

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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BIG

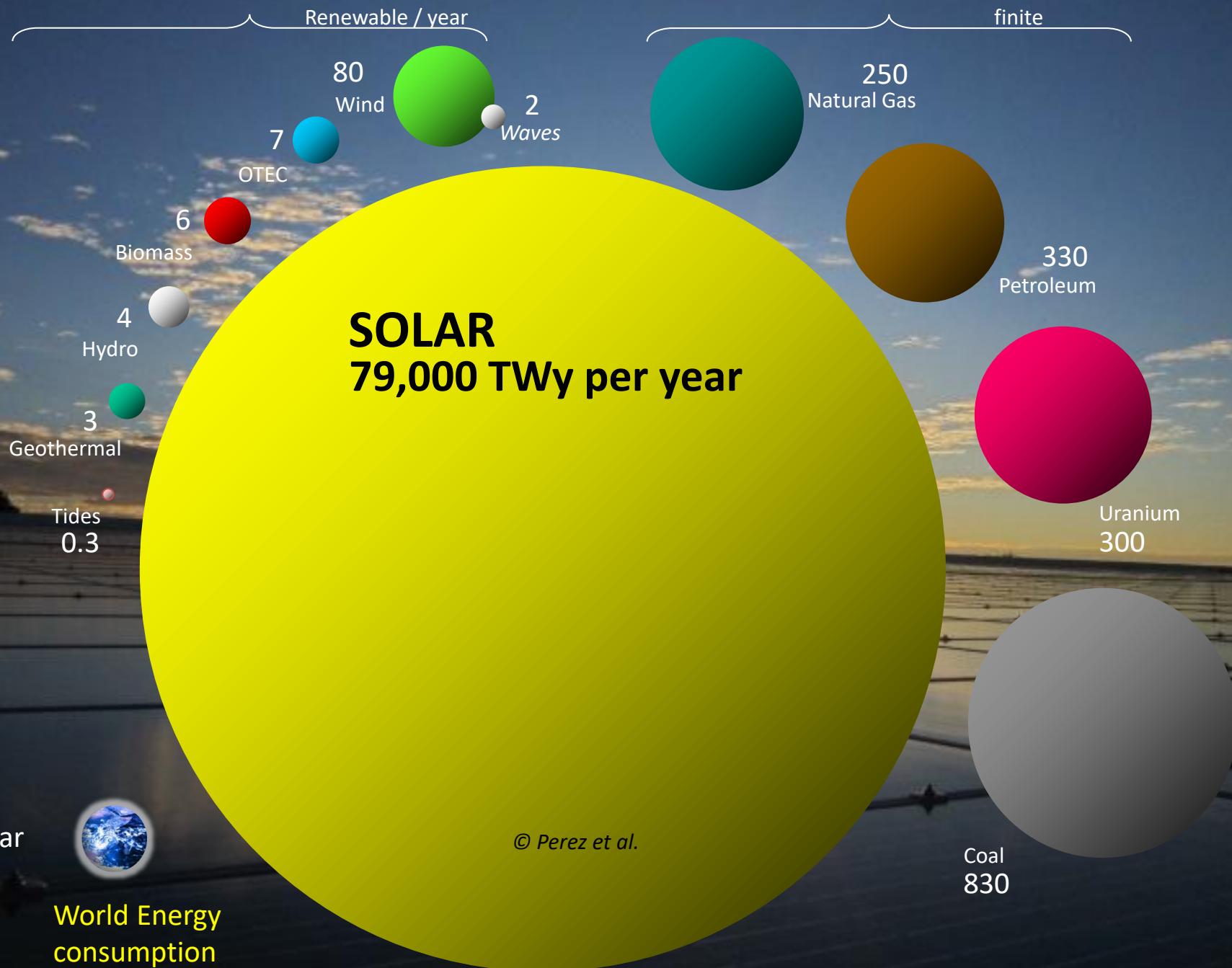
INEXPENSIVE

24/365

BIG

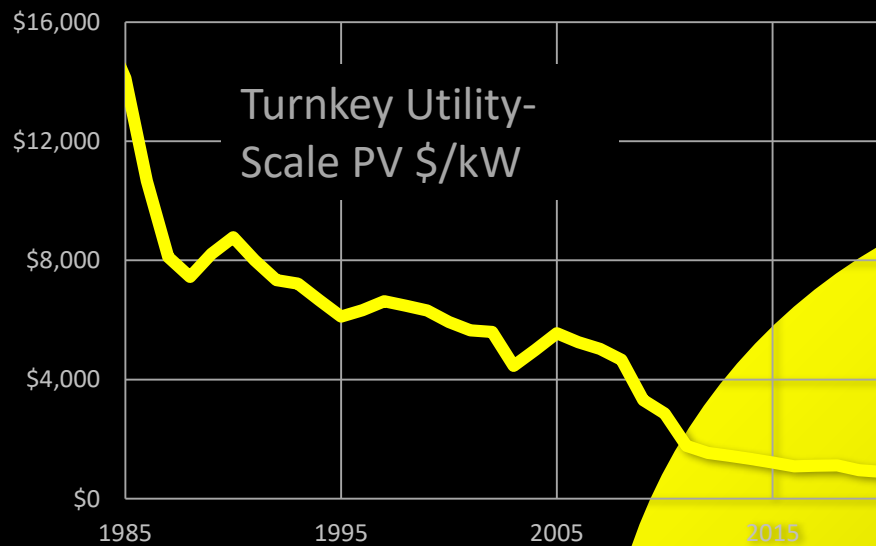
19 TWy per year

World Energy
consumption

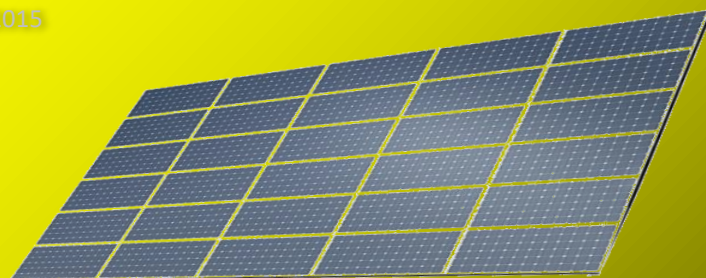


Perez, M., and R. Perez, (2015) : Update 2015 -- A Fundamental Look at Supply Side Energy Reserves for the Planet. International Energy Agency SChP Solar Update -- Vol. 63, Nov. 2015

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EXPENSIVE



Photovoltaic power generation



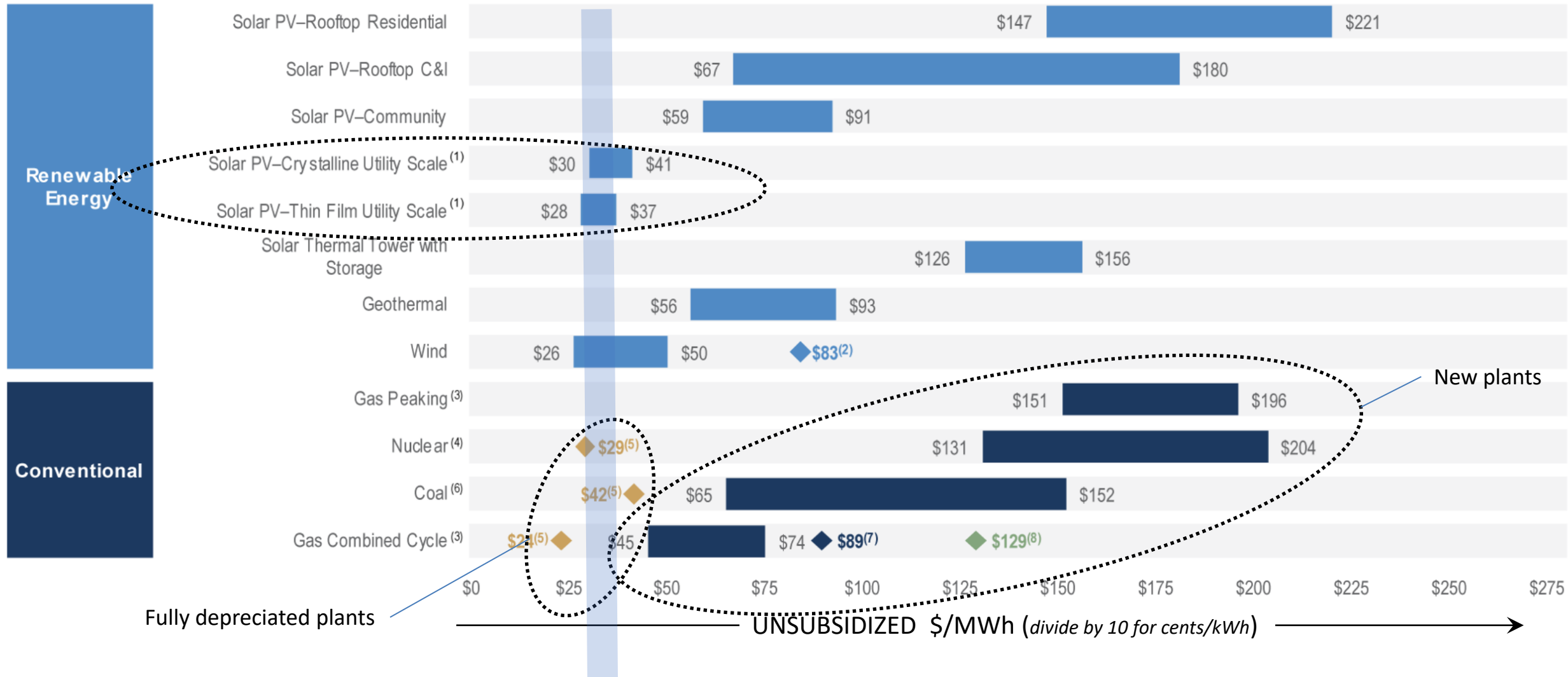
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Lazard's Levelized Cost of Energy Analysis, Version 14.0

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

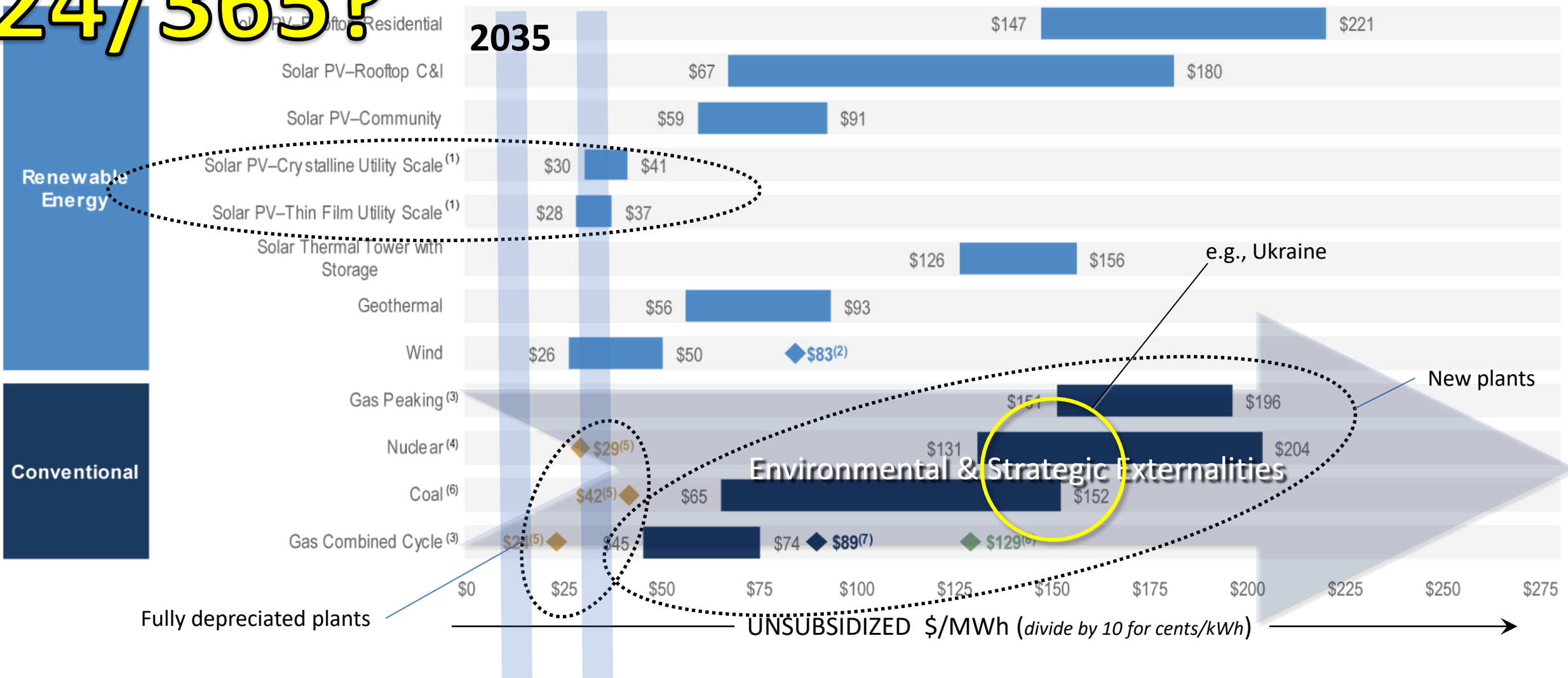
2021

Levelized Cost of Energy Comparison—Unsubsidized Analysis

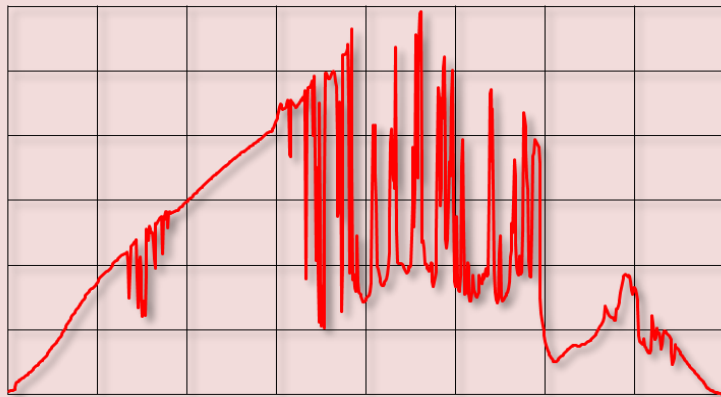
Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances

24/365?

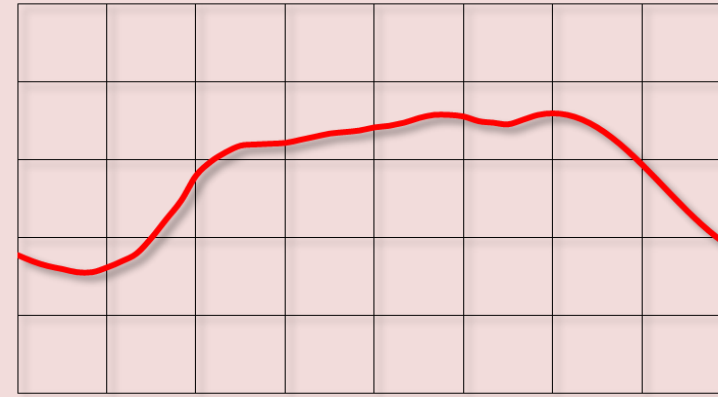
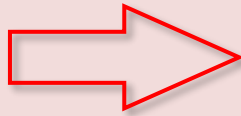
2035



24/365?



PV



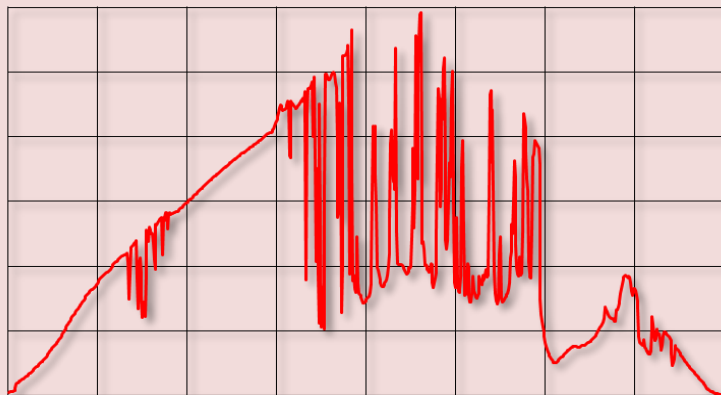
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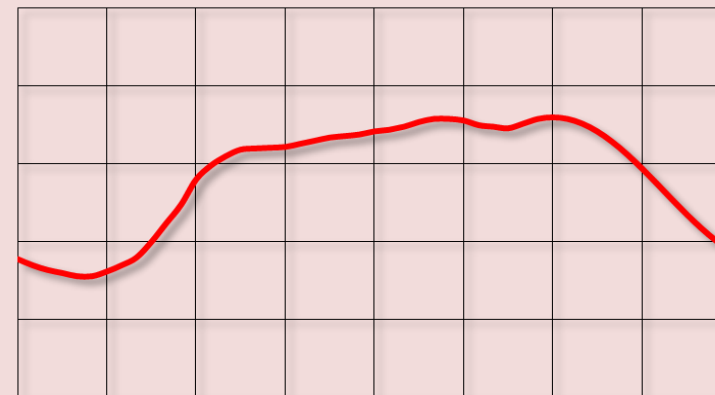
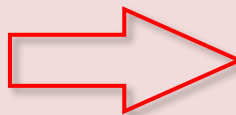
FIRM/DISPATCHABLE

24/365?

Electrical Demand



PV

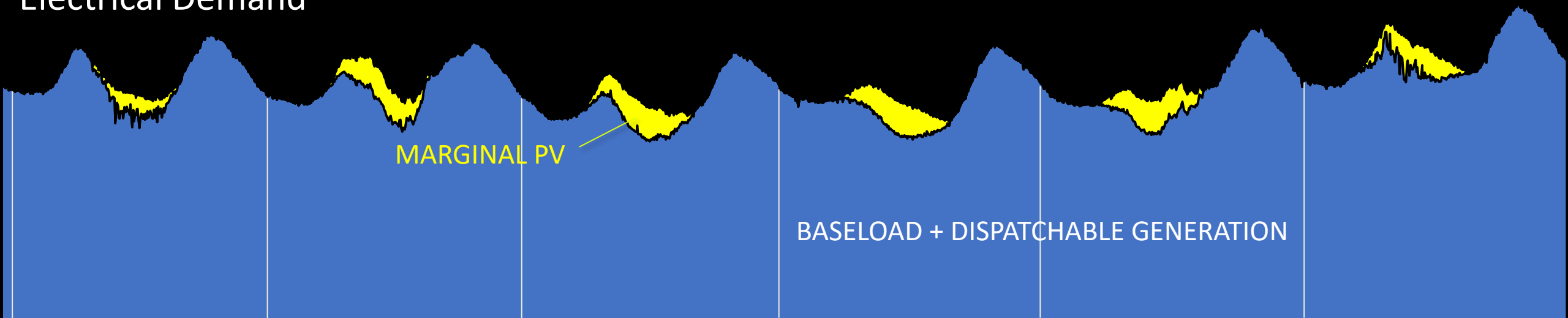


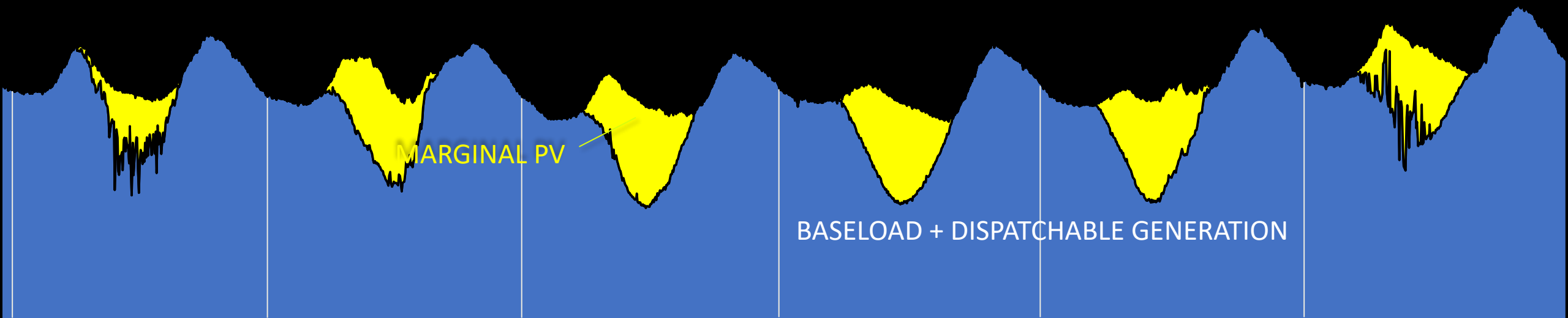
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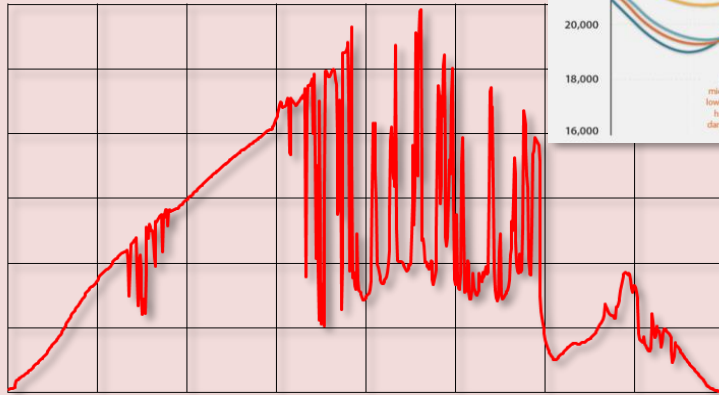
FIRM/DISPATCHABLE

Electrical Demand

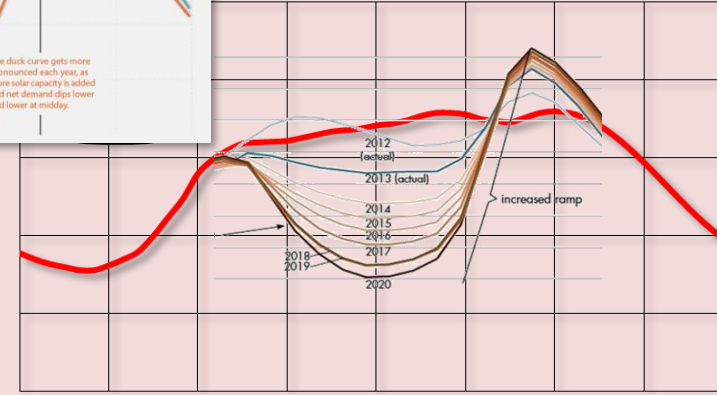
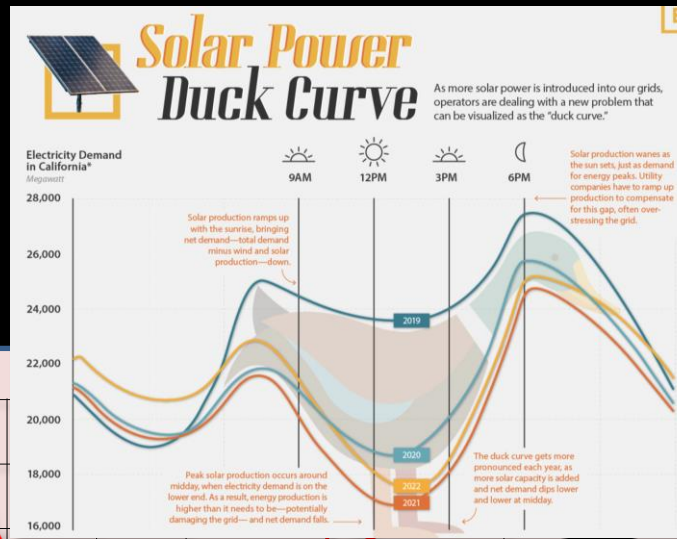




INTRADAY



PV

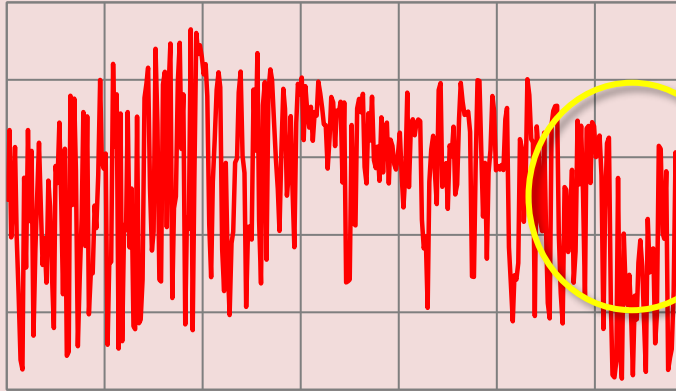


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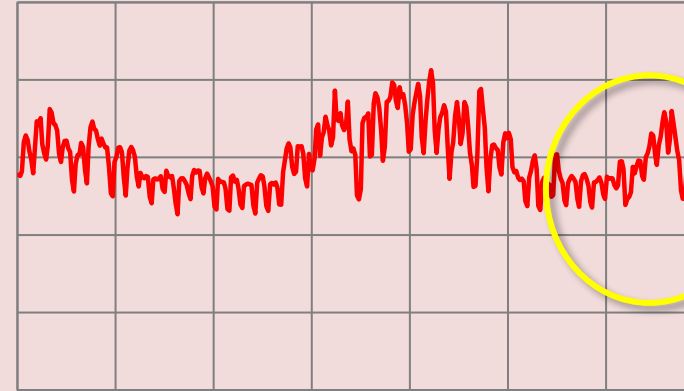
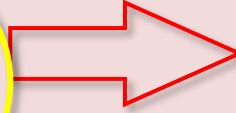
INTERMITTENT

FIRM/DISPATCHABLE

**MULTI-DAY
SEASONAL**



PV



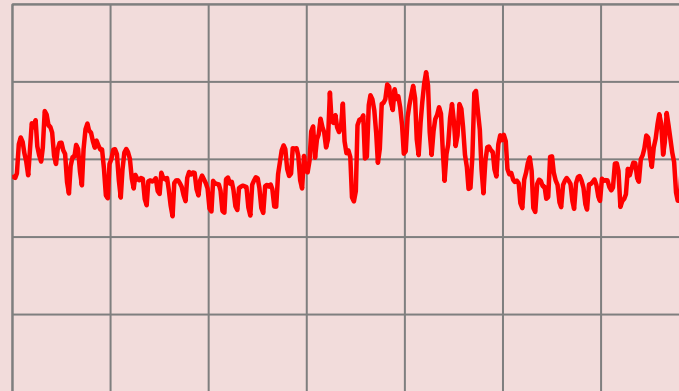
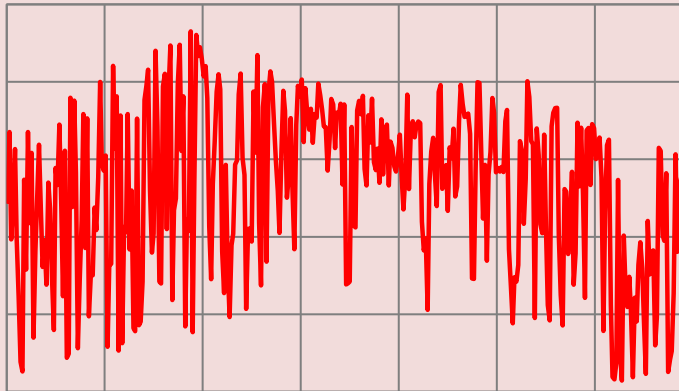
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INTERMITTENT

FIRM/DISPATCHABLE

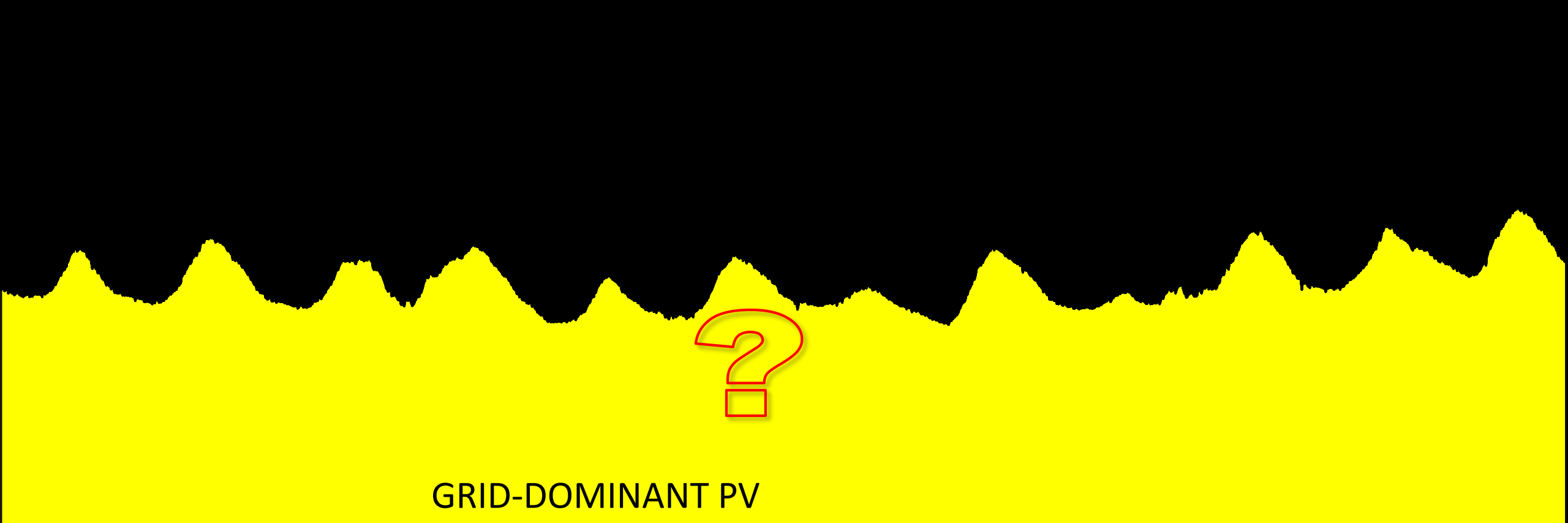
24/365?

MULTI-DAY
SEASONAL



INTERMITTENT

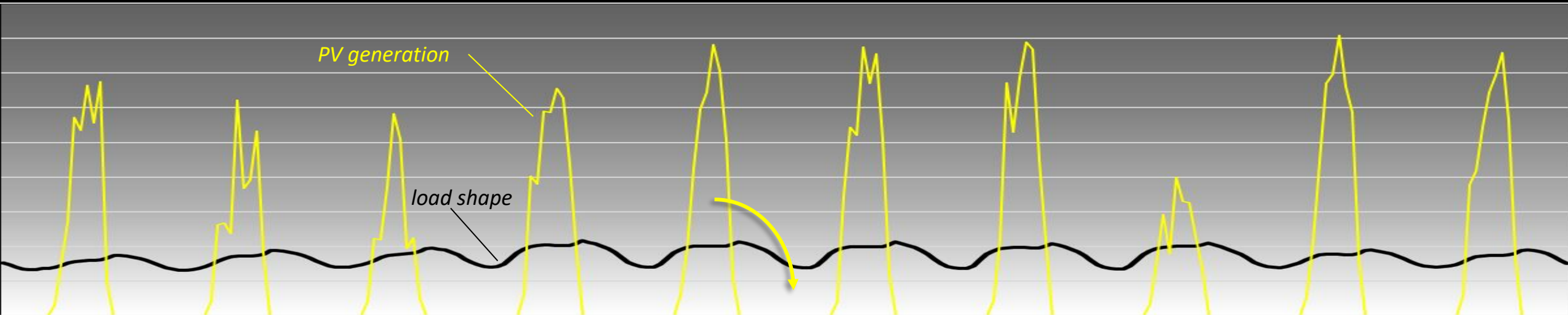
FIRM/DISPATCHABLE



GRID-DOMINANT PV

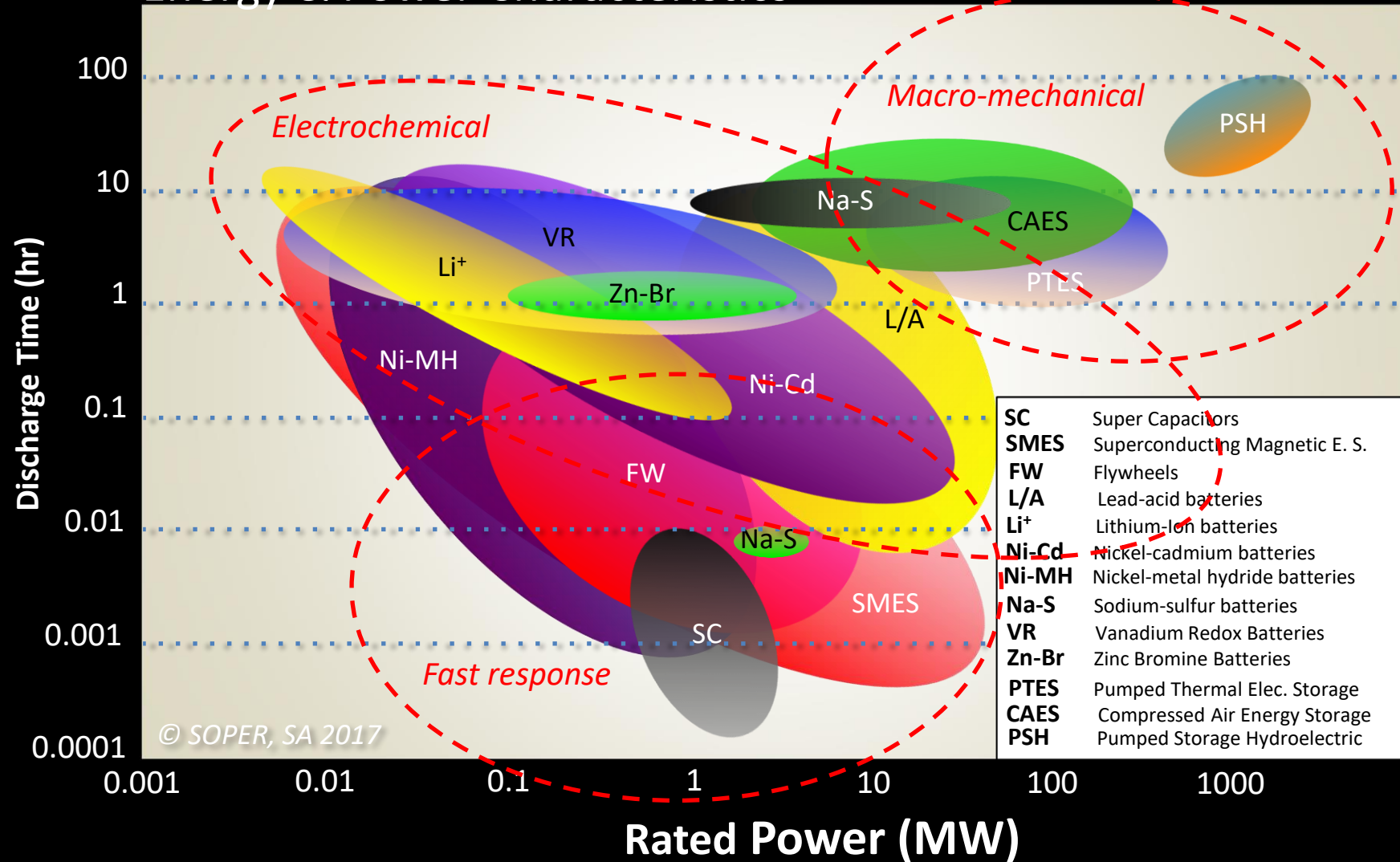
ENERGY STORAGE

Transform PV into load shape



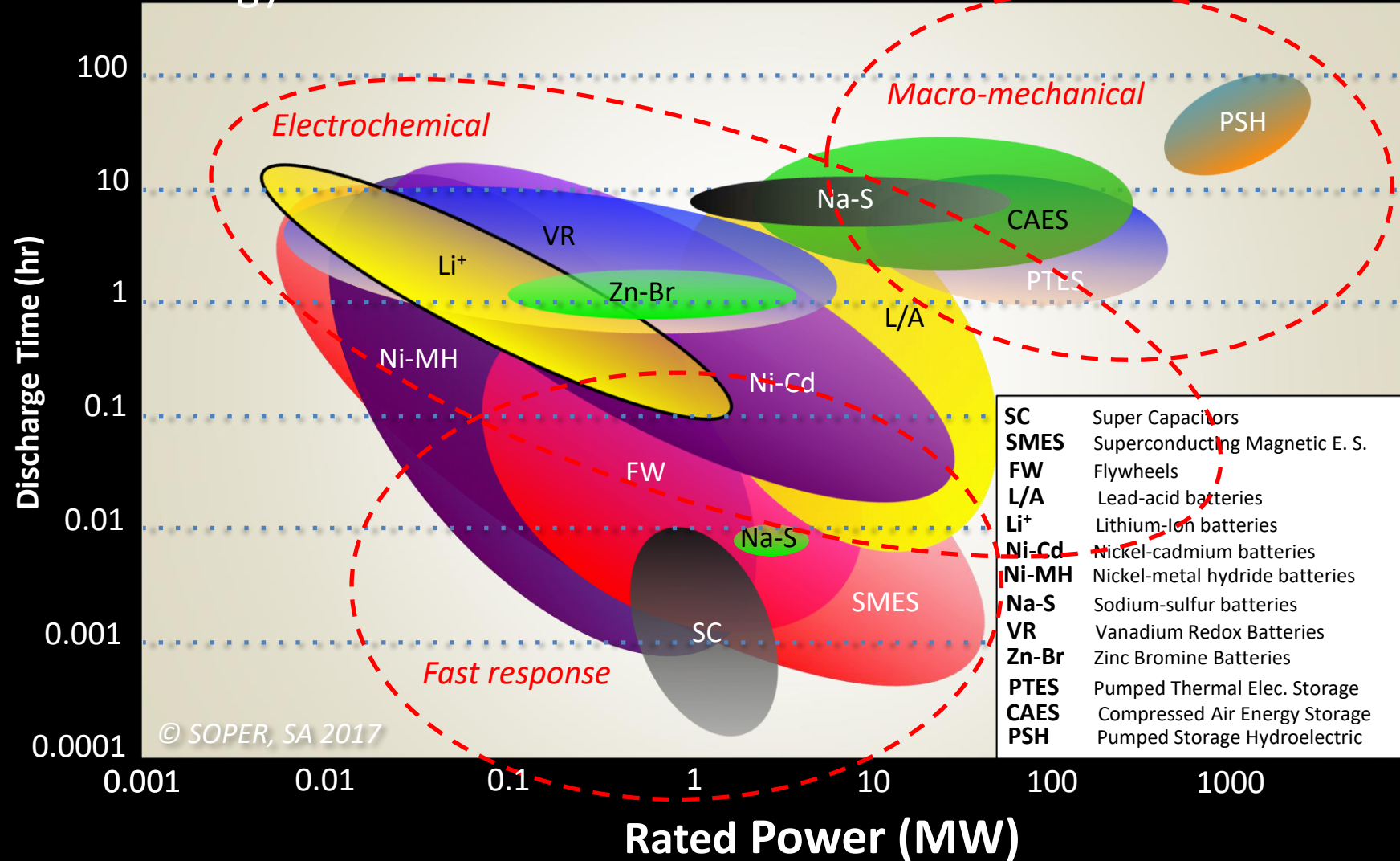
ENERGY STORAGE

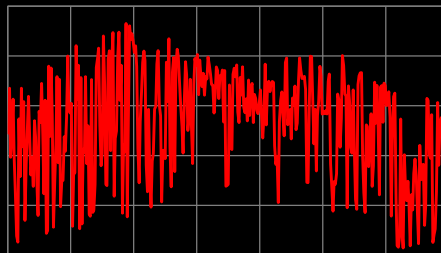
Energy & Power Characteristics



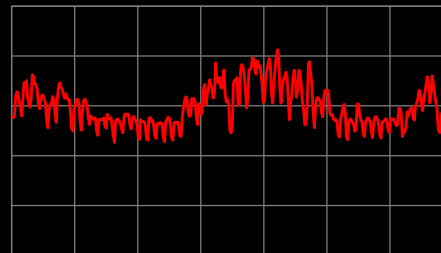
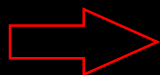
ENERGY STORAGE

Energy & Power Characteristics





INTERMITTENT

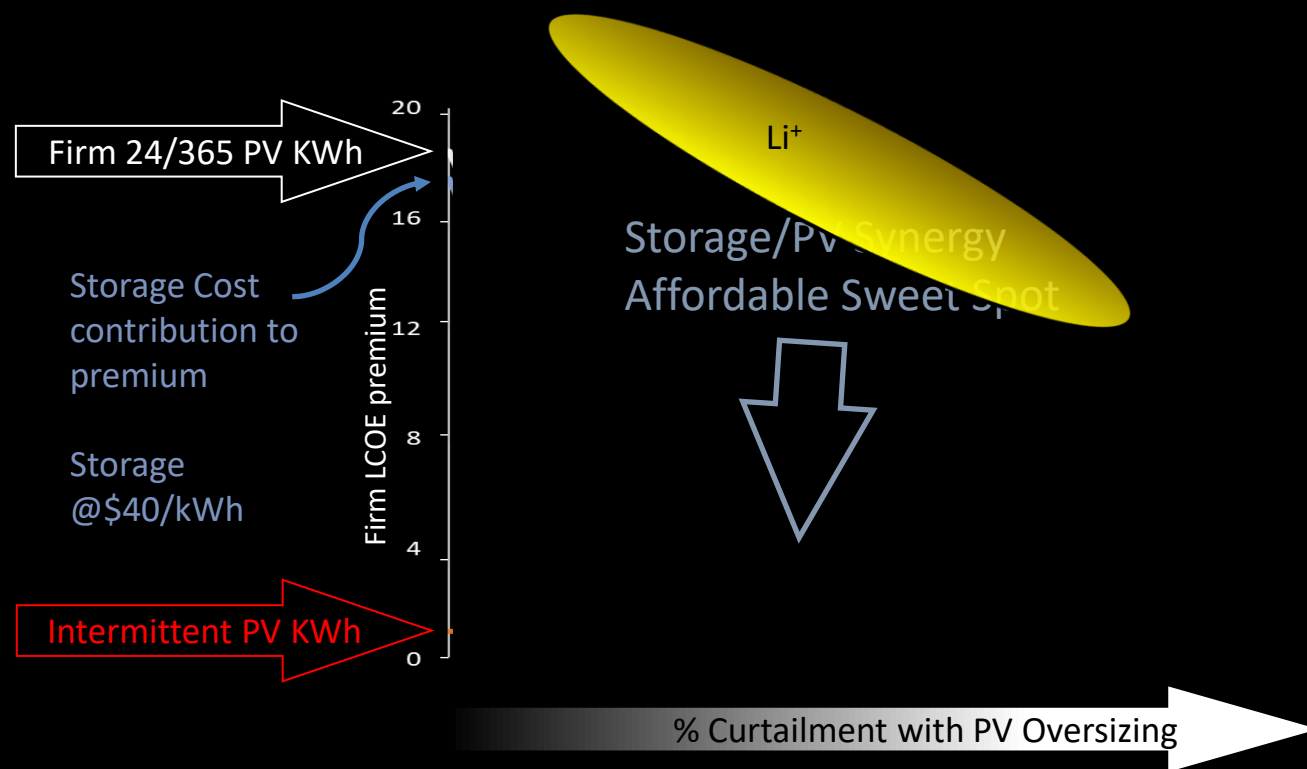


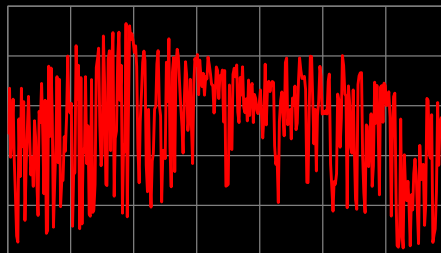
FIRM/DISPATCHABLE

ENERGY STORAGE

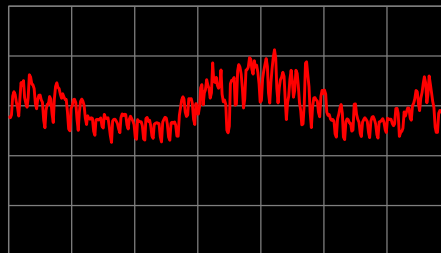
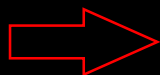
+ OVERBUILD SOLAR & CURTAIL

IMPLICIT STORAGE





INTERMITTENT



FIRM/DISPATCHABLE

ENERGY STORAGE

+ OVERBUILD SOLAR & CURTAIL

IMPLICIT STORAGE **NOT MONETIZABLE TODAY**

QUARTZ

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

More energy than we know what to do with.

By **Michael J. Coren**
Climate reporter

SWITZERLAND

MISO

Midcontinent System Operator

WECC

Western Electricity
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