Firm Power Generation for 100% Renewable Power Grids

Richard Perez, University at Albany

ISES Webinar

IEA PVPS Task 16: Firm PV Power

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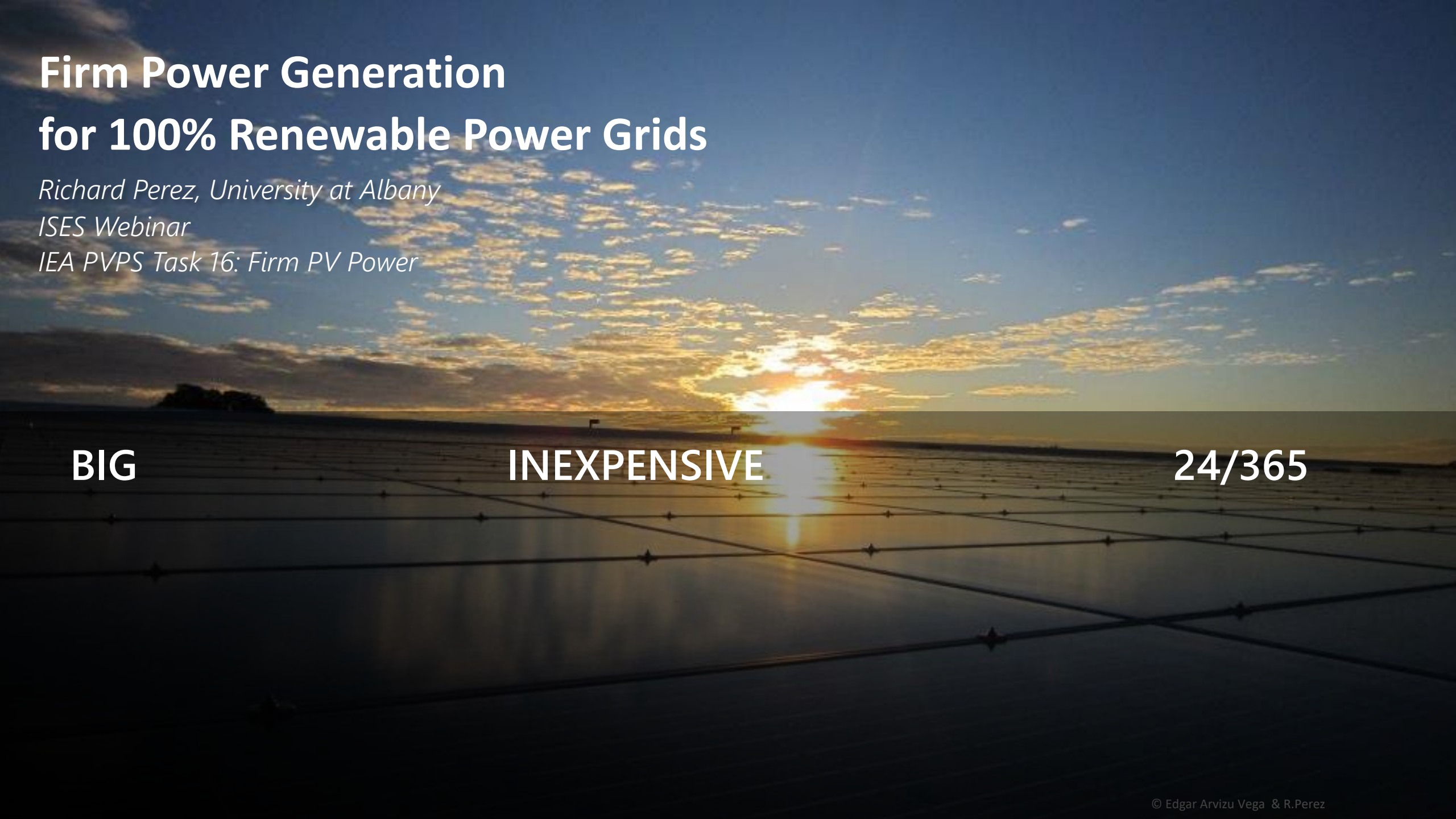
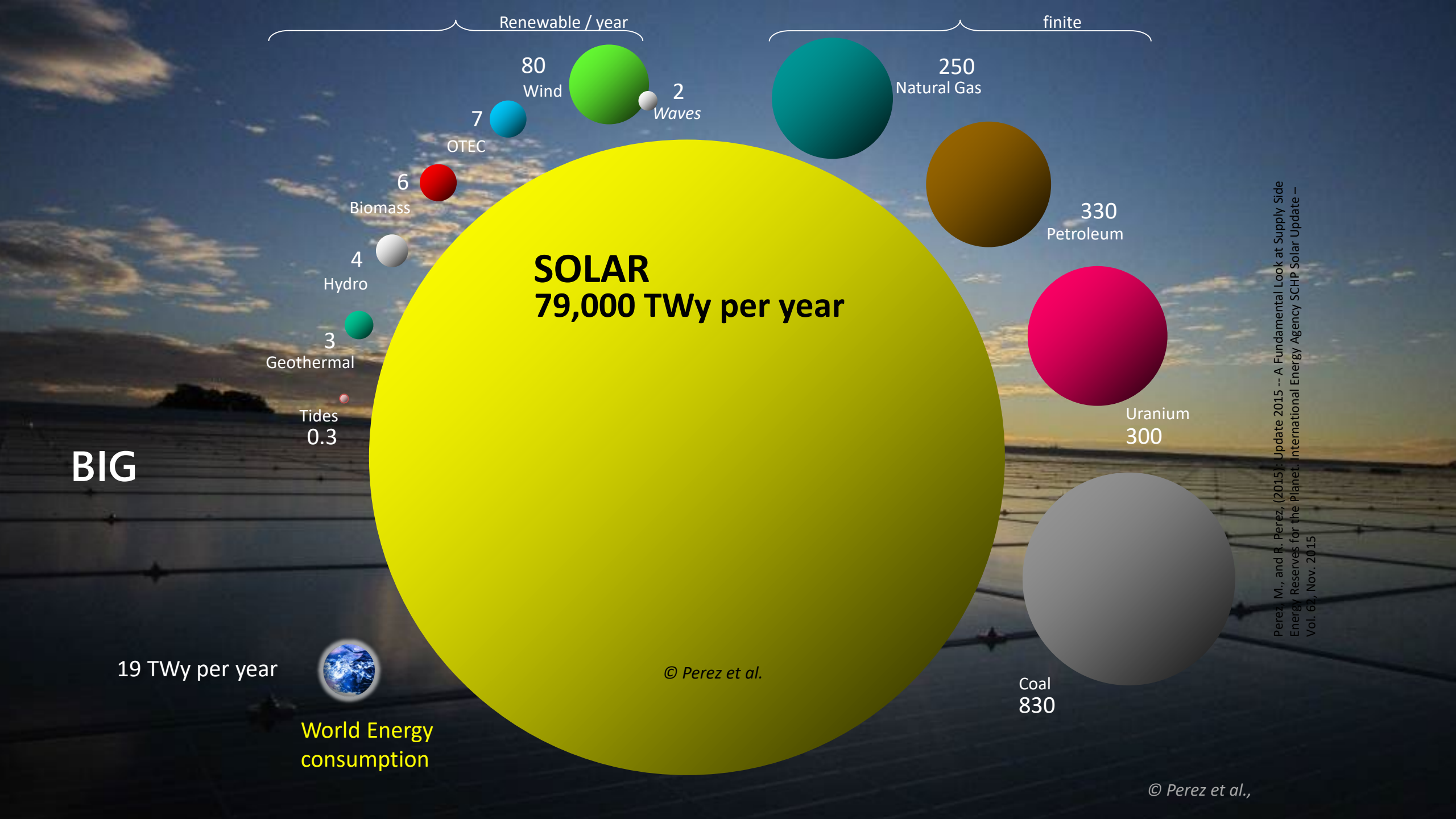
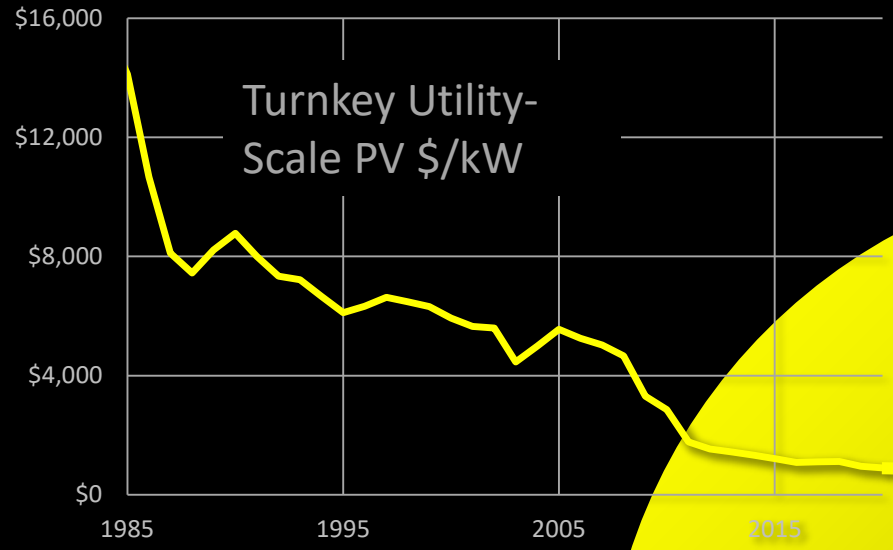
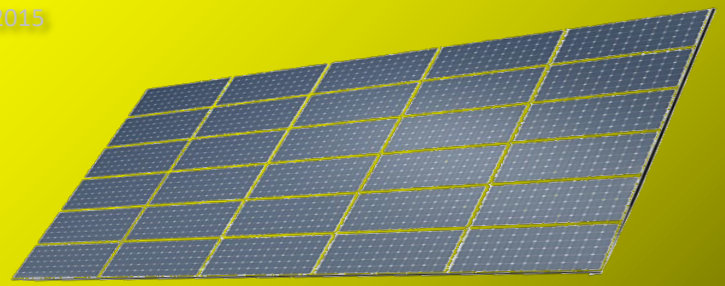



Renewable / year
finite
80
Wind
2
Waves
7
OTEC
6
Biomass
4
Hydro
3
Geothermal
Tides
0.3
250
Natural Gas
330
Petroleum
Uranium
300
Coal
830
SOLAR
79,000 TWy per year
© Perez et al.
BIG
19 TWy per year
World Energy
consumption
Perez, M., and R. Perez, (2015): Update 2015 -- A Fundamental Look at Supply Side Energy Reserves for the Planet. International Energy Agency SCHP Solar Update – Vol. 62, Nov. 2015
© Perez et al.,



BIG EXPENSIVE



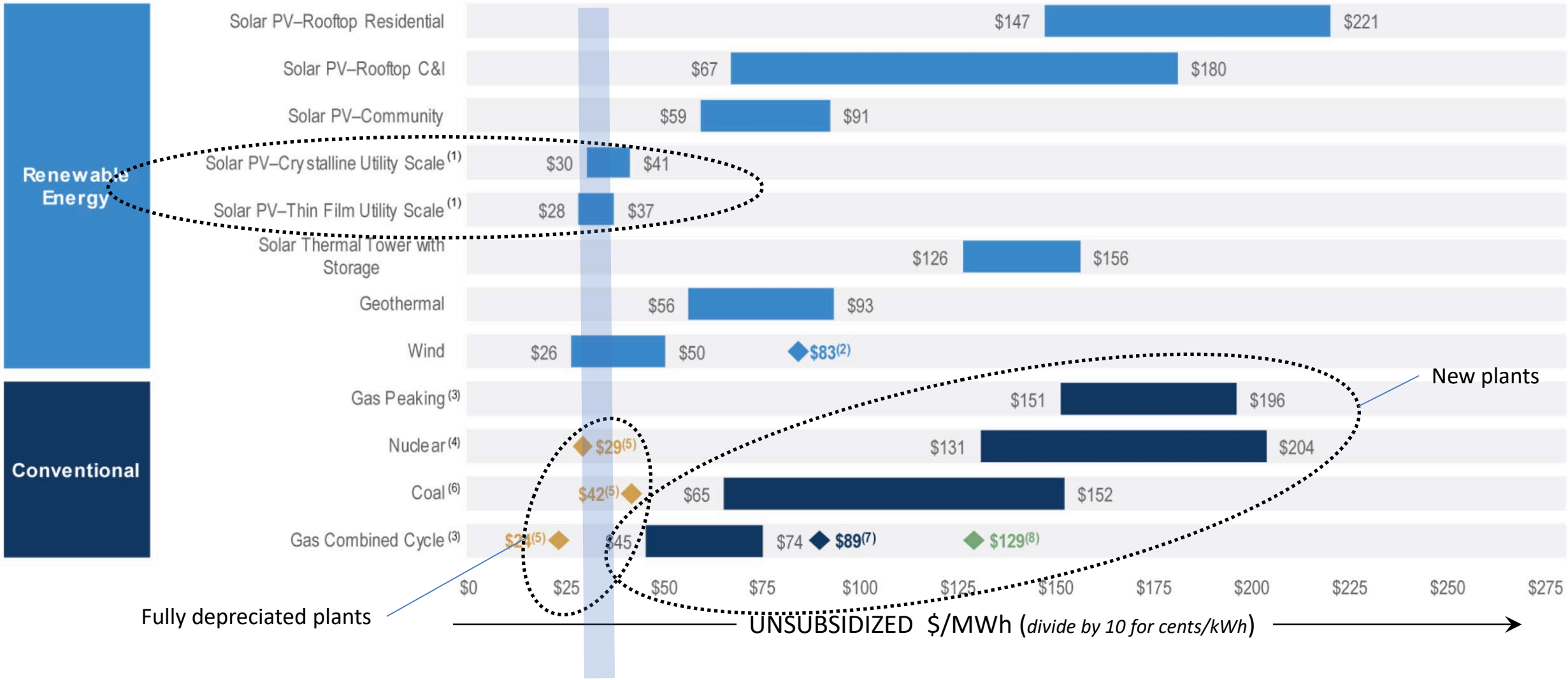
Photovoltaic power generation

Lazard's Levelized Cost of Energy Analysis, Version 14.0

2021

Levelized Cost of Energy Comparison—Unsubsidized Analysis

Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances

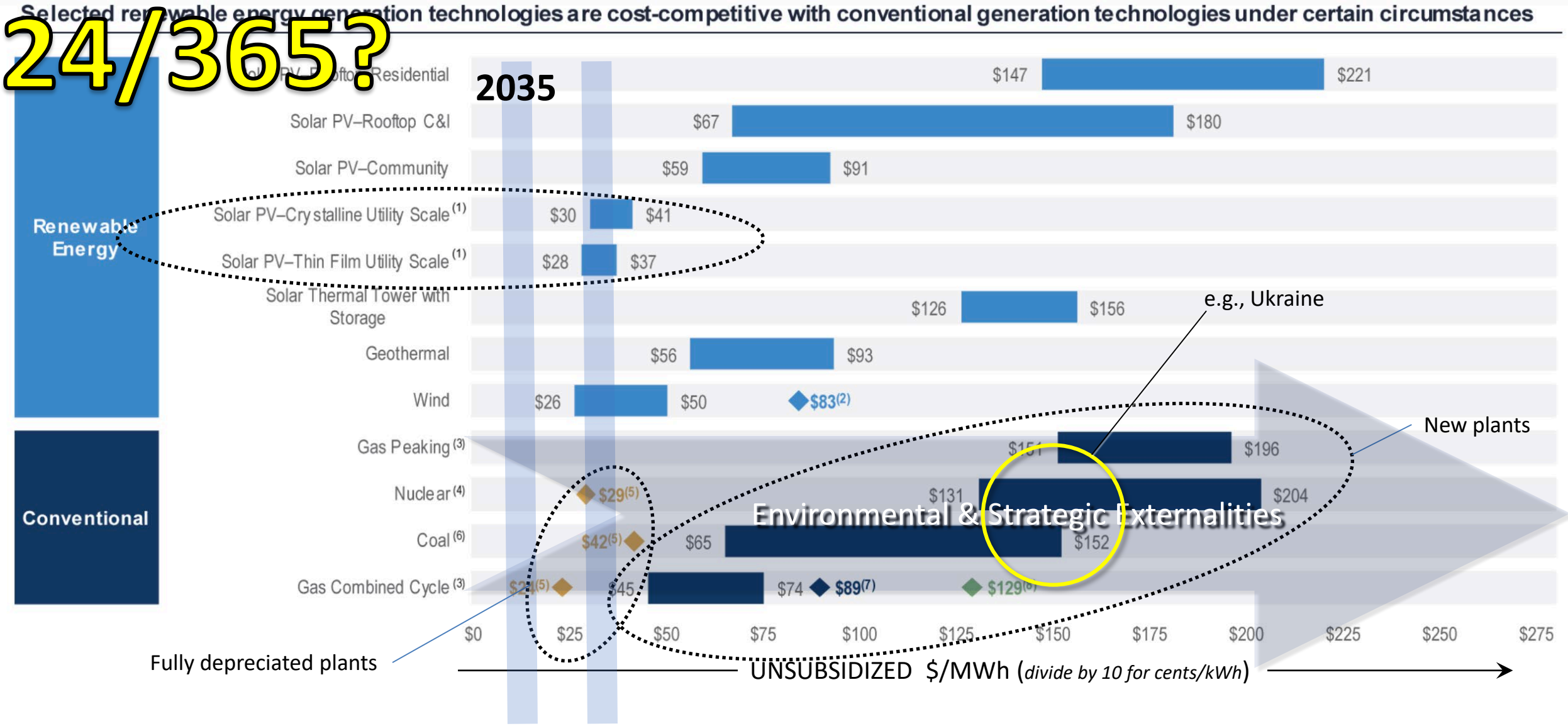


Lazard's Levelized Cost of Energy Analysis, Version 14.0

2021

Levelized Cost of Energy Comparison—Unsubsidized Analysis

24/365?



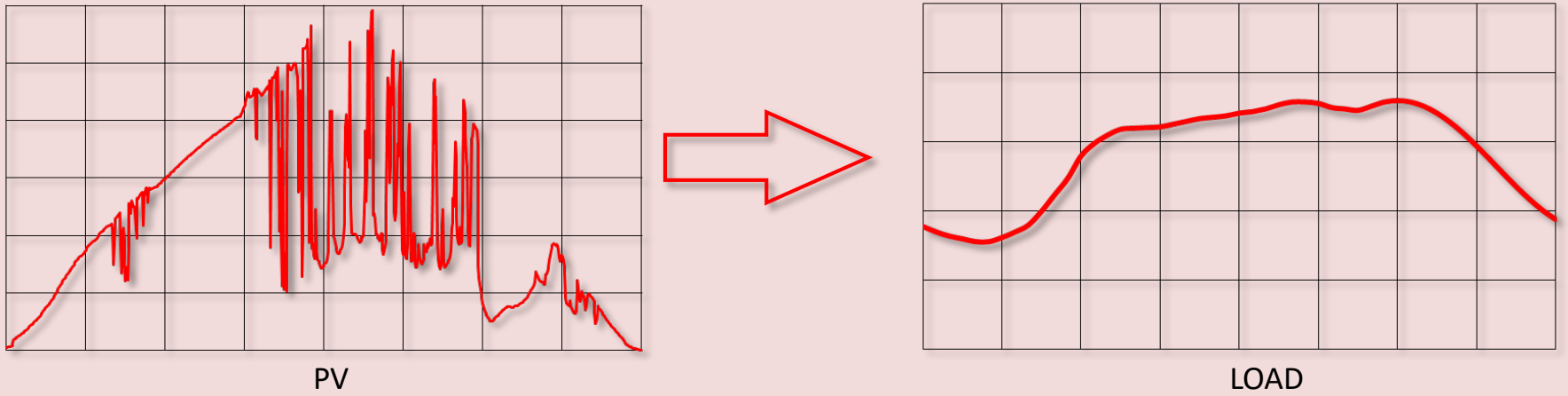
24/365?

INTERMITTENT MARGINAL RESOURCE

FIRM/DISPATCHABLE

24/365?

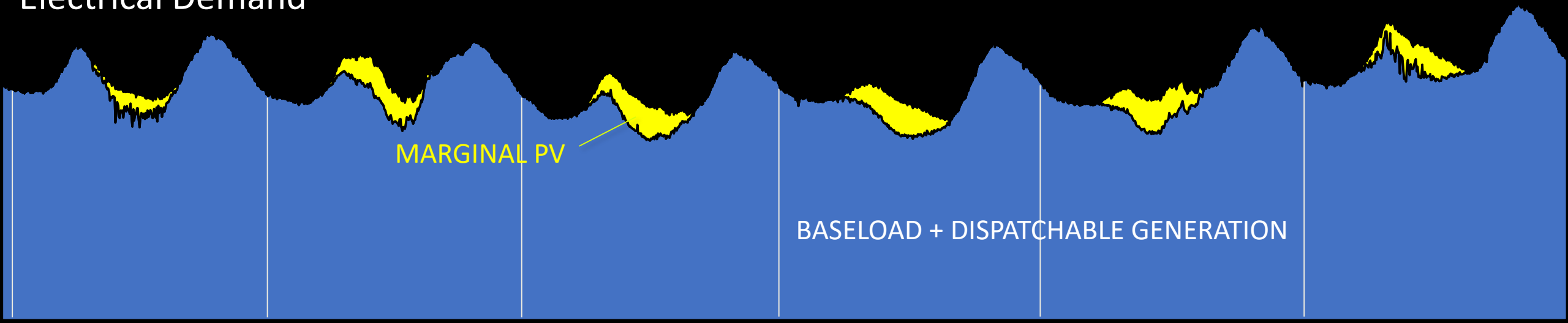
Electrical Demand

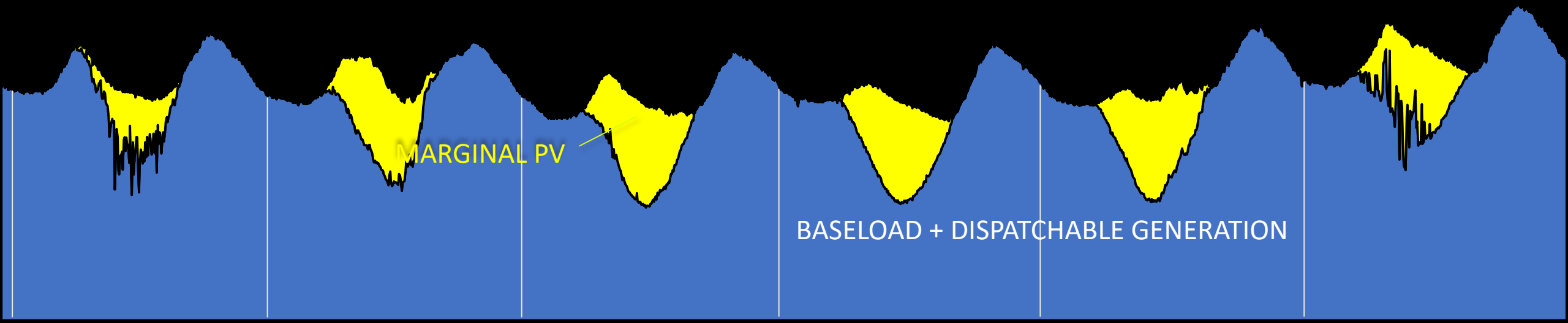


INTERMITTENT MARGINAL RESOURCE

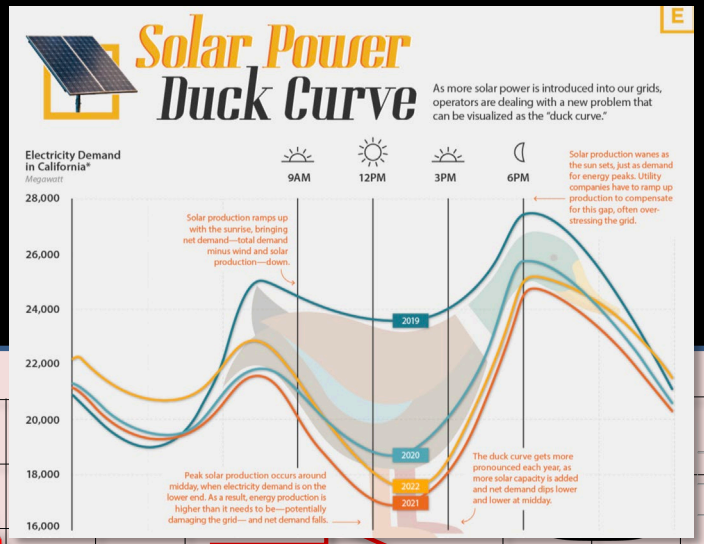
FIRM/DISPATCHABLE

Electrical Demand





INTRADAY



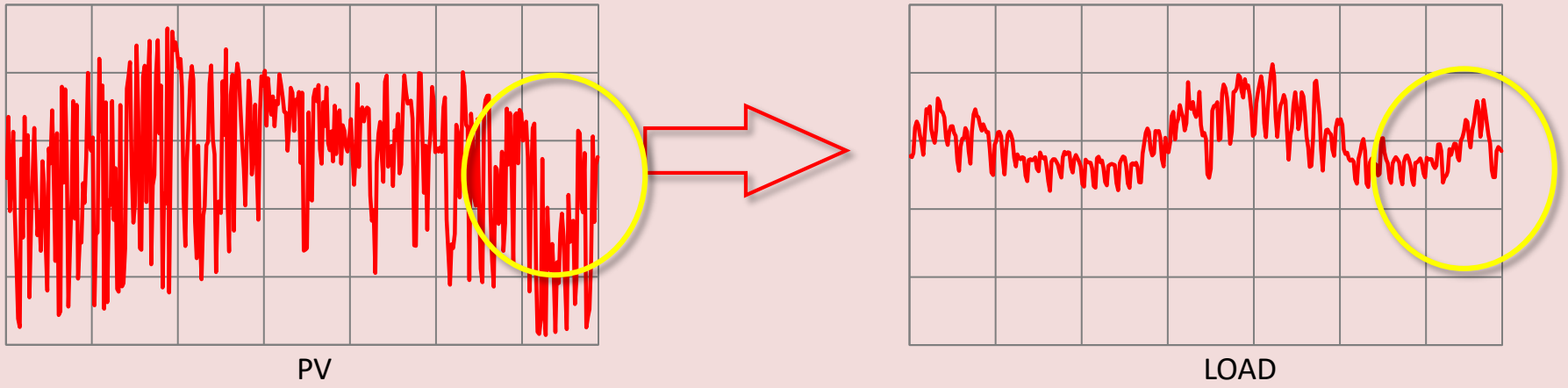
PV

LOAD

INTERMITTENT

FIRM/DISPATCHABLE

MULTI-DAY SEASONAL

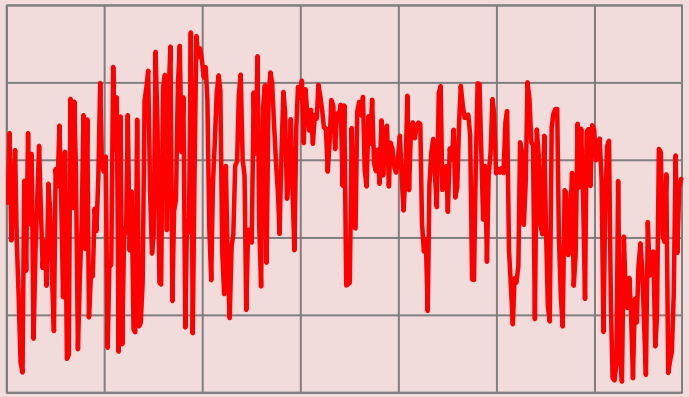


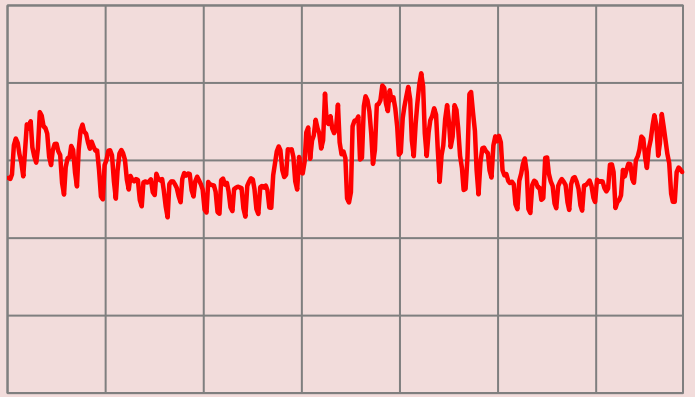
INTERMITTENT

FIRM/DISPATCHABLE

24/365?

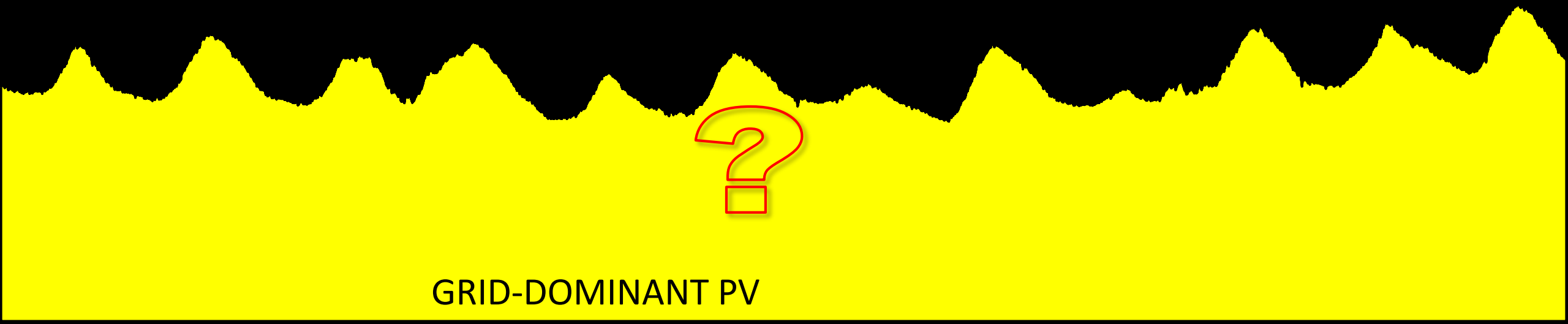
MULTI-DAY SEASONAL





INTERMITTENT

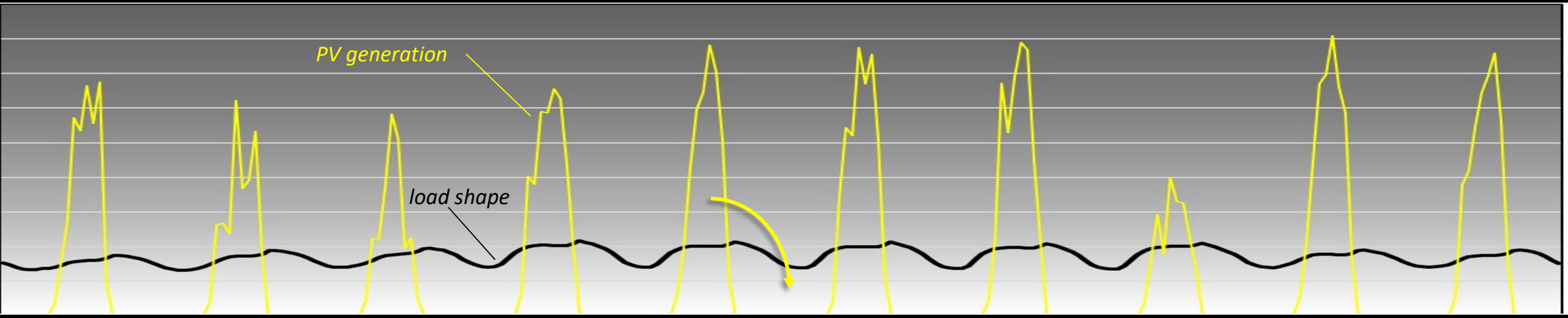
FIRM/DISPATCHABLE



GRID-DOMINANT PV

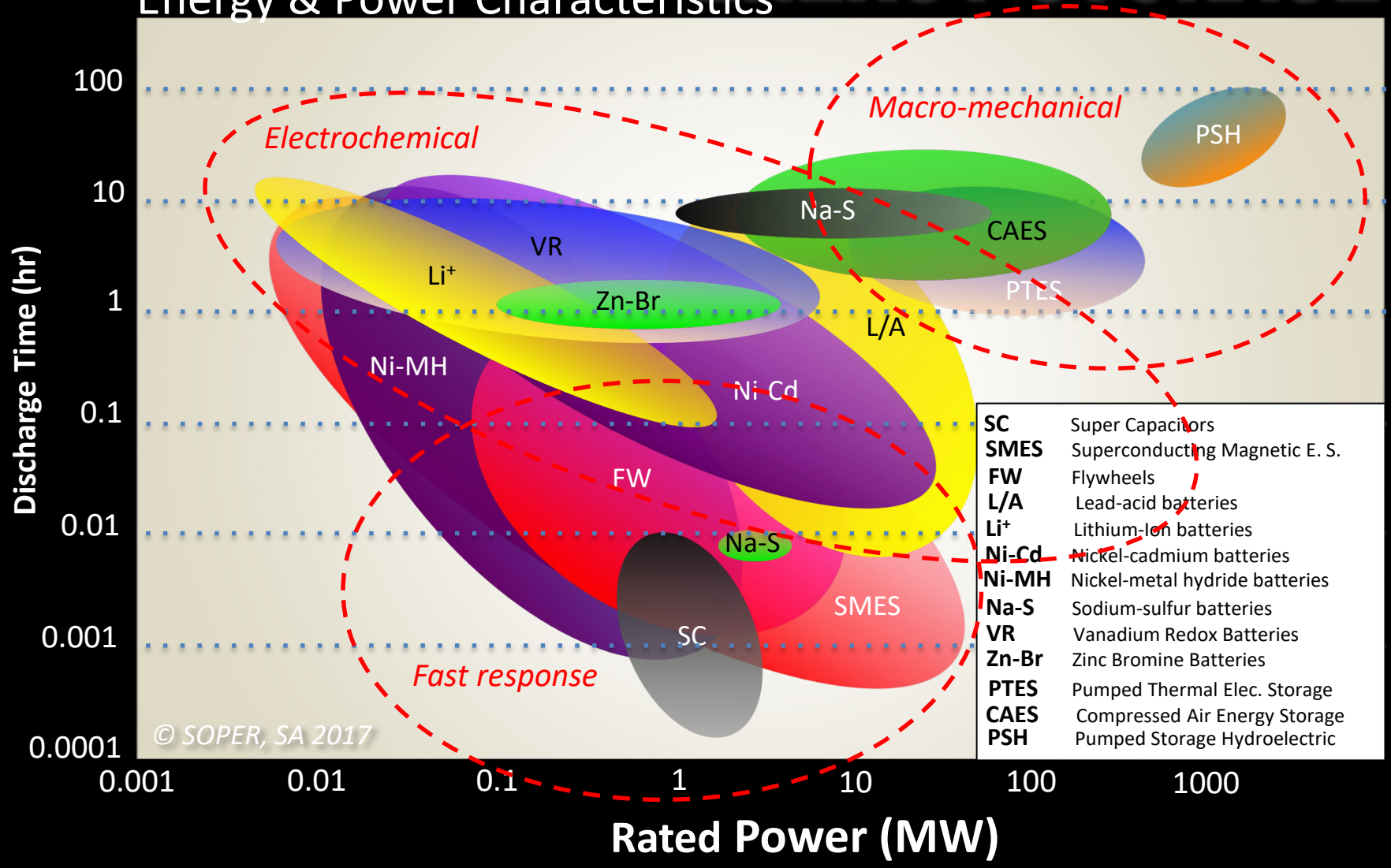
ENERGY STORAGE

Transform PV into load shape



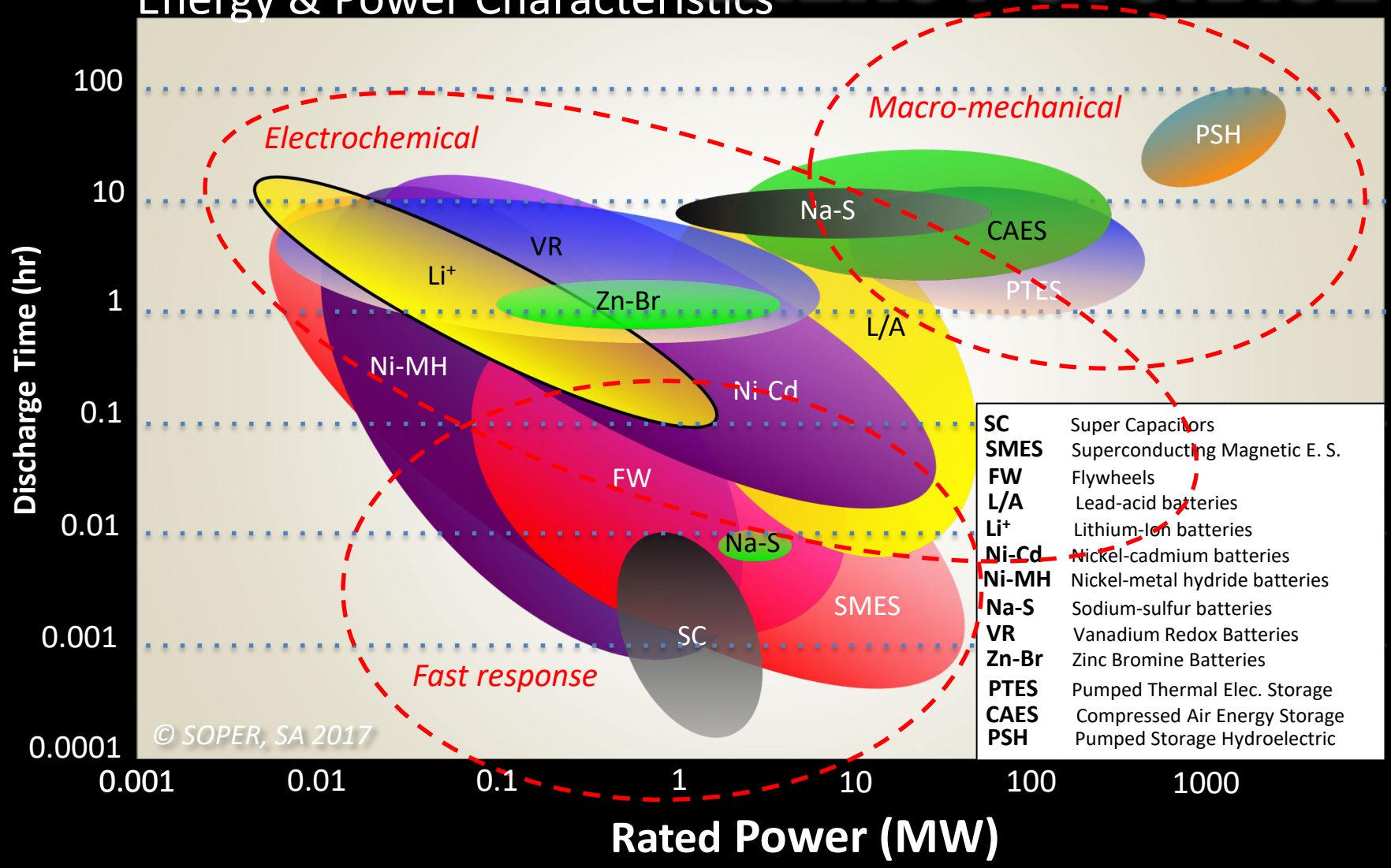
ENERGY STORAGE

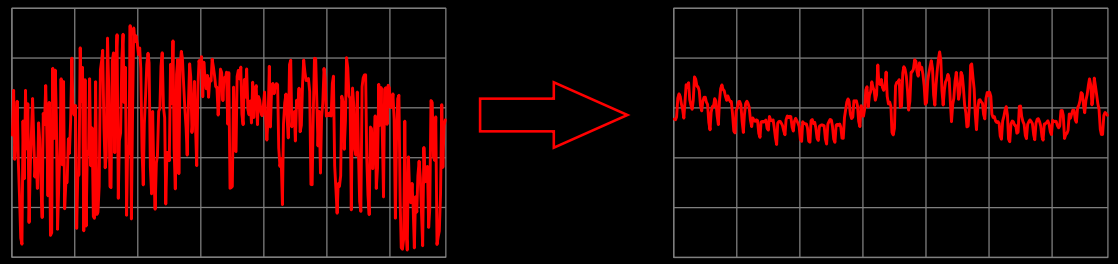
Energy & Power Characteristics



ENERGY STORAGE

Energy & Power Characteristics





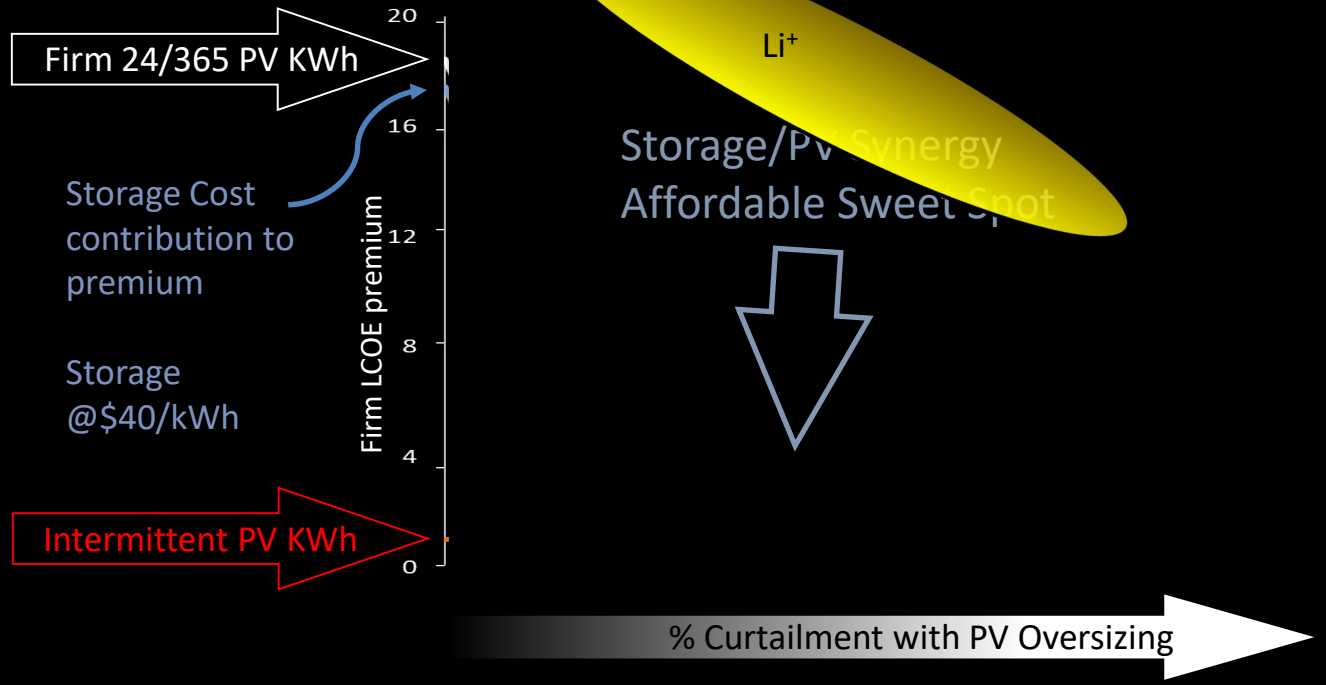
INTERMITTENT

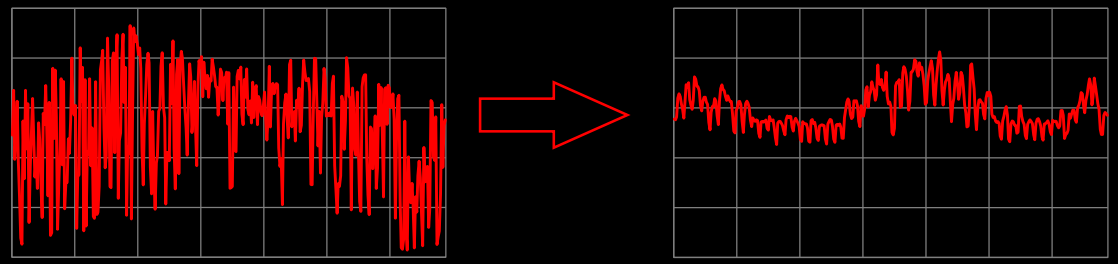
FIRM/DISPATCHABLE

ENERGY STORAGE

+ OVERBUILD SOLAR & CURTAIL

IMPLICIT STORAGE





INTERMITTENT

FIRM/DISPATCHABLE

ENERGY STORAGE

+ OVERBUILD SOLAR & CURTAIL

IMPLICIT STORAGE ***NOT MONETIZABLE TODAY***

QUARTZ

Solar energy is so cheap that it ~~can~~ must be wasted

More energy than we know what to do with.

By **Michael J. Coren**
Climate reporter

SWITZERLAND

MISO

Midcontinent System Operator

WECC

Western Electricity Coordinating Council

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