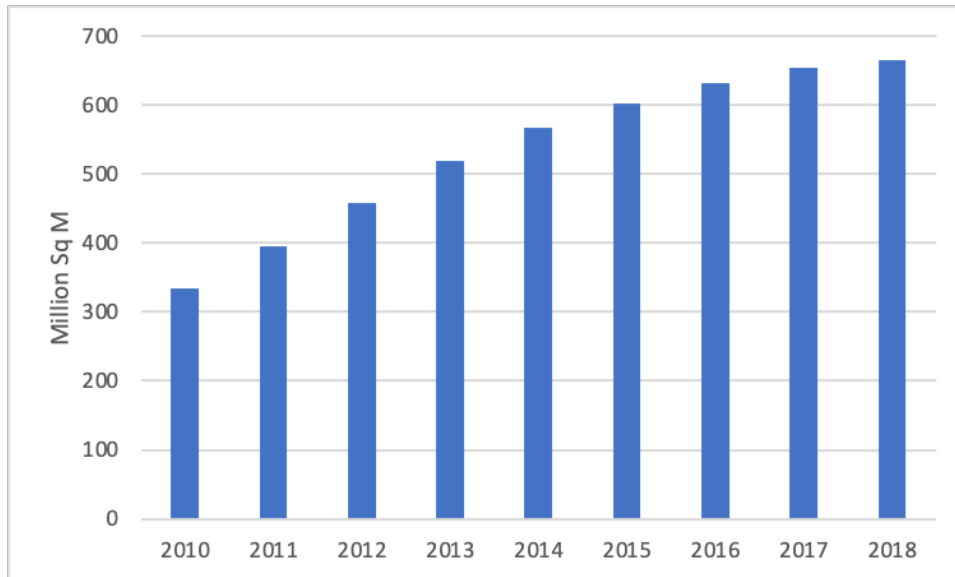


Figure 94: Cumulative installed solar water panel capacity 2010-2018 broken down into ETC and FPC
Source: IEA SHC

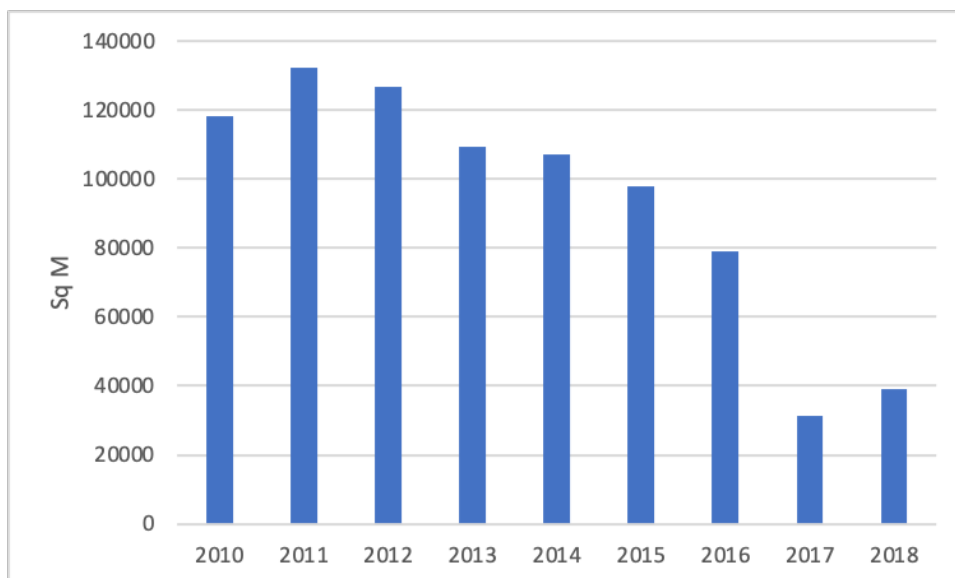


Figure 95: Annual installed air heating panel capacity 2010-2018 for Canada and USA
Source: IEA SHC

2011

- The Austrian company **S.O.L.I.D.** commissioned the largest solar cooling installation worldwide at the United World College in Singapore. The 2.73 MW_{th} / 3,900 m² solar thermal collector field powers a 1,500 kW cooling unit, which is based on a single-effect lithium bromide absorption chiller.
- 25 MW_{th} (36,300 m²) Plant Produces Heat for Princess Nora Bint Abdul Rahman University in Riyadh Saudi Arabia.

2012

- **First IEA SHC International Conference** on Solar heating and cooling for buildings and Industry held in San Francisco in 2012, etc Joined with ISES Solar World Congress in 2017 in Abu Dhabi and 2019 in Santiago.

2013

- Chile 27.5 MW_{th} (39,300m²) with 4,000m³ of storage provides 85% of the Heat for Copper Mine installation at Codelco Gabriela Mistral mine site for heating baths used for electrolytic refining of copper

2014

- Establishment of the **Global Solar Certification Network (GSCN)**, during its first meeting in Spain, in April 2014. The GSCN was developed under the framework of the IEA SHC Task 57 “Solar Standards and Certification”. **It was managed by Jan Erik Nielsen with Harald Drück as Chairman.**

2016

- Opening of the **Silkeborg (Denmark)** solar district heating plant comprising 150 000 m² of large module collectors (110 MW_{th}) built by **Arcon**. **The Silkeborg plant was the largest among more than 100 district heating plants with solar collector arrays of 2 – 110 MW_{th} (1 500 – 150 000 m² collector area) that, based on the technology pioneered in Sweden in the early 1980's, were installed in Denmark from around 2007 until end 2017.**
- The Chinese solar district heating plant using parabolic trough collectors The installation in Baotou in Inner Mongolia, consists of two fields of parabolic trough collectors, a 22,000 m² rooftop field and a 71,000 m² system put up at ground level. The 93,000 m² (65 MW_{th}) SDH plant was the world's second-largest installation but the biggest using concentrating collectors.

2019

- Two of the largest sub-Saharan solar heating systems launched in South Africa. Each of these two SOLTRAIN projects include 600 m² solar heating plant using 10 m² Austrian collectors They are a district heating plant for Wits University residences and a solar process heat plant for the Klein Karoo International tannery, and are supported by the South African National Energy Development Institute (SANEDI).
- The southern Tibetan town of Saga has been home to the fourth solar district heating plant in the region after similar systems had already been installed in **Langkazi, Shenzha and Zhongba**. The plant has a heat generation capacity of 13.4 MW_{th} (19,136 m²) and includes large flat plate collectors by Chinese manufacturer Jinheng Solar as well as two storage units that can hold 4,500 m³ each.
- Tibet's first solar district heating plant made up of parabolic trough collectors installed by Vicot Solar Technology, the turnkey solar field supplier based in Dezhou, China. The 20,000 m² system supplies heat to 1,800 households in the town of Shenzha, in the Naqu prefecture in northern Tibet.

2020

- **360 MW installed capacity at Miraah Oman.** Originally planned by Glasspoint to be a 1GW plant for Enhanced Oil recovery.

11.6 CSP 2010-2021

2010

- The 75 MW Martin Next Generation Integrated Solar (CSP) Combined Cycle was completed and came online.
- Ain Beni Mathar Integrated Solar (CSP) Combined Cycle 20 MW plant began operation in Morocco. This is the first of five ISCC plants supported by the World Bank GEF program.

2011

- Kuraymat Integrated Solar (CSP) Combined Cycle 20MW plant began operation in Egypt and the Hassi R'mel Integrated Solar (CSP) Combined Cycle 20 MW plant began operation in Algeria.
- In Spain, Gemasolar, a 17 MW molten-salt tower plant with 15 hours of thermal energy storage became the first commercial molten-salt tower plant to come online.

2013

- Agua Prieto Integrated Solar (CSP) Combined Cycle 15 MW plant began operation in Mexico.
- The Godawari Solar Project became the first CSP project to operate in India. As of 2020, three CSP plants are operating in India with a total capacity of 200 MW.
- The last 50 MW trough CSP plant out of a total of fifty CSP plants began operation, bringing the total capacity of CSP plants in Spain to 2.3 GW.
- Solana, a 250 MW trough plant with six hours of thermal energy storage came online in Arizona.
- Ivanpah, a complex of 3 solar power towers, with a total capacity of 377 MW came online in California.
- Shams 1, a 100 MW CSP trough plant in Abu Dhabi began operation.

2014

- Mojave and Genesis, each 250 MW trough plants located in California came online.
- Crescent Dunes, a 110 MW molten salt power tower with 10 hours of thermal energy storage, located in Nevada, came online.

2015

- The 100 MW Kaxu parabolic trough plant came online in South Africa. As of 2020, there are six CSP plants with a combined capacity of 500 MW operating in South Africa.
- Noor I, a 160 MW parabolic trough plant with 3 hours of TES, became the second commercial CSP plant in Morocco. As of 2020, there are three CSP plants operating in Morocco with a combined capacity of 500 MW.
- SEGS 1 and 2, the first commercial CSP projects in the US, shutdown at the end of their power purchase agreements after operating for 30 years.
- China approved 20 demonstration CSP projects ranging in size from 50 to 100 MW. Proposed projects include power tower, trough and linear Fresnel technologies.

2016

- The first commercial CSP plant to come online in China was a 10 MW tower. As of 2020, there are 11 commercial CSP plants operating in China with total capacity 521 MW.

2018

- The Ashalim A 110 MW parabolic trough with 4.5 hours of TES and Ashalim B 121 MW superheated steam power tower began operation in Israel.

2019

- The 50 MW Shagaya CSP plant with 10 hours of TES began operation in Kuwait.
- Waad Al-Shamal Integrated Solar (CSP) Combined Cycle 50 MW plant began operation in Saudi Arabia.

2020

- Spain submitted to the EU Commission its National Energy and Climate Plan which calls for an additional 5 GW of CSP by 2030.
- Portugal has plans for 30 MW of new CSP capacity by 2030 and Italy has plans for 500 MW of new CSP capacity by 2030.
- Most of the southwestern States in the US have legislated 100% carbon free generation and the corresponding and evolving needs of the grid has opened a window of opportunity for CSP with TES to allow electricity generation in the evening and night. As of 2020, the CSP capacity in the US is 1,740 MW.

2021

- The 110 MW Cerro Dominator molten-salt tower project with 17.5 hours of TES is expected to begin operation in the Atacama Desert in Chile.
- The 200 MW trough and 100 MW MS tower are scheduled to come online for DEWA project in Dubai UAE with two additional 200 MW trough plants to follow. This plant includes 250 MW of PV.
- Midelt, a 400 MW of CSP trough with 5 hours of TES hybrid with 400 MW of PV, is under construction in Morocco.

11.7 Solar Architecture Buildings 2010-2019

2010

- With the growth of “Zero Energy Buildings” the US national Renewable Energy laboratory develops a classification system defined in a report : *Net-Zero Energy Buildings: A Classification System Based on Renewable Energy Supply Options*
- In May 2010 the EU Energy Performance of Buildings Directive states:
Each Member State shall establish a long-term renovation strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private, into a highly energy efficient and decarbonised building stock by 2050, facilitating the cost-effective transformation of existing buildings into nearly zero-energy buildings.
- IEA-SHC Task 40 / EBC Annex 52 launches a website with an interactive map of the world showing locations of Net Zero Energy Buildings. Clicking on the building location on the map provides information on that building. (<https://batchgeo.com/map/net-zero-energy-buildings>)

2011

- The first Zero passive house in Iran, the Payesh Energy House (PEH) or Khaneh Payesh Niroo is launched.

2014

- IEA -SHC Task 41 Solar Energy and Architecture launches in 2014 a website with a collection of case studies including a wide range of new built or retrofitted building types such as single and multi-family housing, offices, schools and universities, stadiums, culture buildings, etc. The case studies include active solar (photovoltaic and solar thermal) and passive solar. More than 230 case studies were proposed and evaluated by a broad range of trained architects from universities, research institutes, dissemination organisations and professional practices. 50 projects from 11 countries were selected to be included in the Collection of Case Studies. (<http://task41casestudies.iea-shc.org>)
- In April Japan realised the Basic Energy Plan which comprised following targets:
 - Net Zero Energy Buildings in newly constructed public buildings, etc. by 2020 and in newly constructed buildings on average by 2030
 - Net Zero Energy House (ZEH) in newly built ordinary residences by 2020 and in newly built residences on average by 2030
- India's first net zero building is Indira Paryavaran Bhawan , located in New Delhi , is inaugurated

2015

- IEA -SHC Task 47 releases the report: *Lessons Learned from 20 Non-Residential Building Renovations*. The report summarizes the findings from 20 exemplary renovation projects. The buildings are divided into three categories; educational buildings, office buildings and historic & protected buildings. In this summary chapter, the key findings from all the buildings are described. More detailed information for each building category is presented under the respective chapters.

2016

- The Sustainable Energy Development Authority Malaysia (SEDA Malaysia) started a voluntary initiative called Low Carbon Building Facilitation Program.
- The European Commission developed guidelines for the promotion of nearly zero-energy buildings in order to ensure that by 2020, all new buildings are nearly zero-energy buildings.

2017

- IEA-SHC Task 51 Solar Energy in Urban Planning releases a collection of 34 case studies from Austria, Canada, China, Denmark, France, Germany Italy , Norway, Sweden and Switzerland. The case studies are indicative of the state of the art of leading developments in the planning of solar energy in new and existing urban areas and also include examples of solar landscape planning. The report is available from following website <https://task51.iea-shc.org/Data/Sites/1/publications/Task51-Report-C1-1805031.pdf> while there is a clickable map on the case studies from the following site <https://task51.iea-shc.org/case-studies>
- In May, The Canadian Home Builders Association - National launched the Net Zero Homes certification label, a voluntary industry-led labelling initiative.

- In August, the Government of Canada released Build Smart - Canada's Buildings Strategy which seeks to dramatically increase the energy efficiency of Canadian buildings in pursuit of a net zero energy ready level of performance.
- In December, the BC Energy Step Code entered into legal force in British Columbia, Canada. The regulation is designed as a technical roadmap to help the province reach its target that all new buildings will attain a net zero energy ready level of performance by 2032.

2018

- In March, SEDA Malaysia started the Zero Energy Building Facilitation Program
- The California Energy Efficiency Strategic Plan is launched with ambitious goals for the development of zero net energy buildings. These include:
 - All new residential construction will be zero net energy (ZNE) by 2020.
 - All new commercial construction will be ZNE by 2030
 - 50% of commercial buildings will be retrofitted to ZNE by 2030
 - 50% of new major renovations of state buildings will be ZNE by 2025.
- The EU Energy Performance of Buildings Directive requires all new buildings to be nearly zero-energy by the end of 2020.

2019

- In January The National University of Singapore (NUS) launched Singapore's first net-zero energy building to be built from scratch at its School of Design and Environment (SDE).

2020

- The Pertamina Energy Tower -a net-zero energy skyscraper opens in the centre of Jakarta, Indonesia. It is 99 stories high and serve as the headquarters of Pertamina, the national energy company. In addition to the 20,000 people who will work there, it is the centrepiece of a campus that has a mosque, a sports centre and a 2,000-seat auditorium for the performing arts.

11.8 PV in Developing Countries 2010-2019

This decade sees the off-grid market focused on two solutions for the unelectrified people in developing countries. The solutions are plug and play Solar Home Systems and Mini-Grids. However, there is still a market for component based solar home systems which have a higher peak watt rating than those being provided by plug and play systems. Lighting Global introduces a Product Quality Assurance program for the testing and approval of plug and play solar home systems. The Global Off-Grid Lighting Association (GOGLA) is formed and many of its members are from those companies providing the products approved through Lighting Global. In the second half of the decade, bi-annual off grid solar trend reports are developed, and the results are summarised below. The mini-grid market expands as a solution for electrifying villages globally and in particular those in Sub-Saharan Africa. Many bi-lateral and multi-lateral donors now focus in on this area and the number of companies and products has grown. A key driver for all of this interest in off grid solutions was Sustainable Development Goal 7 (SDG7), which called for universal access to sustainable energy by 2030. A significant development as the decade progressed is that with the growth of the plug and play market, product prices were greatly reduced and in parallel with this is the development of more efficient appliances and LED lighting. This resulted in a 50W PV system being able to power similar appliances to what would need a 300-500W system 20 years prior. Due to the rapid expansion of the plug and play market and the installation of micro-grids in the developing countries, the data provided for this decade focuses on those installations as distinct from the donor projects as shown in previous decades.

- In 2010 1.14 billion people in the world did not have access to electricity, representing 16.5% of the total population. This had decreased to 939 million by 2016, representing 12.6% of the population.

Table 35: Percentage of Population without access to Electricity 2010-2016

2010	16.5%
2011	17.5%
2012	14.9%
2013	14.8%
2014	14.3%
2015	12.9%
2016	12.6%

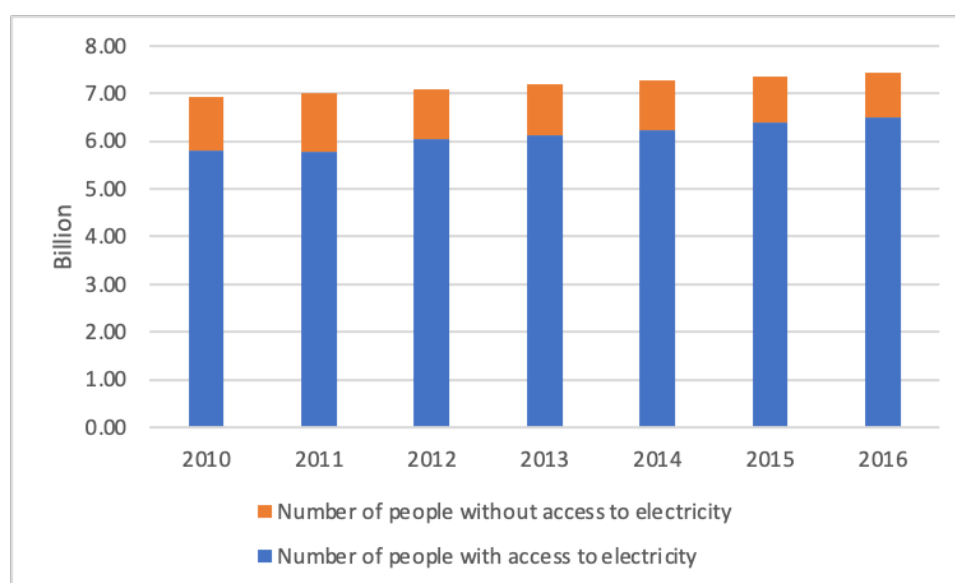


Figure 96: Access to Electricity 2010-2016

Table 36: Access to Electricity by Regions 2010 and 2016

Region	2010		2016	
	Number of People without access (million)	% of Total Population	Number of People without access (million)	% of Total Population
East Asia and Pacific	99.4	4.5%	70.9	3.1%
Latin America and Caribbean	24.4	4.1%	14.0	2.2%
Middle east and North Africa	15.6	4%	8.6	2%
South Asia	405.8	24.9%	254.9	14.3%
Sub Saharan Africa	591.3	67.4%	591.0	57.2%

Source for above data: <https://ourworldindata.org/energy-access>

2010

- The **Stiftung Solarenergie (The Solar Energy Foundation)** commences publication of the e-news titled **Sun-Connect News**, the world's leading news platform for the off-grid industry, with articles, news, document database, product database and a comprehensive list of manufacturers and local distributors.

2011

- Peter Aldemann and his daughter Catherine founded **Fosera**, a German company manufacturing of plug and play solar home systems. and other products for the off-grid market. Catherine Aldemann is the current CEO of the company.
- Former UN Secretary-General Ban Ki-moon launched the **Sustainable Energy for All initiative (SEforALL)**. Today an independent organization, SEforALL's is an international organization working with leaders in government, the private sector and civil society to drive further, faster action toward achievement of **Sustainable Development Goal 7 (SDG7)**, which calls for universal access to sustainable energy by 2030.

2012

- The **Global Off Grid Lighting Association (GOGLA)** is established. **GOGLA** is the global association for the off-grid solar energy industry. **GOGLA** now represents over 180 members as a neutral, independent, not-for-profit industry association. Their services assist the industry in building sustainable markets and profitable businesses delivering quality, affordable off-grid electricity products and services to as many customers as possible across the developing world. **GOGLA** industry members are those involved in companies/businesses whose main income is generated from the sale of off-grid lighting and electricity products or services.
- The IFC launches **Lighting Asia** with a report on the off grid solar lighting market for seven Asian countries. The overall program becomes known as **Lighting Global** with Lighting Africa and Lighting Asia being regional programs. **Lighting Global's** quality assurance program tests off-grid lighting products while also providing business support to companies who sell products that meet the quality standards. These standards have been adopted as IEC international standards. **Lighting Global** maintains a website database listing all the approved products, allowing consumers and resellers to confirm that the product they are buying has been tested and found to meet the Quality Standards.

2015

- The **Sustainable Development Goals (SDGs)**, were adopted by all United Nations Member States as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. Sustainable Development Goal 7 (SDG7) calls for universal access to sustainable energy by 2030.
- In order to monitor the progress towards SDG7, the **World Bank/ESMAP** and the **International Energy Agency** led a consortium of 23 international agencies to establish the SE4All Global Tracking Framework (GTF) which describes how to measure baseline and progress towards the SE4All goals by gathering energy data regularly. This led to measuring energy access in the tiers as identified in the following table. Tiers 1, 2, and 3 can include many of the SHS's on the market.

		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5	
		ATTRIBUTES	1. Peak Capacity	Power capacity ratings ²⁸ in W or daily Wh	Min 3W	Min 50W	Min 200W	Min 800W
Min 12 Wh	Min 200Wh				Min 1.0kWh	Min 3.4kWh	Min 8.2kWh	
2. Availability (Duration)	OR Services		Lighting of 1,000 lmhr/day	Electrical lighting, air circulation, television, and phone charging are possible				
			Hours per day	Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
3. Reliability	Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4hrs	
							Max 14 disruptions per week	Max 3 disruptions per week of total duration <2hrs
4. Quality							Voltage problems do not affect the use of desired appliances	
5. Affordability							Cost of a standard consumption package of 365 kWh/year < 5% of household income	
6. Legality							Bill is paid to the utility, pre-paid card seller, or authorised representative	
7. Health & Safety							Absence of past accidents and perception of high risk in the future	

Figure 97: Multi-Tier Matrix for Measuring Access to Household Energy Supply

- The World Bank Group through its Lighting Global program commissioned the Off Grid Solar Trends report. The research was undertaken by Bloomberg New Energy Finance with support by GOGLA. The first report was released in February 2016. This is then the start of Lighting Global and GOGLA undertaking twice-yearly market surveys and producing the Global Off-Grid Solar Semi-Annual Market Reports. Some key data from reports are shown in the following figure 127 and 128.

By end of 2019

- Nearly 180 million people have benefited from using **Lighting Global** quality verified solar products, and more than 52.4 million people are currently meeting their basic (Tier 1) electricity needs. More than 42.1 million quality verified products have been sold since 2009. Since then, 37 million metric tons of carbon-dioxide equivalent (CO_{2e}) have been avoided due to the use of quality verified products instead of fuel-based alternatives.
- An estimated 420 million people worldwide are benefitting from off-grid solar products but only 55% of these people (231 million) currently benefit from Tier 1 or better access to electricity.

Data on Off-Grid Solar Devices 2010-2019

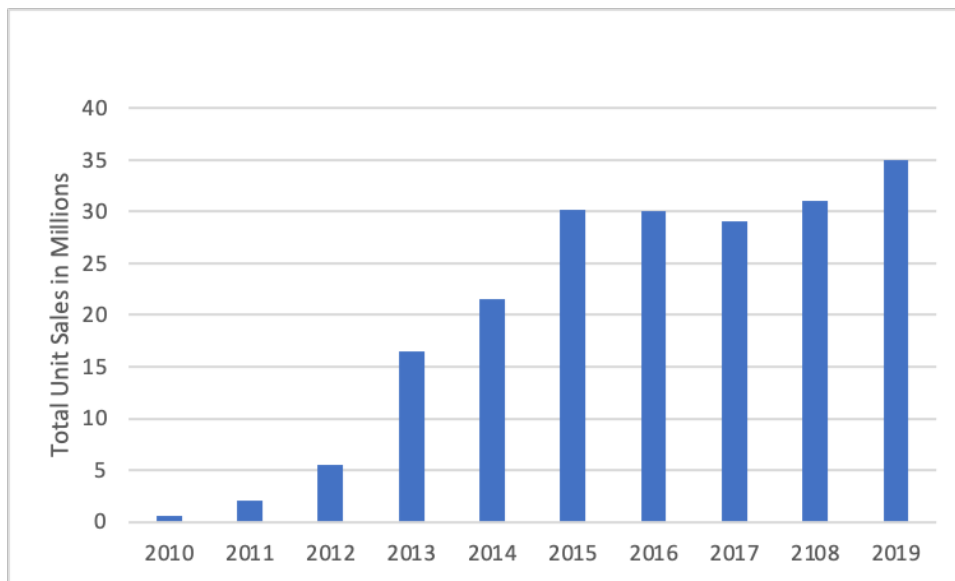


Figure 98: Estimated Annual Sales of Off-Grid Solar Lighting Systems

Source: Off Grid Solar Market Trends Report 2020 (Lighting Global and ESMAP with support by GOGLA)

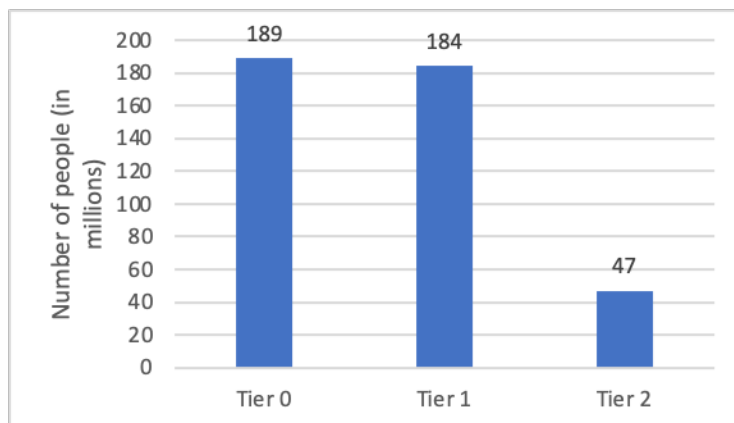


Figure 99: Conservative Estimate of the Number of People Worldwide Benefiting from Access to Electricity through Off-Grid Solar Devices

Source: Off Grid Solar Market Trends Report 2020 (Lighting Global and ESMAP with support by GOGLA)

Data on Mini-Grids 2009-2019

In accordance with the “State of the Global Mini-Grids Market Report 2020” released by Sustainable Energy for All SEforAll in March 2020:

“As of February 2020, there were 5,544 installed mini-grids identified in the mini-grid asset database built in this research, of which 60 percent and 39 percent were in Asia and Sub-Saharan Africa respectively. Generation capacity totalled 2.37GW.”

Figure 100 shows the breakdown in fuel sources across the 5544 mini-grids while figures 130 and 131 show the growth in installed mini-grids in Sub-Saharan African and Asia since 2009.

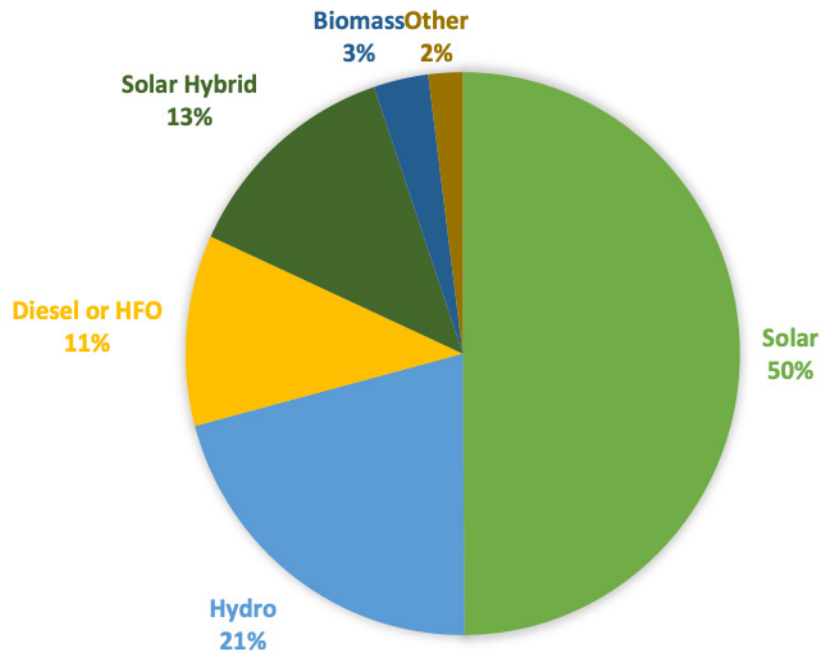


Figure 100: Installed Mini-Grids by Technology

Source: State of the Global Mini-Grids Market Report 2020 (SEforALL)

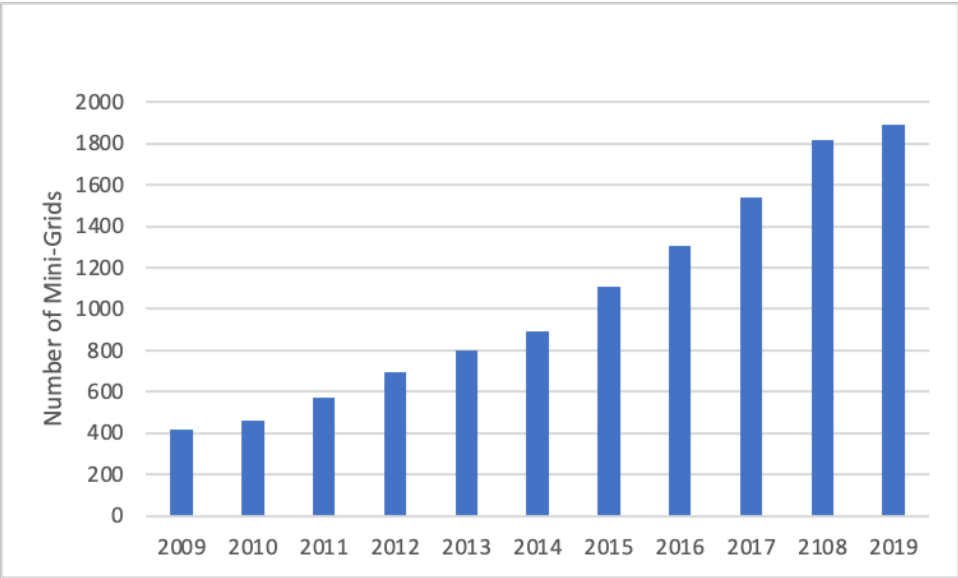


Figure 101: Annual Cumulative Installed Mini-Grids in Sub-Saharan Africa
 Source: State of the Global Mini-Grids Market Report 2020 (SEforALL)

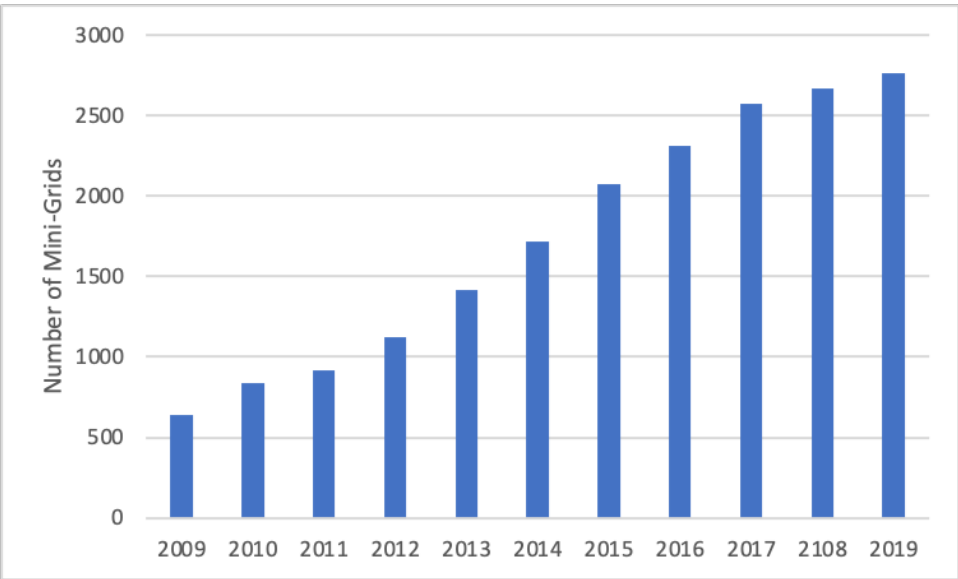


Figure 102: Annual Cumulative Installed Mini-Grids in Asia
 Source: State of the Global Mini-Grids Market Report 2020 (SEforALL)

11.9 SWC50 Supporter: Global Solar Council



GLOBAL SOLAR COUNCIL: THE VOICE OF THE GLOBAL INDUSTRY

What does it mean to be the voice of the global solar industry in 2020 with our eyes fixed on the landmark decades ahead, to 2030, 2040 and 2050? The Global Solar Council recognizes that the enormous potential of solar PV has implications that go far beyond the field of electricity generation: shifting away from centralized energy systems built around fossil fuels and towards far greater penetration of solar power will change economic and social relations, creating new opportunities for people in a vast range of jobs and benefits for the Planet, People and Prosperity.

That is the spirit that lies behind the work of the Global Solar Council, a non-profit body representing national, regional and international associations as well as leading solar sector corporations (see box). Founded at the 2015 Paris climate conference as a private-sector response to the climate emergency, the GSC brings together associations from both established and emerging markets that represent companies all along the solar supply chain.

Our Vision

Solar energy is the leading solution to the world's energy needs.

Our Mission

To promote the rapid adoption of solar energy globally, through market development, partnerships and education.

GLOBAL SOLAR COUNCIL MEMBERS



It's impossible to talk about the future of the solar PV industry, however, without recognizing the turbulent year we've been living through in 2020 and the implications the Covid-19 crisis has on solar power's prospects. The Global Solar Council took action in April 2020, surveying about 500 businesses in over 60 countries worldwide to get real-time information from companies on the ground about how they were being impacted and get their input on how governments and institutions could respond and support the PV sector.

Building Back Better After The Pandemic

In the short-term, the pandemic was particularly disruptive - a dramatic contrast to the growth story that had been common in recent years. Firstly, there was the local factor, cited by more than half of respondents (57%), because lockdowns and restrictions on work and travel hampered day-to-day operations on installations and interrupted the administrative procedures; secondly, just over a third (37%) of respondents said they had problems getting orders, suffering from lower client demand, and struggled to finalize contracts. A lesser problem was the interruption to global supply chains, helped for sure by the rebound in activity in China.

What has emerged from these challenging business conditions has been a **broader political and social consensus about the need to "build back better" and put clean energy technologies such as solar power at the heart of government stimulus plans.** Nowhere has this been clearer than in the European Commission's "green deal" package of recovery policies but there are many other examples around the world.



Climate Action Means Solar Jobs

A central topic for recovery plans is of course employment. And it's a topic that the Global Solar Council has already put at the heart of its mission, **setting a target of boosting the sector's employment to 10 million solar jobs by 2030** from 3.75 million in 2019 as estimated by the International Renewable Energy Agency (IRENA). Solar PV is already the biggest renewable energy employer globally, having overtaken bioenergy in terms of jobs in 2015.

Getting to that 10 million-job level will require trillions of dollars in long-term, stable investments and multiple terawatts of PV generation. The Global Solar Council has adopted policy positions that support action and implementation towards this goal. They were presented at the COP24 climate summit in Poland in December 2018 and at the COP25 in Madrid in 2019.

These recommendations remain critical today. That's why, **as members of the IRENA Coalition for Action, the Global Solar Council was among 100 leading renewable energy organizations to actively support its joint call for action, putting forward concrete recommendations on how governments can ensure a rapid and sustained economic recovery that aligns with climate and sustainability objectives.** They involve shifting support away from fossil fuels and towards renewables, promoting a just transition and strengthening international cooperation.

GLOBAL SOLAR COUNCIL PARTNERS



But solar power is about much more than jobs and investments and new technologies, as important as those issues are today: solar power is set to play a key role in unleashing an array of environmental, social and economic benefits and can accelerate our trajectory towards the United Nations' Sustainable Development Goals (SDGs), thanks to PV's ability to deliver not only our climate objectives but also bring advantages in terms of employment, health, education, gender equality and poverty alleviation.

PV's Global Ripple Effect

The relevance of solar for the SDGs is highlighted by a few key facts: 789 million people today remain without access to electricity (SDG 7), 300 million children are without power at primary school (SDG 4) and a staggering 90% of the global population is at risk due to air pollution (SDG 3). That said, 11.5 million people are already employed in renewable energy (SDG 8) and 32% of them are women (SDG 5) while 17.1% of final energy consumption comes from renewables (SDG 13).

Solar PV's "ripple effect" – a potent factor in regions such as sub-Saharan Africa and south east Asia – is well illustrated by the economic, social and health benefits gained by increasing access to energy through off-grid and micro-grid technologies and by providing clean water to all, for example using solar to create cost-effective, green desalination solutions on both a small and large scale.

The Global Solar Council has been active throughout 2020 in raising awareness about the important role the industry can play at a global level. Following the pandemic-focused industry survey, the council has organised a series of webinars and its first Virtual Forum, hosting dozens of industry representatives and experts in energy and development hailing from Indonesia to Italy and from Nigeria to Brazil and the USA.

To further promote the adoption of solar power in new, emerging markets, **the Global Solar Council has set up three regional task forces focusing on: Africa, Latin America and South East Asia.** The aim of each group is to stimulate cooperation among PV associations, share best practices and promote high potential emerging markets to international investors.

The Global Solar Council is an active partner in promoting mass adoption of solar power, fully aware of the widescale benefits that will flow from that future scenario. Not only for our industry and achieving climate goals but also for the sustainable development of our economies and the wellbeing of our communities.

11.10SWC50 Supporter: GWNET



GWNET
Global Women's Network
for the Energy Transition

Our History

It is a well-known fact that the energy sector continues to be male-dominated. The absence of gender equality can be observed in all parts of the world.

Gender inequality is even more prevalent at decision-making levels. Women are generally under-represented on company boards and across senior management positions, as well as in politics. This reality of under-representation is even more accentuated in energy-related fields. As a result, the few women that manage to secure top positions are often less connected with their peers than their male colleagues.

It is important to note that gender equality has proven to be an indispensable factor in reaching sustainability. Gender diversity drives innovation, opens new pathways for technology deployment, brings fresh perspectives to the development of societies and attracts and retains a richer pool of talent.

These observations motivated four women professionals working in the sustainable energy field to found the **Global Women's Network for the Energy Transition (GWNET)**. GWNET is a global network aiming at empowering women working in sustainable energy in all parts of the world, at different career levels from both the public and the private sector. GWNET is an international non-profit organisation founded in 2017 under Austrian law.



Our Activities

GWNET aims to advance the global energy transition by empowering women in energy through interdisciplinary networking, advocacy, training, coaching and mentoring.

GWNET seeks to address the current gender imbalances in the energy sector and to promote gender-sensitive action around the energy transition in all parts of the world, through:

- **Networking:** facilitating connections among women working in the fields of renewable energy and energy efficiency to advance the energy transition, through events and the cutting edge Women in Energy Expert Platform.
- **Advocacy:** generating and disseminating [information on the role of women in the energy transition](#) as well as organising conferences, seminars, [webinars](#), and workshops which foster discussions and promote gender-sensitive action around the energy transition.



- **Mentoring:** leading the development of several regional and global women mentoring programmes, designed to accelerate the careers of women in the energy sector, support their pathway to leadership positions and foster a global network of mentorship, knowledge-sharing and empowerment.

Learn more here: <https://www.globalwomennet.org/about-gwnet/activities/>

Our Membership: The Women in Energy Expert Platform



GWNET's [Women in Energy Expert Platform](#) connects and empowers women working in sustainable energy in all parts of the world with the aim to encourage greater visibility, networking opportunities and professional connections between women.

The platform which has over 1400 members from 100+ countries demonstrates the diversity of roles and skills of women already active in the sector, refuting the claim that there are no women in renewable energy.

Women working in sustainable energy are encouraged to explore the platform and create their profile so that they can begin engaging with other professionals: <https://www.globalwomennet.org/members/become-a-member/>

Image credits: GWNET and Dena

11.10 SWC50 Supporter: SEIAPI



In 2008, while undertaking a project in Fiji, Geoff Stapleton from GSES was approached by Clay Engineering (Fiji) on whether GSES could assist the Pacific Islands establish a designers/installers technician certification program similar to the Clean Energy Councils “accreditation” program in Australia. After further discussions with othersolar energy companies in the Pacific region it was decided that an industry association should be formed which could manage the accreditation program and also develop technical guidelines for the region.

GSES successfully applied for funding from the Renewable Energy and Energy Efficiency Programme (REEEP) starting in 2010.

The output of this 2-year project was the establishment of the Sustainable Energy Industries Association of the Pacific Islands (SEIAPI). Initially the association was registered in Solomon Islands however it is now registered in Fiji. The funding from REEEP allowed for the development of :

- The association by-laws/constitution;
- The rules for a technician certification programme and
- A 5-year business plan,

SEIAPI covers all Pacific Island Countries and Territories within the North and South Pacific Oceans. There are 21 Countries and Territories with a total combined population of approximately 12+ million people.

SEIAPI first executive committee met in Guam in November 2010.



SEIAPI First Executive Committee Meeting-Guam 2010

L to R: Bruce Clay (Fiji), Fred N Skilling (Kosrae), Nick Ritsinias (Vanuatu). Peter Konings (Pohnpei) and Faustino Yangmog (Yap). Committee members not in Photo : David Iro Fulaga (Solomon Islands); Vaughn Columbus- (Fiji) and Eric Kerres- (Vanuatu)

SEIAPI has three membership categories:

- Industry Member (sustainable energy business located in the Pacific Islands)
- Associate Member (sustainable energy business located outside of Pacific Islands)
- Honorary Member (Government Departments, NGO's, Donors and training institutions)

In addition to supporting the members of the association the principle role that SEIAPI has played is in building technical capacity within the region.

The focus has been in development of technical guidelines and training which will benefit the growth of the industry.

In 2011 SEIAPI developed the following four technical guidelines in:

- Design of Grid connected PV Systems
- Installation of Grid connected PV Systems
- Design of Stand-Alone PV Systems
- Installation of Stand-alone PV Systems

In early 2011, to support the technician certification scheme, SEIAPI led the formation of a regional committee of relevant stakeholders to oversee the development of training unit competencies. These identified the skills and competencies that should be included within a training course for various applications. This resulted in SEIAPI overseeing the development of the following training competency standards:

- Designer of Solar Based Off-Grid Power Systems
- Installer of Solar Based Off-Grid Power Systems
- Maintainer of Solar Based Off-Grid Power Systems
- Designer of grid connected PV Systems; and
- Installer of Grid Connected PV Systems.



The certification/accreditation program was officially launched by the President Epeli Nailatikau (Fiji) at the Pacific Launch of Sustainable Energy4All in April 2012.

Launch of Certification/accreditation Program-Suva 2012

Left to Right:

Cathy Stapleton, Geoff Stapleton (current SEIAPI Secretary, Hon President Epeli Nailatikau and Brice Clay (current SEIAPI President) at the launch of the SEIAPI certification/ accreditation program

In 2012 SEIAPI signed an MOU with the Pacific Power Association (PPA).The PPA is the association of the 22 electricity utilities located in the Pacific Island Countries and Territories. Under this MOU all technical documents relating to renewable energy will be jointly published as PPA/SEIAPI documents and the certification/accreditation program is known as the PPA/SEIAPI program.

Since the completion of the REEEP funded project GSES has acted as the Secretariat for SEIAPIbecause it is a voluntary administered organisation.

In 2018 GSES, on behalf of SEIAPI, was successful in being awarded a contract from the Pacific Power Association (PPA) to provide the technical assistance services under the Sustainable Energy Industry Development Project (SEIDP). The PPA was the Project Implementation Agency for the World Bank funded SEIDP.

The project covered twelve countries including: Federated States of Micronesia (FSM), Fiji, Kiribati, Republic of Narau, Papua New Guinea (PNG), Republic of Marshal Islands (RMI), Republic of Palau, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu

This project concluded in August 2020 and the outcome was :

- The updating of the original 4 technical guidelines;
- The development of 12 new technical guidelines:
- 19 training unit standards being developed and submitted for approval onto the Pacific Qualifications and Standards Registry (PRQS).
- Thirty-two (32)4-day workshops being conducted in the 12 countries. These workshops were based on the guidelines that were developed.

The guidelines and training unit standards are available from the association’s website: www.seiapi.com

For the project GSES appointed Mr Sandip Kumar to assist and he is now based within the PPA office in Suva, Fiji. Though he is employed by GSES his other role is to undertake the duties of secretariat of SEIAPI. The key focus of SEIAPI now is the development of technical training across the Pacific for the benefit the SEIAPI members. (Note: All PPA members are also members of SEIAPI under the MOU).

11.12 ISES Institute Member: The Australian Centre For Advanced Photovoltaics



ACAP (ACAP—The Australian Centre for Advanced Photovoltaics) is a world-leading, dynamic national centre where solar photovoltaic research institutions across Australia collaborate. ACAP's broad range of research work is driving Australia's international lead in solar technology and development, as global economies transition to renewable energy.

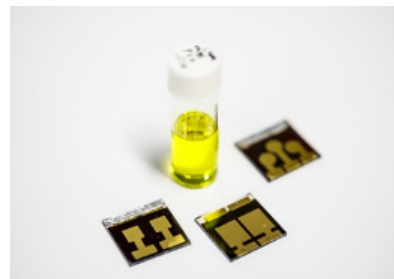
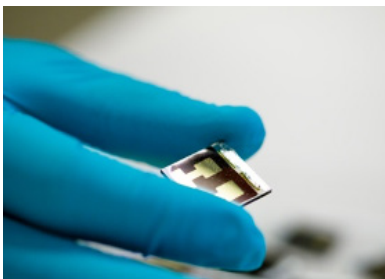
Federally funded by the Australian Renewable Energy Agency (ARENA) since 2013, and led by the University of New South Wales, ACAP's partner institutions include the Australian National University, the CSIRO, Melbourne University, Monash University, and the University of Queensland. International partner institutions include Georgia Tech, Stanford University, Molecular Foundry at Berkley, QESST and the Green Energy Institute. Our industry partners are BlueScope Steel, Raygen, Tindo Solar, PV Lighthouse, BT Imaging, Trinasolar, and Suntech.

ACAP is headquartered in Sydney, at the School of Photovoltaics and Renewable Energy at UNSW. There, it is led by Professor Renate Egan (NODE lead), Scientia Professor Martin Green (Director) and Professor Richard Corkish (Chief Operating Officer.) Scientia Associate Professor Xiaojing Hao was recognised as the 2020 Malcolm McIntosh Physical Scientist of the Year, for her work at the centre investigating the many opportunities of perovskite solar cells.

Over its history, ACAP has fostered research initiatives between more than 762 solar and renewable energy researchers, who have collaborated on projects which have broken 11 world records in solar cell efficiencies, in addition to filing 172 technology patents.

This strong pipeline from research to industry is what makes ACAP a world leader in solar power technology development. Today's \$50b+ global solar industry exists as a direct result of our proud history of collaboration with our partners around the world. This global success story has brought solar power to millions of people, both here and around the world. This is the work that ACAP will continue to undertake as we develop the next generation of solar cell technologies that will power the globe.

For further information visit: acap.org.au



12. THE FUTURE

12.1 Introduction

A global renewable energy revolution is underway. This revolution is intimately connected with significant societal transformations that are also occurring. While this chapter focuses on the details around the renewable energy revolution, we first want to highlight the importance of the connection between renewable energy and society here.

12.1.1 Renewable Energy and Society

Fossil fuels have powered the creation of tremendous global wealth over the past two centuries. However, this wealth creation has been accompanied by growing income disparities, energy injustice, and environmental threats. Societies around the world are stepping up to fight these inequalities, environmental crises, and government inaction. Major changes in our energy system are a key response in this fight. As affirmed at the ISES Solar World Congress 2019, these changes are not only possible – they are underway around the world. A distributed renewables-based energy system offers much greater energy access and provides many more people with a much greater say in how their energy is produced and used, leading to energy justice along with environmental recovery and improvement. In order to rapidly achieve the goal of 100% renewable energy in all end-use sectors electricity, transportation, heating and cooling in all cities, regions and nations throughout the world, effective pathways regarding technologies, markets, policies, community actions and public support must be identified and followed.

12.1.2 Overview of this Chapter

The growth of renewables is due to the confluence of three key interacting factors: 1) quality and reliability improvements, combined with a continuous drop in capital costs, of renewable technologies and associated balance of systems, which leads to 2) more bankable projects and access to private capital, which further leads to 3) more and more favorable renewable energy policies and targets throughout the world. On top of this, public acceptance of these technologies and a desire for a carbon-free future is further driving the revolution.

During the past 50 years ISES has played a leading role in the growth of renewables. ISES members have worked to advance the cost-effectiveness, reliability, and efficiency of solar energy technologies and related renewable energy and building efficiency programs from laboratory research to commercial success. In the case of PV technologies, for example, ISES research and organizational members have advanced cell technology and manufacturing processes, module efficiencies, and balance of system components such as inverters and mounting systems to support the dramatic commercialization of off-grid and grid-tied PV systems. Research in electrical and thermal energy storage, so critical towards achieving a 100% renewable energy target, is being undertaken. Our members are conducting key research and undertaking projects in new net-zero energy building design and in older building renovation to achieve high efficiency standards. The ISES community is also engaged in system analysis and integration studies, policy innovations, effective financing schemes, and garnering public support and acceptance of the technological changes taking place in this energy revolution.

This booklet has highlighted many key events that have contributed to this success story throughout the history of ISES. In this chapter, we take a look at the Future of Renewables that can be anticipated over the next 50 years, building on the success stories of the past half century, and the key roles that ISES will be playing in furthering the global energy transformation to achieve 100% renewables.

12.2 What are Some Pathways to 100% Renewables?

There are numerous studies, including by organizations with which ISES has a strong partnership, that outline the bright future for renewables and the pathways to achieving 100% renewables. Mitigating climate change is certainly a key motivator, although other significant societal issues, such as improved local air quality, access to secure energy supplies free from foreign influences, and the recognition of a dwindling finite supply of economically accessible fossil fuel reserves are among the other key motivators for these studies. The points that support the practicality of these studies, such as the steep declines in the costs of renewable technologies and their deployments, are indisputable.

12.2.1 The Selected Studies

Three specific studies are chosen here to evaluate options for achieving a completely carbon-free and 100% renewable energy supply well before the end of this century: IRENA's Sustainability and Climate Change Analysis (formerly known as ReMAP), published most recently in their 2020 Global Renewables Outlook [1]; the recent Springer book by the University of Technology Sydney (UTS) titled "Achieving the Paris Climate Agreement Goals" [2]; and the study by the Finnish Lappeenranta University of Technology (LUT) and Energy Watch Group titled "Global Energy System based on 100% Renewable Energy – Power, Heat, Transport and Desalination Sectors" [3]. Clearly there are many other studies that have been undertaken in recent years, such as those by Greenpeace International, the International Energy Agency (IEA), the Intergovernmental Panel on Climate Change (IPCC), Shell Renewables, and others that the reader is encouraged to explore. The three studies summarized here have been chosen mainly to establish the foundational principles that must be met to achieve 100% renewables.

12.2.2 The Climate Argument for 100% Renewables

Each of these studies referenced below are motivated by the Paris Climate Agreement, negotiated at the Conference of the Parties (COP) 21 in Paris in December 2015 and ultimately by signed by all 196 nations. The Agreement calls for steps to be taken by all nations to urgently reduce greenhouse gas emissions to levels that will limit global warming to no more than 2°C above preindustrial levels and ideally to 1.5°C by the end of this century. The 2018 IPCC report [4] estimates that global warming has already reached approximately 1.0°C. The 1.5°C target has become an even more crucial to achieve given the potential catastrophic impacts of climate change, including severe droughts and flooding, sea-level rise, dramatic shifts in agricultural patterns, increases in airborne disease vectors, and a resulting displacement of hundreds of millions, if not billions, of climate "refugees", as reported in [4].

However, when the Paris Climate Agreement was signed, limiting global warming to 2°C was still considered to be a meaningful target given the state of science at the time. This target had been set in an earlier IPCC study [5]), and also reflected the willingness of countries to establish GHG emission-reduction measures that could realistically be achieved given the current political and economic conditions. The 1.5°C target was added into the Paris Agreement as an aspirational target to which the UNFCCC and the signatory countries should strive. Even a 2°C target would mean that all global GHG emissions would need to be eliminated entirely by 2075. Given that roughly ¾ of global anthropogenic GHG emissions are related to energy production and consumption, the energy sector would already need to take aggressive action to achieve the 2°C target.

But with the more recent findings of the IPCC in [4] which calls for limiting global warming to no more than 1.5°C, the need to decarbonize our energy systems is even more urgent and must be done even more rapidly than what was thought at the time of the Paris Agreement. Between the two IPCC reports (from 2007 to 2018) global GHG emissions increased by roughly 30%. Therefore, the new 1.5°C target requires all countries to find the means to eliminate GHG emissions a full generation earlier, or by 2050. Despite this ambitious target, however, the Nationally Determined Contributions (NDCs) submitted by all signatory countries at the time of the signing of the Paris Agreement would still result in global warming to increase to 3.6°C.

Rapid expansion of renewable energy technologies to the point where they provide all of our end-use energy needs, combined with aggressive energy efficiency measures that dramatically reduce energy intensity per capita is seen as the most cost-effective way to achieve the Paris Climate goals while maintaining social justice and economic prosperity. A number of studies such as those cited below have been undertaken to identify pathways to achieve the Paris targets, especially without resorting to any expansion of nuclear energy or to implementing costly and risky technologies such as large-scale carbon capture and storage.

12.2.3 The Coronavirus Pandemic Impact on the Near-Term and Longer-Term Future of Renewables

The onset of the coronavirus pandemic in early 2020, and the stringent measures taken by governments around the world to control its spread, has produced severe economic consequences. At the peak of the first surge in late March/early April governments responded to the economic fallout by introducing a variety of stimulus packages to alleviate the impacts of lost jobs, reduced commerce, and drops in national GDPs. Many renewable energy organizations such as IRENA developed [policy statements](#) that encouraged governments to include measures that would accelerate the use of renewable energy deployments and to jump-start programs designed to mitigate climate change. While some governments have adopted climate-friendly stimulus measures, many have not.

There is ample evidence that the immediate impacts of the of the pandemic on renewable energy deployments have been reduced demand for these technologies, company shutdowns, and disruptions in supply chains. On the other hand, some industry associations such as Solar Power Europe are predicting that the longer-term impacts on the growth of PV deployments [would be relatively small](#).

At the time of this writing parts of the world have entered into a second, more serious surge of the pandemic, threatening further lockdowns and economic disruptions. Governments are continuing to explore stimulus packages to alleviate the economic consequences of the measures that need to be taken to control the pandemic, and the call for supporting the renewable energy sector in these packages continues.

Despite the tragic consequences that the pandemic is currently reaping on society and the profound impacts on the short-term growth of renewable energy technologies, the renewable energy industry remains optimistic that impacts on renewable energy development will, in the long run, be relatively minimal. Where government stimulus is available for clean energy development, the longer-term impact of the pandemic could actually result in an acceleration of renewable energy development over pre-pandemic levels.

The International Energy Agency has [reported](#) that, global carbon dioxide emissions decreased by up to 8% (2.6 Gt) compared to 2019 due to substantially reduced economic activity and demand for energy services, particularly in the power and mobility sectors. Although such an annual decrease is in line with what the IPCC [4] recommends securing a 1.5°C cap by 2050, it is likely that emissions will once again increase post pandemic, perhaps even at a greater rate than pre-pandemic levels, without sustained government action to enact measures to maintain the decreases over the long term.

12.2.4 Overview of Assumptions in the Three Studies

The three studies presented here (all developed prior to the outbreak of the coronavirus pandemic) have many common elements for achieving the Paris Climate goals through an energy transformation to 100% renewables. However, based on assumptions related to technology costs, political will, and technology innovation, they offer somewhat different pathways, resulting in differing outcomes in terms of technology mixes, deployment rates, overall costs, etc. The outcomes differ in the level of decarbonization achieved by 2050, and they all require further actions to continue to be taken during the remainder of the century. But all studies ultimately achieve 100% renewables, and all reflect a very positive future for renewable and related clean energy technologies.

IRENA Global Renewables Outlook 2020 [1]: Since 2014, the International Renewable Energy Agency (IRENA) has been undertaking studies to determine how the world can achieve sustainable energy and mitigate climate change, known as the Global Energy Roadmap, or REMap. Initially their analyses went out to 2030, using a pathway that doubles the share of renewable energy. In 2018 they extended the outlook to 2050 and have elaborated on their analysis most recently in their first Global Renewables Outlook 2020 [1].

The Roadmap examines in detail a “Transforming Energy Scenario”, which is described as an ambitious, yet realistic transformation pathway based largely on renewable resources and energy efficiency measures aimed to keep the rise of global warming to well below 2°C and towards 1.5°C by the end of this century. This scenario contrasts to their “Planned Energy Scenario”, which is their reference case and is based on governments’ current energy plans, targets, and policies, including the NDCs established by individual countries under the Paris Agreement. An even lesser-ambitious scenario, the Baseline Energy Scenario, is predicated on policies and commitments in place just prior to the Paris Agreement.

The Transforming Energy Scenario is achieved through a number of factors and assumptions. First and foremost, the costs of solar PV and other renewables will continue to decline, and policies that currently support subsidies to the fossil industry will shift to renewables. The scenario specifically assumes the following: 1) a major shift towards the electrification of the transport and heating and cooling sectors, resulting in more than a doubling of the current contribution of the power sector, so that electricity supply represents 49% of total energy demand; 2) the percentage of renewables providing this electricity supply will grow from 25% (2017 levels) to 86% by 2050, with solar and wind representing the majority of this supply due in large part to their falling prices (solar PV will provide 25% of total electricity demand, compared to its current contribution of ~3%); 3) hydropower will continue to provide important synergies to a future energy system; 4) besides increased electrification, renewables will also contribute significantly to the heating and cooling and mobility sectors; 5) the energy intensity of the global energy demand will fall by 2/3 due to electrification, renewables, and energy efficiency measures; 6) modern bioenergy and biofuels, and the emergence of green hydrogen, will also provide key roles in meeting a transformed energy supply. The energy mix resulting from these assumptions is shown in Figure 103.

The Transforming Energy Scenario does not bring carbon emissions down to the level recently recommended by the IPCC [4], which requires a fully decarbonized energy system by mid-century in order to achieve the 1.5°C Paris Climate Agreement target. The Transforming Energy Scenario, albeit ambitious, cuts 70% of the world’s energy-related CO₂ emissions by 2050, 90% of which is accomplished through renewables and energy efficiency measures. By 2050 this scenario still shows annual CO₂ emissions of 9.5 Gt, although this is more than 80% below current levels. The study does offer additional recommendations to cut CO₂ emissions beyond 2050 to zero or net-zero, especially with the emergence of cost-competitive green hydrogen utilisation.

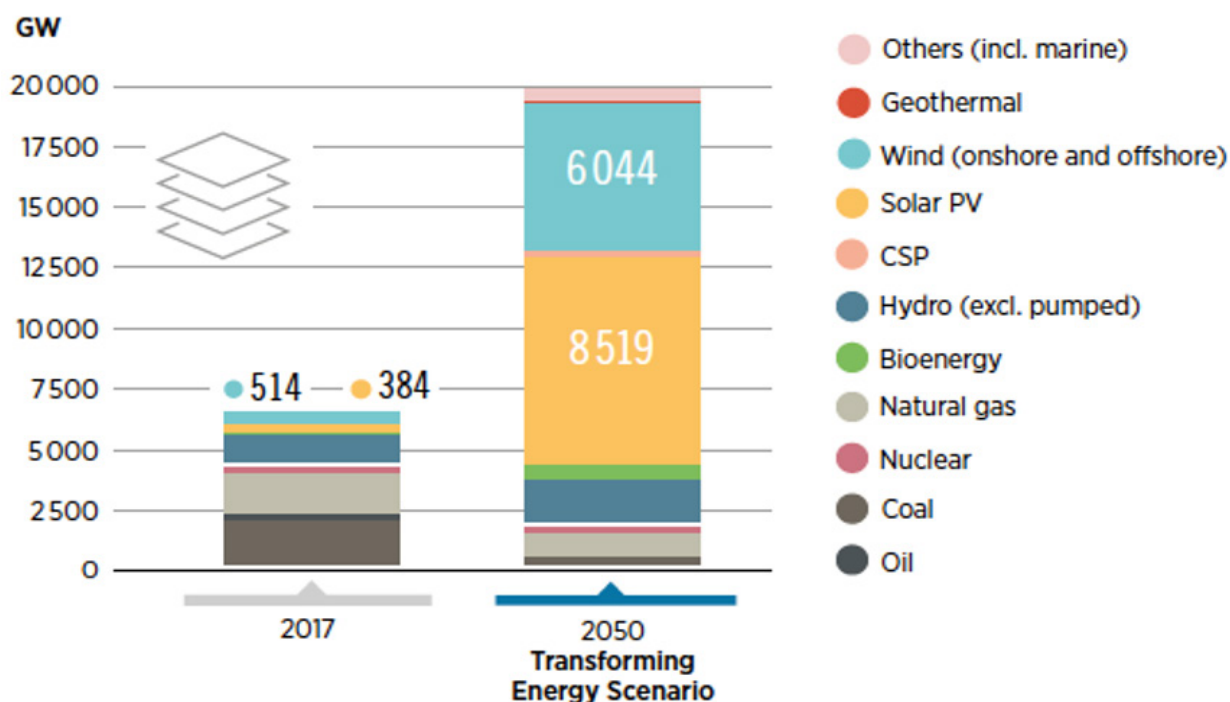


Figure 103: The growth in capacity levels required to achieve expected electricity supply by 2050 under the Transforming Energy Scenario. Under these capacity levels, solar PV will contribute 25% of total electricity supply in 2050 (see ref. [1])

University of Technology Sydney (UTS) Study for Achieving the Paris Climate Goals [2]: In 2019 the University of Technology Sydney (UTS) published an online Springer book titled “Achieving the Paris Climate Agreement Goals” [2] that directly addresses the IPCC 2018 findings of completely decarbonizing the energy sector by mid-century. The approach of this comprehensive volume is to examine mitigation strategies for three scenarios of future global warming by the end of this century: 5.0°C (the “reference scenario”), 2.0°C (the Paris Agreement target), and 1.5°C, or the level urgently recommended by the IPCC 2018 [4]. The authors approach their analysis using a variety of computer model and statistical approaches. The analysis goes beyond the energy sector to examine mitigation strategies for non-energy related CO₂ emissions. The study employs a rigorous modeling approach following the technology assumptions from the main author’s earlier work in the Energy [R]evolution analysis by Greenpeace. Besides the statistical and modeling approaches, the two key assumptions that differ from the IRENA study in the 1.5°C scenario are 1) The 1.5°C scenario is achieved by allowing for no more than an accumulated total of 450 Gt of CO₂ emissions between 2015 and 2050, leaving no energy-related carbon emissions by 2050; and 2) no consideration is given to societal or political interventions; the scenario is achieved strictly through technology deployments and costs. The result is an even more electrified energy system (56% for the 1.5°C scenario compared with IRENA’s 49%), and a 100% renewable energy supply 100% (compared with IRENA’s 86%) in 2050. As an example, as to how these assumptions impact the energy mix, by 2050 the UTS study results in 12,864 GW of installed PV capacity, or nearly 49% of total electricity supply, compared with IRENA’s 8,519 GW.

Lappeenranta University of Technology (LUT) and Energy Watch Group (EWG) Study on 100% Renewables [3]: The LUT/EWG study examines least-cost options for achieving a cap of 1.5°C global warming by the end of this century based on significant electrification of all end-use energy demand and a 100% renewable energy system. The model simulates a transition to 100% renewables across nine major regions and 145 subregions at 5-year time increments from 2015 to 2050. The LUT/EWG study projects that electrification will grow by a factor of four to five by 2050 from 2015 levels, due primarily to substantial electrification of the transport and the heating and cooling sectors. By 2050, 90% of all end-use energy supply will come from the power sector, compared to 57% for the UTS analysis and 49% for the IRENA analysis. Cost considerations result in the scenario favoring wind and solar technologies as the most predominate sources of electricity supply in the 2050 scenario. Specifically, solar PV provides 69% of all primary energy, or 76% of electricity, by 2050, as shown in Figure 104. This results in PV capacity that is 6 to 10 times higher than the other two studies indicate.

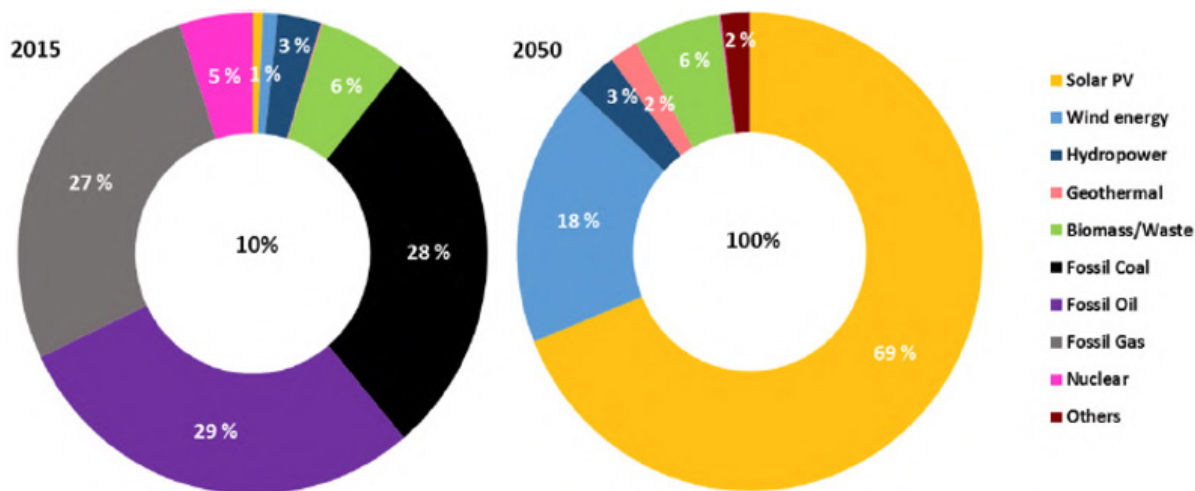


Figure 104: Shares of primary energy supply in 2015 and 2050 in the LUT/EWG analysis [3]

12.2.4 Summary

The studies referenced here all demonstrate the significant opportunities for renewable energy technologies in the coming decades. For example, the table below provides an overview of how the electricity sector will grow under the three scenarios analyzed (currently the electricity sector represents approximately 23% of our end use energy consumption), and the dramatic role that solar PV will play in this growing sector. Capacity projections for solar PV in the LUT/EWG scenario have been estimated using solar resource and performance ratio assumptions to convert PV energy production into PV installed capacity.

Name of Study	Name of Scenario	Electricity in Total End Use Energy Consumption	Electricity supplied by PV	Projected PV Capacity by 2050, GW
IRENA [1]	Transforming Energy Scenario	49%	25%	8,519
UTS [2]	1.5 °C Target Increase Scenario	57%	49%	12,684
LUT/EWG [3]	100% RE by 2050	90%	76%	~79,000

12.3 What is ISES' Position on the Key Elements of these Studies?

In principle there are ten major aspects to the transformation to 100% renewables, many of which are common to all of these studies, that ISES supports:

- Overall energy demand per capita will decrease as we greatly improve the efficiency of the buildings in which we live and work, and efficiencies in industrial and manufacturing processes.
- The electricity sector, which currently makes up approximately 25% of our global energy supply, will expand greatly in future years as electricity becomes the “energy of choice”, directly contributing to expanded use of electricity in the transport sector and the heating and cooling sector.
- Continued decrease in the cost of renewables, and in particular solar PV, CSP and onshore and offshore wind, will result in expanded use of these technologies in the global electricity supply including for currently unserved populations.
- Nevertheless, the utility sector will continue its transformation into a more distributed and flexible system giving more and more consumers a choice on electricity supply and the reliability of this supply. Such a system can reduce the need for expansion of transmission grids, with the possible exception of the use of “supergrids” based on high-voltage DC transmission technologies to bring renewable-generated from distant high-resource areas distances to end-use markets.

- All power requirements can be met by renewables combined with storage systems; technologies, such as nuclear and gas-fired power plants will not be needed in this transformed energy infrastructure.
- Furthermore, carbon capture and storage technologies are not needed to achieve 100% renewables.
- Besides the electrification of the heating and cooling and the transport sectors, there will remain a need for other renewable technologies to decarbonize many processes that cannot be easily achieved through electrification, such as the production of process heat in manufacturing, mining and food processing. As costs come down, green hydrogen produced by electricity and power-to-gas technologies can also be used to meet a portion of our end use energy requirements.
- The technological capabilities for a 100% renewable energy world are already in existence, and as their costs come down the access to finance for this transformation will continue to increase. What will be needed are ambitious policy initiatives, including, perhaps, a global price on carbon, and excellent communication strategies to ensure public understanding and acceptance, as well as equitable access to energy for all people within the energy transformation process.
- A well-educated research community as well as a strong workforce training program and easily accessible retraining activities must be an inherent part of this energy transformation. Among other key interventions, governments should still support and expand the financing of renewable energy technology innovation.
- Aggressive action to ensure global quality standards for renewable technology manufacturing and installation processes must be inherent in all aspects of the energy transformation and included as part of this workforce development.

12.4 What Will Be the ISES' Role in Leading and Supporting the Renewable Energy Future?

For its next 50 years, ISES will focus its work on these ten basic elements of a transformation to a 100% renewable energy system. Specific examples of the ISES activities will be as follows:

- Advocate for R&D to support technology innovations that further brings down costs, improves system efficiency and reliability (as well as longevity) and reduces financial risks and improves investor confidence and project bankability essential to achieve a 100% renewable energy target.
- Support specific enabling policies (e.g., carbon pricing, innovative financing schemes, technology deployment targets) to advance the transformation.
- Broaden our effective communications to our stakeholders and the public through our publications, journals, (infographics, webinars, congresses, press releases) to achieve broad and, ideally, universal support for the energy transformation.
- Develop educational programs that focus on building an equitable and sustainable energy transformation, as well as programs that broaden the awareness of renewable energy curricula to young students and make mentorship programs available to students without access to institutions that carry these curricula.
- Expand our Young ISES activities to encourage much broader participation in the energy transformation by young people from a wide variety of backgrounds and interests entering their professional careers.
- Continue to engage with and provide technical support to key partners (REN21, IRENA, ISA, IEA, GSC, etc.) and establish new partnerships with broad and diverse communities that are stakeholders in the transformation.
- Commit to ensuring that all ongoing and future ISES programs embrace the JEDI (Justice, Equity, Diversity and Inclusivity) principles.

These actions all support the ISES vision of a 100% renewable energy world readily available to the entire global community.

12.5 References

- [1] IRENA, 2020:Global Renewables Outlook Edition: 2020.Energy Transformation 2050.International Renewable Energy Agency, April 2020.https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Apr/IRENA_Global_Renewables_Outlook_2020.pdf
- [2] Teske, Sven (Editor), 2019:Achieving the Paris Climate Agreement Goals, Springer-Open, <https://doi.org/10.1007/978-3-030-05843-2>.
- [3] Ram M., Bogdanov D., Aghahosseini A., Gulagi A., Oyewo A.S., Child M., Caldera U., Sadovskaia K., Farfan J., Barbosa LSNS., Fasihi M., Khalili S., Dalheimer B., Gruber G., Traber T., De Caluwe F., Fell H.-J., Breyer C., 2019: Global Energy System based on 100% Renewable Energy – Power, Heat, Transport and Desalination Sectors. Study by Lappeenranta University of Technology and Energy Watch Group, Lappeenranta, Berlin, March 2019.
- [4] IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. P.an, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. <https://www.ipcc.ch/sr15/>
- [5] IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.<https://www.ipcc.ch/report/ar4/syr/>

13. BIBLIOGRAPHY

As mentioned in the acknowledgments a number of people assisted in the development of the highlights in the history of ISES and the different solar technology applications. Many of the highlights came from the knowledge that these individuals have in the particular technology areas, and they also undertook their own book and internet searches.

The following websites and books were used by Geoff Stapleton in compiling the sections where he took the lead in developing.

Books:

The Fifty-Year History of the International Solar Energy Society and its National Sections. Edited by Professor Karl Boer and published by the International Solar Energy Society, 2005.

Green Energy for a Billion Poor by Nancy Wimmer Published by MCRE Verlag UG , 2012.

A Guide to the Photovoltaic Revolution by Paul D. Maycock and Edward N. Stirewait . Published by Rodale Press, 1985.

Let it Shine The 6000 Year Story of Solar Energy by John Perlin. Published by New World Library, 2013.

Power for the World by Wolfgang Palz. Published by Pan Stanford Publishing Pte. Ltd , 2011

The Solar Generation by Philip R. Wolfe. Published by IEEE Press, 2018.

Sun Above the Horizon by Peter F Varadi. Published by Pan Stanford Publishing Pte. Ltd, 2014

Sun Power by Neville Williams. Published by Tom Doherty Associates LLC , 2014

Reports:

Numerous reports were reviewed. The following list contains the main ones.

International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS) Annual Trends Reports 1997 to 2018 : IEA PVPS.

International Energy Agency (IEA) Solar Heating and Cooling Programme (SHC) Annual Reports 1994 to 2019: IEA SHC.

Global Off Grid Lighting Association (GOGLA) Global Off-Grid Solar Market Reports 2015-2019: GOGLA.

Global Status Reports 2005-2020 : REN21.

Global Tracking Framework: ESMAP, IEA and World Bank.

Mini Grids for Half a Billion People: ESMAP 2019.

Off Grid Solar Market Trends Report 2020: Lighting Global, GOGLA and ESMAP 2020.

Selling Solar: Lessons from a Decade of IFC and World Bank Experience: IFC 2007.

State of the Global Mini-grid Market Report 2020: Sustainable Energy 4 All, Bloomberg NEF and Mini0Grid Partnerships 2020.

Tracking SDG7 The Energy Progress Report 2020: IBRD/World Bank 2020.

World Bank/GEF solar home systems projects: experiences and lessons learned 1993-2000 : E. Martinot*, A. Cabraal, and S. Mathur World Bank, 2001.

Magazines:

Sun at Work in Europe : ISES Europe
SunWorld : International Solar Energy Society

Websites:

Many internet searchers were undertaken to confirm data and find photos to be used in the museum.
The following are some of those used in compiling the highlights.

International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS) <https://iea-pvps.org>

International Energy Agency (IEA) Solar Heating and Cooling Programme (SHC) www.iea-shc.org

Lighting Global www.lightingglobal.org

Global Off Grid Lighting Association (GOGLA) www.gogla.org

Lighting Global www.lightingglobal.org

REN21 www.ren21.net

Timeline of solar power https://timelines.issarice.com/wiki/Timeline_of_solar_power

Timeline of solar cell: https://en.wikipedia.org/wiki/Timeline_of_solar_cells

Historical Development of PV Resources <http://www.pvresources.com/en/introduction/history.php>

14. APPENDIX 1 PROGRAM FROM 1970 CONFERENCE

**1970 INTERNATIONAL
SOLAR ENERGY SOCIETY
CONFERENCE**

PROGRAMME

MELBOURNE

2ND.- 6TH. MARCH, 1970

1970 INTERNATIONAL
SOLAR ENERGY SOCIETY CONFERENCE

PROGRAMME

Conference Venue

The Conference is being held in the National Science Centre at Clunies Ross House, 191 Royal Parade, Parkville, Melbourne. Situated about 3 kilometres north of the city centre in pleasant surroundings, it is close to the University of Melbourne and within easy walking distance of the three Conference motels.

All technical sessions (and also the Opening Ceremony) will be held in the well-equipped auditoria on the ground floor of the building. Morning and afternoon teas will be served in the Supper Room on the first floor, in part of the premises occupied by the Sciences Club.

Similarly, the Opening and Farewell Luncheons are being held in the Club dining room, where lunch will also be available on other days. The Conference Dinner will take place in the University Union, about 300 metres away across Royal Parade in the grounds of the University of Melbourne.

By courtesy of the management of the Sciences Club, arrangements have been made for all Conference participants to have full use of the facilities available there, either as temporary members of the Club or as the guests of other members. This applies to the ladies as well as to the men. The Club is open between the hours of 12 noon and 10 p.m., Monday to Friday, and those using its facilities are requested to conform to its rules and requirements while on the Club's premises.

Conference Badge

Each participant is issued at the time of registration with a Conference Badge, bearing his name and country. This badge provides the authority for his or her admittance to all Conference functions, and participants are urged to wear their badges on all relevant occasions.

Technical Sessions

Technical sessions will be held at the following times:-
Mornings : 9.15 - 10.45 a.m., 11.15 a.m. - 12.45 p.m.
Afternoons : 2.00 - 3.30 p.m., 4.00 - 5.30 p.m.

Morning and afternoon tea will be provided between the respective sessions.

All single sessions will be held in the No. 1 auditorium. For concurrent sessions Nos. 1 and 2 (or 1 and 2 + 3) auditoria will be used.

The first half of each session is allocated to the presentation of papers and the second half to their discussion. If so desired, participants can give the session Chairman prior notice of their wish to contribute to the discussion on a paper, using the form provided. A second form is available for written contributions, which must be handed in to the Information Desk before the end of the Conference, if they are to be included in the printed discussion to be mailed to participants after the Conference. Authors are asked to contact their appropriate Session Organizer as soon as possible after registration, to enable their projection and lecture aid requirements to be established and a meeting arranged with their Session Chairman.

The official language of the Conference is English and no arrangements exist for simultaneous translation. It is hoped that all speakers will use the English language.

Speakers and audience are asked to be punctual in their attendance at the technical sessions and in their return to the auditorium from lunch or tea, to avoid disruption of the programme.

Preprints

With limited exceptions, all papers being presented at the Conference have been preprinted, and each participant will have received a full set.

Additional copies of any particular preprint can be obtained from the Conference Organizer at the end of the Conference at a cost of 50 cents each.

Notices

A Conference Notice Board is located in the main foyer. This will be used to advise participants of any alterations to the programme, telephone messages for individuals and the like.

Information and Travel Desks

An Information desk will be maintained in the foyer throughout the Conference to assist participants with any queries that they may have. Other desks have been established in the same location by Qantas Airways and Ansett Airlines of Australia, to assist with travel arrangements and provide details of scenic tours.

Banking and Postal Facilities, etc.

A sub-branch of the Commonwealth Trading Bank is located on the ground floor of Clunies Ross House. Travellers cheques and the like can be cashed there and limited banking facilities provided.

A public telephone for local calls is located in the foyer. Interstate and overseas calls can be arranged through the Ian Clunies Ross Foundation office on the 2nd floor of the building (telephone No. 34 6629). Postage stamps can be purchased there and arrangements made for the dispatch of cables and telegrams.

Dress

Dress for all technical and social functions will not be formal.

Conference Committee

R. N. Morse (Chairman)
F. G. Hogg (Conference Organizer)

Australia:

D. J. F. Allen-Williams
J. G. Baker
E. L. Beasley
R. J. Brown
C. D. Campbell
E. T. Davey
R. V. Dunkle

H. J. de V. Koop
Mrs. R. N. Morse
W. R. W. Read
C. M. Sapsford
F. J. Scully
N. R. Sheridan

New Zealand:

R. F. Benseman

Canada:

G. T. Ward

U. S. A. :

A. J. Drummond
J. A. Duffie
P. E. Glaser

CONFERENCE PROGRAMME

MONDAY, 2ND MARCH

Time	Event	Auditorium or other Venue
9.00-12.00	Registration (including Ladies).	No. 2
12.00-12.30	Opening of Conference and welcome to participants (with Ladies).	No. 1
12.30- 1.00 1.00- 1.45	Sherry Opening Luncheon } (with Ladies).	Sciences Club
	SUBJECT 1: WORLD SURVEY OF SOLAR ENERGY.	
2.00- 3.30	Session 1a: Chairman - Sir Frederick Whitte. A series of papers will be presented surveying solar energy research, development and utilisation around the world.	No. 1
2.00- 4.00	Ladies: Spinning and weaving demonstration by the Hand Weavers and Spinners Guild of Victoria.	No. 3
3.30- 4.00	Afternoon tea.	Supper Room
4.00- 5.30	Session 1b: Chairman - Sir Frederick Whitte. Continuation of world survey.	No. 1
Evening	Free.	

TUESDAY, 3RD MARCH

9.00	Buses leave Clunies Ross House.	
9.40- 1.00	Visit (with Ladies) to the Laboratories of the CSIRO Division of Mechanical Engineering, Highett, including a light lunch. (After a brief tour of the Laboratories, the ladies visit members' homes before returning to Highett for lunch.)	Highett
1.00	Buses leave Highett for Clunies Ross House. Ladies: Afternoon free.	
	SUBJECT 3: RADIATION MEASUREMENT, PROCESSING SOLAR, SIMULATION AND PHOTOBIOLOGY.	
2.00- 3.30	Session 3a: Chairman - A.J. Drummond 44 H. Tabor (Israel) - Spectral solar radiation station. 45 J.T. Fallett & A.L. Pittinger (U.S.A.) - Silicon cell pyranometer. 37 D.J. Morris (Australia) - Diffuse sky radiation. 105 E.S. Trickett (Australia) - Solar radiation measurement.	No. 2
	SUBJECT 5: SOLAR DISTILLATION.	
2.00- 3.30	Session 5a: Chairman - V. Storelli. 115 F. Daniels (U.S.A.) - Small plastic water stills. 53 D. Proctor (Australia) - Effect of adding waste heat to a solar still. 102 S.B. Soliman & M. Kobayashi (U.A.R. & Japan) - Water distillation by solar energy. 2 R.R. Hay (U.S.A.) - Sun, soil and deep dew.	No. 1
3.30- 4.00	Afternoon tea.	Supper Room
4.00- 5.30	Session 5b: Chairman - A.J. Drummond. 63 B. Grossmlynek & R. Dogniaux (Belgium) - An absolute scale for radiation measurement. 21 H. Heywood (U.K.) - Total radiation on inclined surfaces. 6 S.C. Collison & R.A.H. Rabich (Aust.) - Radiometer calibration. 83 Mian A. Mami (India) - Surface and air-borne measurement of solar radiation.	No. 2

4.00- 5.30	Session 5b: Chairman - V. Storelli. 12 T.A. Lawand (Canada) - Solar stills in the West Indies. 74 M. Saif-ul-Rehman (Pakistan) - Solar stills in Pakistan. 39 S.D. Gokhale, S.K. Garg & R.L. Datta (India) - Solar distillation techniques in India. 52 W.R.V. Read (Australia) - Developments and trends in solar distillation.	No. 1
7.00 for 7.30	Conference Dinner (with Ladies).	Union House, University of Melbourne

WEDNESDAY, 4TH MARCH

	SUBJECT 3 (cont'd): RADIATION MEASUREMENT, PROCESSING, SOLAR SIMULATION & PHOTOBIOLOGY.	
9.15-10.45	Session 3c: Chairman - H. Heywood. 47 Radiation in the upper atmosphere and in space. I. A.J. Drummond & J.R. Hickey (USA) - Radiation measurement using high-altitude aircraft. II. P.M. Kahn (USA) - The U.S. BOMEX radiation experiment. III. W.E. Marlatt (USA) - Scattering and absorption of radiation by aerosol. IV. W.R. Bandeen (USA) - Satellite measurements of radiation. 72 E.W. Barrett (USA) - Depletion of short-wave irradiance by suspended particles.	No. 1
9.45	Ladies: Bus departs Clunies Ross House for all-day visit to Healesville, returning by 4.30 p.m.	
10.45-11.15	Morning tea.	Supper Room
11.15-12.45	Session 3d: Chairman - A.J. Drummond. 5 E.E. Jesson (Australia) - Observation of solar radiation by the Bureau of Meteorology, Australia. 46 W.R. Klein (U.S.A.) - Photobiology and solar radiation measurement. 103 K. Murai & K. Sakihara (Japan) - Measurement of solar aureole. 106 Z. Babool & P. Ulrikson (Hungary & Chile) - Distribution of global radiation over Chile.	No. 1
12.45- 2.00	Lunch (available in Sciences Club).	
	SUBJECT 5 (cont'd): SOLAR DISTILLATION.	
2.00- 3.30	Session 5c: Chairman - V. Storelli. 67 R.S. Trayford & L.W. Welch (Australia) - Comparison of measured and calculated still performance. 26 J.R. Hirschmann & S.K. Roffler (Chile) - Thermal inertia of solar stills. 78 G.B. Frick (Chile) - Some new considerations about solar stills.	No. 1
3.30- 4.00	Afternoon tea.	Supper Room
4.00- 5.30	Session 5d: Chairman - V. Storelli. 36 V.A. Zaun, E.B. Beyramov & Yu.N. Malevsky (USSR) - The solar still in the desert. 69 J.A. Eibling, S.G. Talbert & G.O.G. Lof (U.S.A.) - Digest of technology of basin-type solar stills. 34 E.H. Morse, W.R.W. Read & R.S. Trayford (Aust.) - Solar still operation in Australia.	No. 1

7.30-8.30	Annual General Meeting of Solar Energy Society.	No. 2
8.30-10.00	Lecture on Australian aboriginal art by Mr. J.A. Davidson (with Ladies).	No. 1
10.00-10.30	Supper.	Supper Room
THURSDAY, 5TH MARCH		
SUBJECT 7: GENERAL RESEARCH.		
9.15-10.45	Session 7a: Chairman - V. Storallis. 18 A. Keller (Chile) - Selective surfaces of aluminium foils. 81 E.A. Christie (Aust.) - Spectrally selective blacks for solar energy collection. 24 D.J. Close & R.V. Dunkle (Aust.) - Energy storage using desiccant beds. 30 V.A. Baum, G.A. Alatyrisov, Yu.M. Melevsky & E.G. Milevskyy (U.S.S.R.) - Solar thermoelectric generator.	No. 1
10.30-12.00	Ladies: Visit to Arts Centre.	
10.45-11.15	Morning tea.	Supper Room
11.15-12.45	SUBJECT 4: COMMERCIAL USES OF SOLAR ENERGY WATER HEATERS, AIR HEATERS, SOLAR CELLS, ETC. Session 4a: Chairman - F. Daniels. 23 K.G.T. Hollands & R.V. Dunkle (Aust.) - Concentrator for thin-film solar cells. 22 E. Kizura & Y. Haba (Japan) - Silicon solar cell power equipments. 3 M. Kobayashi & Y. Kano (Japan) - Improvement of silicon solar cell power equipments.	No. 1
11.15-12.45	Session 7b: Chairman - V.A. Baum. 64 E.A. Farber (U.S.A.) - Supercharged solar hot air engine. 14 K.L. Sharma (India) - Solar hot air engine. 63 O. Lalude & H. Buchberg (U.S.A.) - Honeycomb-porous bed solar air heaters. 62 D.K. Edwards & M.M. Sun (U.S.A.) - Natural convection in rectangular honeycomb structures.	No. 2
12.45-2.00	Lunch (available in Sciences Club).	
2.00-3.30	Session 4b: Chairman - F. Daniels. 77 R.K. Pillay (Malaysia) - Solar water heating in the tropics. 35 R.V. Dunkle & E.T. Davey (Aust.) - Flow distribution in solar absorber banks. 31 H.P. Garg (India) - Domestic solar water heaters in India. 29 J.C.V. Chinappa (Ceylon) - Pressurised solar water heater.	No. 1
2.00-3.30	Session 7c: Chairman - V.A. Baum. 32 M.K. Selcuk & G.T. Ward (Turkey & Canada) - Terrestrial solar power production, I & II. 66 W.A. Beckman (U.S.A.) - Solution of heat transfer problems on a digital computer. 17 C.M. Ambrose & P.C. Bandopadhyay (Aust. & Nepal) - Asymmetrical heating in non-circular ducts. 11 C.L. Gupta (India) - Dynamic performance of solar energy systems.	No. 2
3.30-4.00	Afternoon tea.	Supper Room

4.00-5.30	Session 4c: Chairman - F. Daniels. 71 E.T. Davey (Australia) - Solar water heating. 51 L.C. Wilson & F. Wickham (Australia) - Solar hot water systems. 48 A. Cheda & W.R.W. Reed (Aust.) - A rock pile thermal storage heating and cooling system. 27 H.B. Suhr (Chile) - Production of sodium sulphate with solar energy and waste heat.	No. 1
8.00-10.00	OPEN FORUM DISCUSSION ON CURRENT SOLAR ENERGY ACTIVITIES: Chairman - J.A. Duffie.	No. 1
10.00-10.30	Supper.	Supper Room
FRIDAY, 6TH MARCH		
SUBJECT 6: SOLAR ENERGY FOR BUILDING AND AGRICULTURE: AIR CONDITIONING, REFRIGERATION, ETC.		
9.15-10.45	Session 6a: Chairman - T. Noguchi. 59 F. Ha Ebi, Masuo Masuo & Ray Yin (Hurma) - Possibilities for solar ice-makers. 118 E.A. Farber (U.S.A.) - A compact solar refrigeration system. 114 R.K. Swartson & C. Swaminathan (Canada) - Solar-powered absorption refrigeration. 107 R.R. Sheridan (Australia) - Performance of the Brisbane solar house.	No. 1
10.45-11.15	Morning tea.	Supper Room
11.15-12.45	Session 6b: Chairman - J.A. Duffie. 116 J.P. Girardier & E. Mascon (Senegal) - Use of solar energy for lifting water. 76 H.D. Sharma (India) - Use of radiation absorbing materials for clearing snow. 65 J.D. Kalra (Australia) - Solar energy and water loss from an irrigated orange plantation.	No. 1
11.15-12.45	SUBJECT 8: HIGH TEMPERATURE PROCESSES. Session 8: Chairman - A.A. Delyannis. 110 T. Noguchi (Japan) - High temperature X-ray diffractometry with a solar furnace. 4 T. Sakurai, O. Kamada & T. Takizawa (Japan) - High temperature X-ray diffractometer using a solar furnace. 109 F. Afzal & J.E. Giannousis (Pakistan & Australia) - Electrical conductivity at high temperatures using a solar furnace. 9 J.P. Courtes & M. Focx (France) - Solar furnace for the study of reactions between gas and molten products. 10 M. Hoes & R. Focx (France) - Remarks concerning solar furnaces in space.	No. 2
12.45-2.00	Farewell Luncheon (with Ladies).	Sciences Club
2.00	Ladies: Function to be arranged.	
2.00-3.30	SUBJECT 2: SOLAR ENERGY FOR DEVELOPING COUNTRIES. Session 2a: Chairman - J.R. Hixschmann. 28 Mian Masood Ameer (Pakistan) - Silicon solar cells for lighting in rural areas of Pakistan. 19 P.P. Kokkalis (Greece) - Three solar distillation units in Greece. 73 I. Taniguchi (Japan) - Commercial solar water heaters in Japan. 18 E.D. Howe (U.S.A.) - Some comments on solar distillation.	No. 1

2.00-3.30	Session 6c: Chairman - T. Noguchi. 8 E.S. Ballantyne & J.V. Spencer (Aust.) - Shading coefficients for horizontal sunshades. 7 M.J. Woldridge (Australia) - Prediction of building shading patterns. 54 H.L. Chapman (Aust.) - Rock pile thermal storage heating and cooling system.	No. 2
3.30-4.00	Afternoon tea.	Supper Room
4.00-5.30	Session 1b: Chairman - J.R. Hixschmann. 42 H.J. Miller & J.A. Duffie (U.S.A.) - Economic-social implications of solar energy use. 108 W.R. Sheridan (Australia) - Criteria for justification of solar energy systems.	No. 1
Evening	Free.	
SATURDAY, 7TH MARCH		
9.30	Buses leave Park Royal Hotel for all-day visit to Hurlingham Peninsula, returning at approximately 7.00 p.m.	
Evening	Free.	
SUNDAY, 8TH MARCH, TO MONDAY, 16TH MARCH		
Post-Conference tour to Central Australia! Melbourne to Alice Springs via Griffith, Adelaide and Cober Pedy.		
SESSIONS ORGANIZER: D.J. Morris.		
SESSION ORGANIZERS:		
Subject 1 -	R.N. Morse.	
Subject 2 -	W.R. Sheridan, E.T. Davey.	
Subject 3 -	A.J. Drummond, D.J. Morris.	
Subject 4 -	J.T. Charnock.	
Subject 5 -	W.R.W. Reed.	
Subject 6 -	E.R. Ballantyne.	
Subject 7 -	C.L. Gupta.	
Subject 8 -	R.V. Dunkle.	

swc50.org

ISBN: 978-3-9820408-5-1