Applications for Solar Resource Products (Chapter 9)

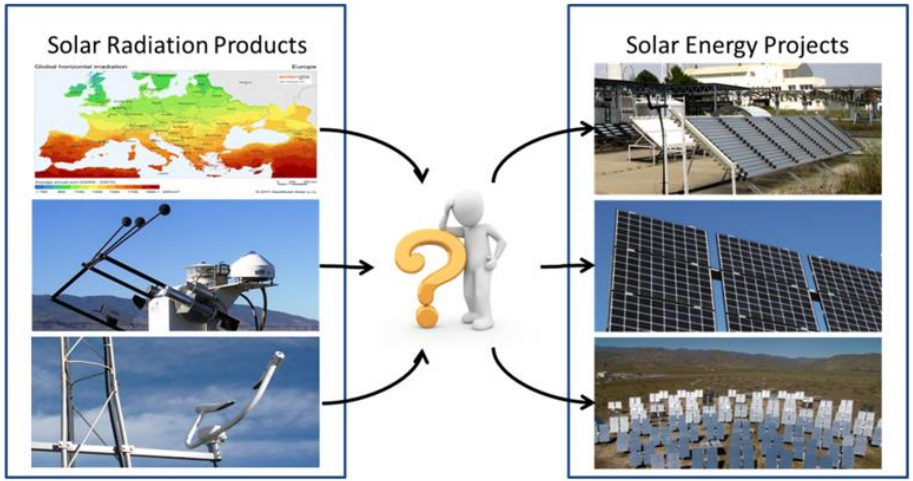
Robert Höller, Kristian Pagh Nielsen, Luis F. Zarzalejo, Janine Freeman, Chris Gueymard, Stefan Wilbert, Manuel Silva, Dave Renné, Lourdes Ramírez, David Spieldenner, Rafael Fritz, Mark Mehos, Richard Perez, and Aron Habte

ISES Webinar, February 18, 2021

Content

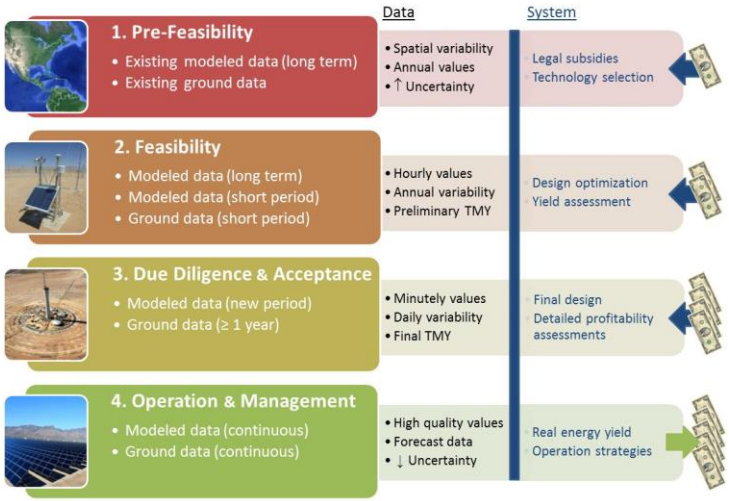
- Introduction
- Stages of a solar project
- Solar resource product matrix
- Applying Solar Resource Data to Selecting a Site
- Inter-annual variability
- Spatial variability of solar resource data
- Statistical assessment and probability of exceedance

Introduction



- The development of solar energy projects need different types of solar radiation products.
- « Solar Energy Projects » include photovoltaics (PV), solar thermal electricity, solar heating applications (central solar heating for district heating, local domestic heating and cooling), and water and air applications (desinfection, desalination, decontamination).

Four Stages of a Solar Power Plant Project



Purposes

- Site selection
- Yield Analysis
- Engineering
- Economical analysis
- Operational performance analysis

- During different stages of a solar project different input data are used.
- Different solar radiation products and evaluation methodologies that can be applied to solar energy projects are described

PVPS

Solar Resource Product Matrix

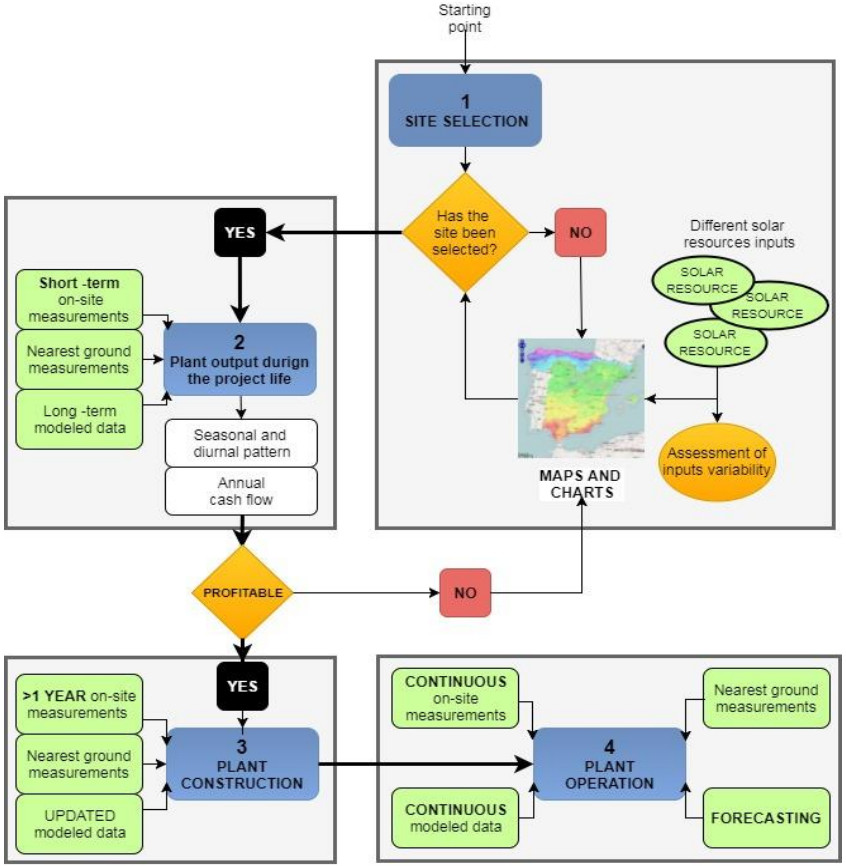
System Size

Project Phase

	Small	Medium	Large
1. Pre-feasibility & Planning	• Long-term averages • Monthly data • Solar cadastres / maps • Simple shading analysis	• TMY • Hourly data • Shading analysis	• Long-term satellite data • Hourly data
2. Feasibility			• Satellite data • Time series (>10 y) • Ground meas. (> 1 year) • Shading analysis • Further site and technology- specific meteo. parameters (e.g. albedo, soiling)
2. Due diligence & Finance		• Satellite data • Time series (>10 y) • Minute data • Shading • Further site and technology-specific meteo. parameters (e.g. albedo, soiling)	• Satellite data • Time series (>10 y) • Ground meas. (> 1 year) • Minute data • Shading analysis • Further site and technology- specific meteo. parameters (e.g. albedo, soiling)
3. Operation & Maintenance	• Simple monitoring	• Local measurements • Forecasts	• Local measurements • Forecasts

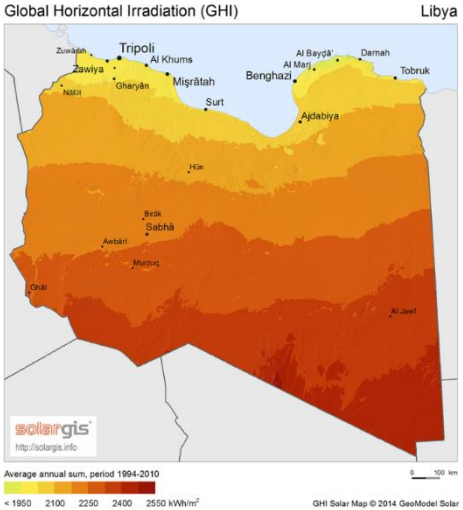
PVPS

Flowchart of Solar Radiation Data Needs

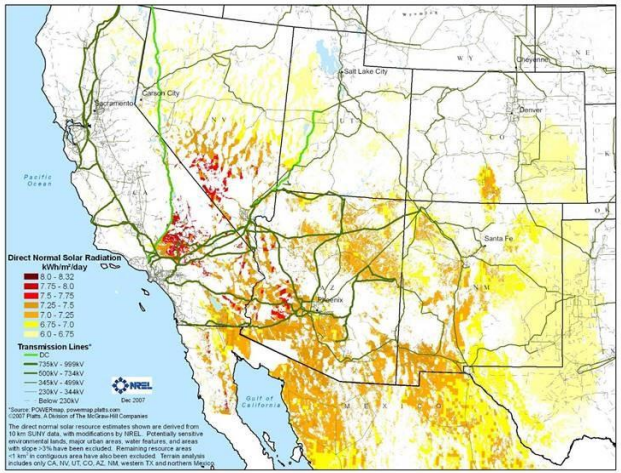


PVPS

Applying Solar Resource Data to Selecting a Site



GHI map of Libya

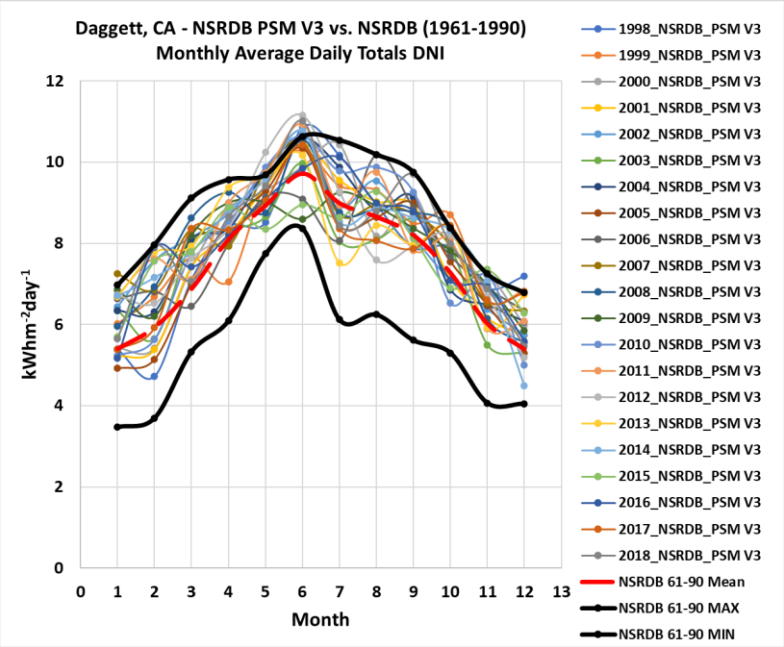


GIS analysis for available site selection using direct normal irradiance (DNI) resource, land use, and 3% terrain slope for the south-west of the United States.

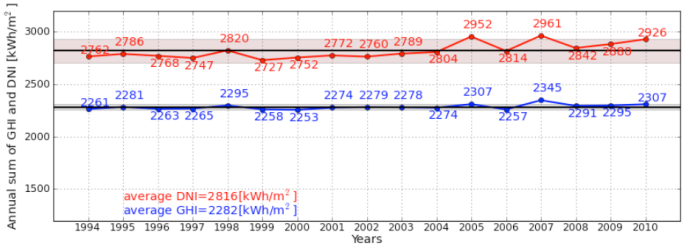
- For site selection historical solar resource data sets are generally used
- Often in the form of maps or from publicly available or commercial gridded data

PVPS

Inter-annual Variability of Solar Resource Data



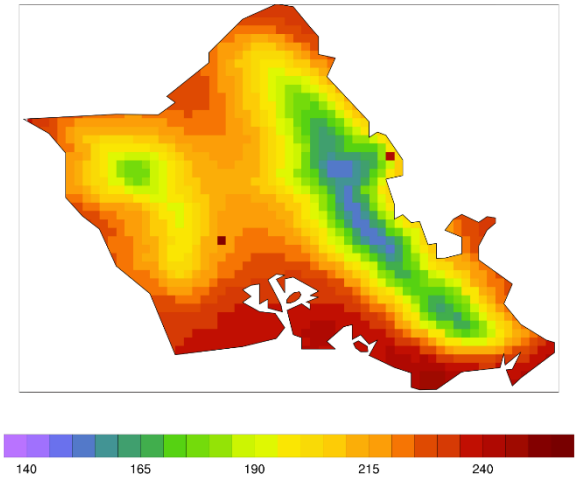
Example of direct-beam monthly average daily total (kWh/m²) inter-annual and seasonal variability from 1961–2018 in Daggett, California (Image by NREL).



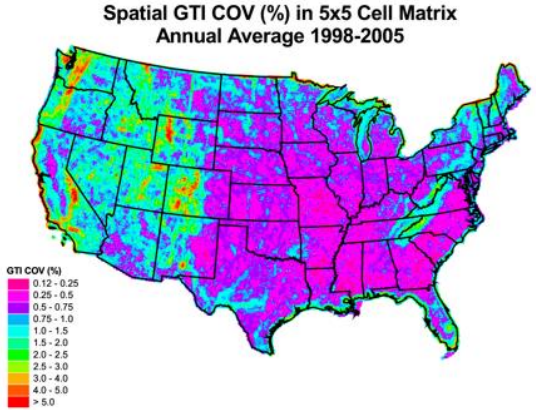
Annual sum of GHI and DNI (kWh/m²) in the 1994-2010 period, including average and standard deviation for a site in Uppington, South Africa (Source: SolarGIS).

PVPS

Spatial Variability of Solar Resource Data



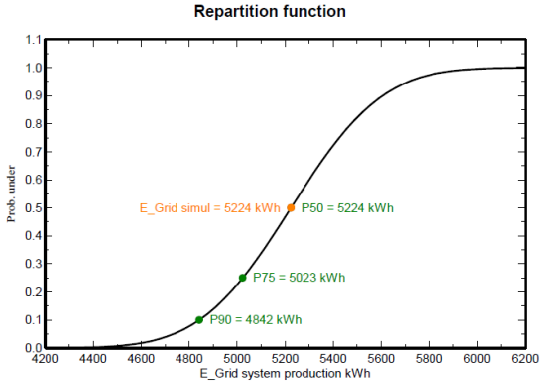
Example of microclimatic spatial variability for the Island of Oahu. The 1-km high-resolution map displays mean hourly GHI in W/m². (Image from SolarAnywhere V3.0)

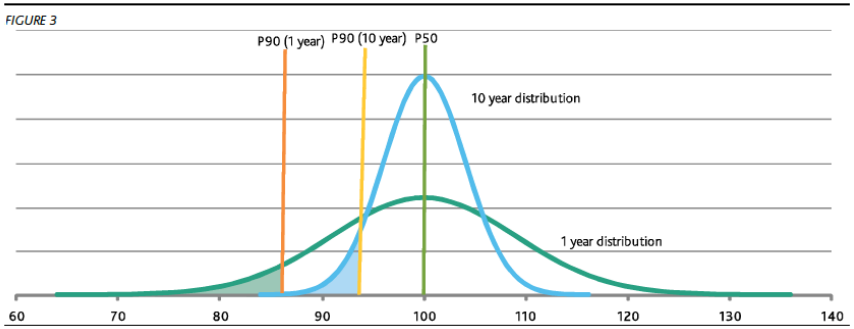


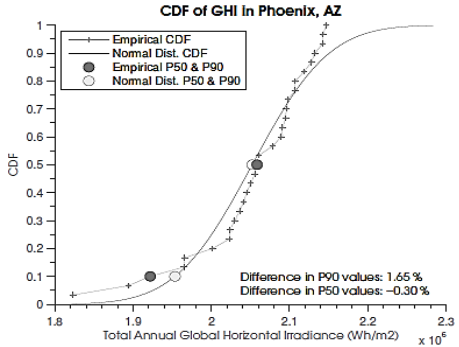
Spatial variability of GTI over the continental United States in terms of percent coefficient of variation (COV). (Image by NREL)

PVPS

Statistical Assessment and Probability of Exceedance



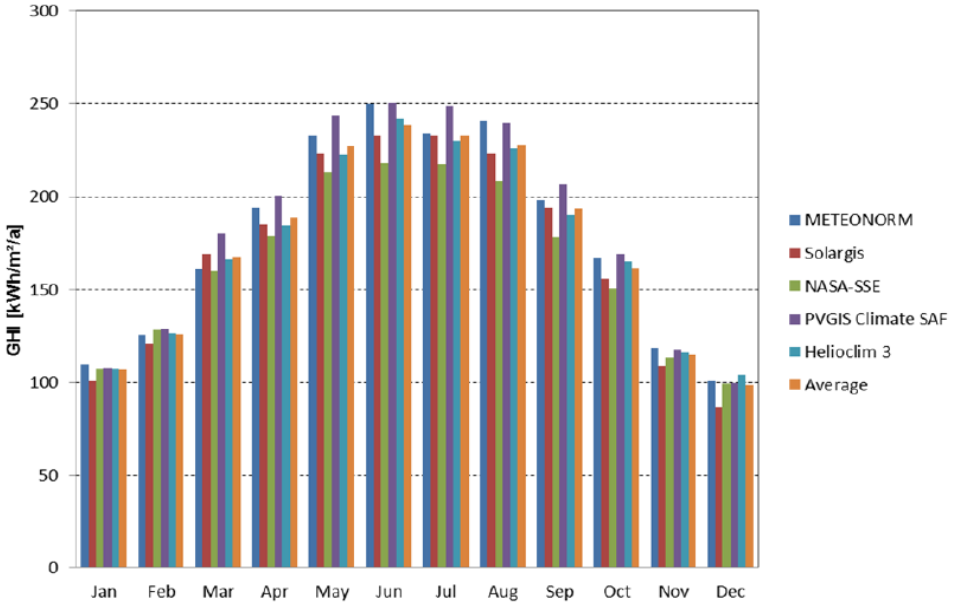




- Uncertainty of the long-term estimates of the mean annual GHI or DNI values is commonly addressed by calculating the annual probability of exceedance (PoE), also denoted by “Pxx”.
- With only 1 year of data, the uncertainty of the value of the true long-term mean is much higher than with 10 years of data (Source: Moody’s Investors Services, 2010)
- Statistically based estimations of the PoE values depends on the assumed probability distribution.

PVPS

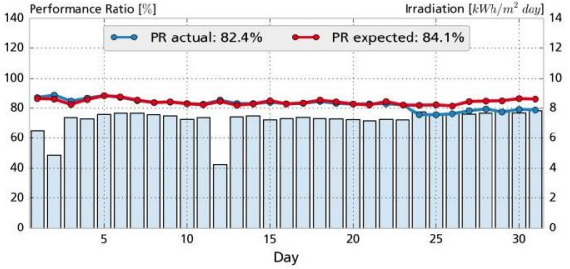
Comparison of GHI data sources



- Using several data sources gives additional security in the long assessment of solar resource data.
- The P50, P75, P90 etc. solar resource data of different sources can be used, depending on the application.

Solar resource data for plant operations

- Real-time monitoring of meteorological conditions at the system's location is important to:
  - Evaluate a performance guarantee (acceptance testing), comparing expected PR with actual PR.
  - Assess the power plant performance to improve yield predictions and gain knowledge toward improvements in future plants
  - Identify conditions of poor performance, including evidence of soiling, shading, hardware malfunction, or degradation, which might lead to warranty replacement, etc.
- In all cases, data from on-site measurements of the solar resource are necessary.
- Small PV systems often do not have on-site radiation measurements. In such cases commercial solar resource data can be applied.



PVPS

Thank you

Dr. Robert Höller (University of Applied Sciences Upper Austria) – IEA PVPS Task 16