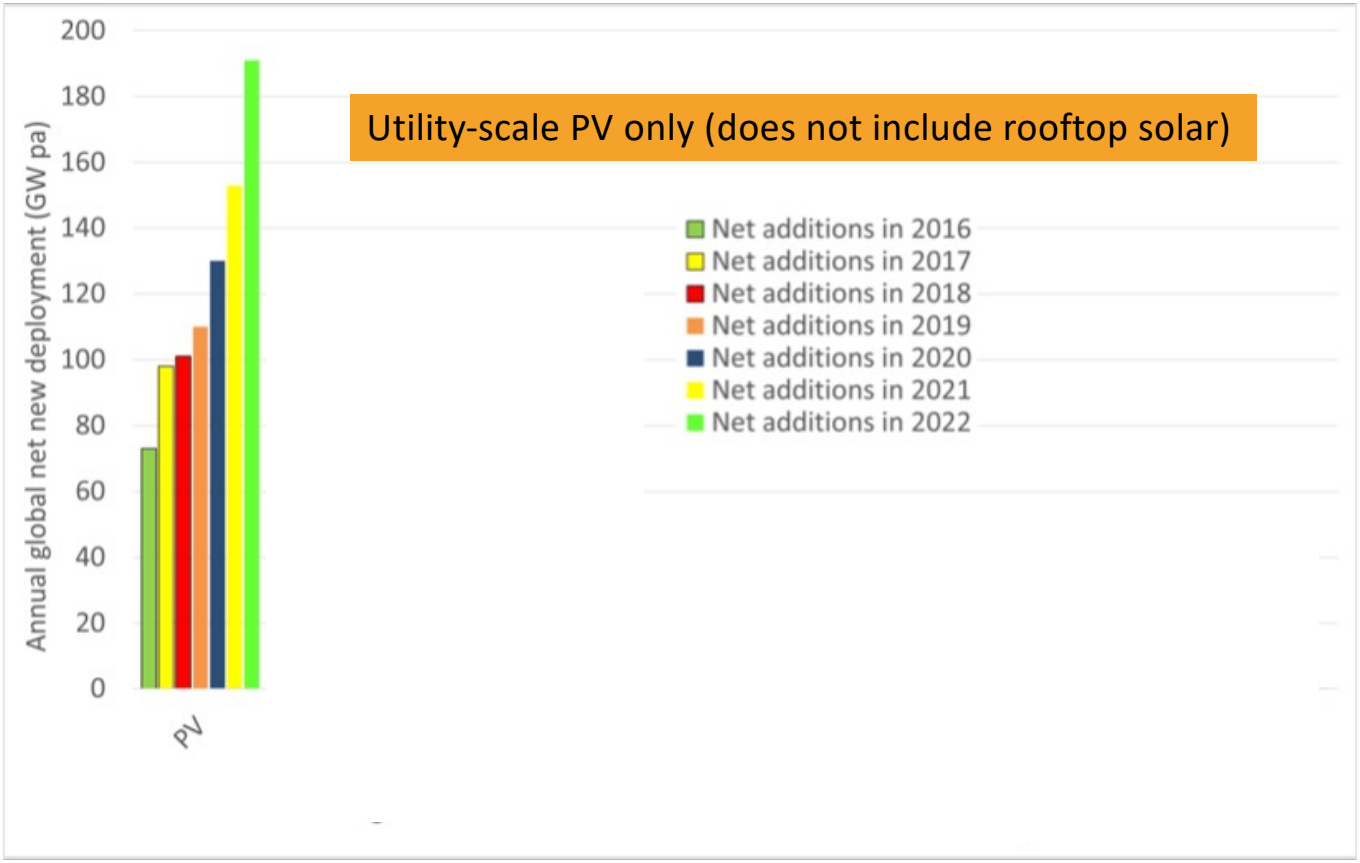
Solar photovoltaics, energy storage, electrical mobility, green hydrogen and agrivoltaics in Brazil

Prof. Ricardo Rüther - Universidade Federal de Santa Catarina - Laboratório Fotovoltaica/UFSC
www.fotovoltaica.ufsc.br

SOLAR PV IS THE FASTEST ENERGY GENERATION TECHNOLOGY WORLDWIDE



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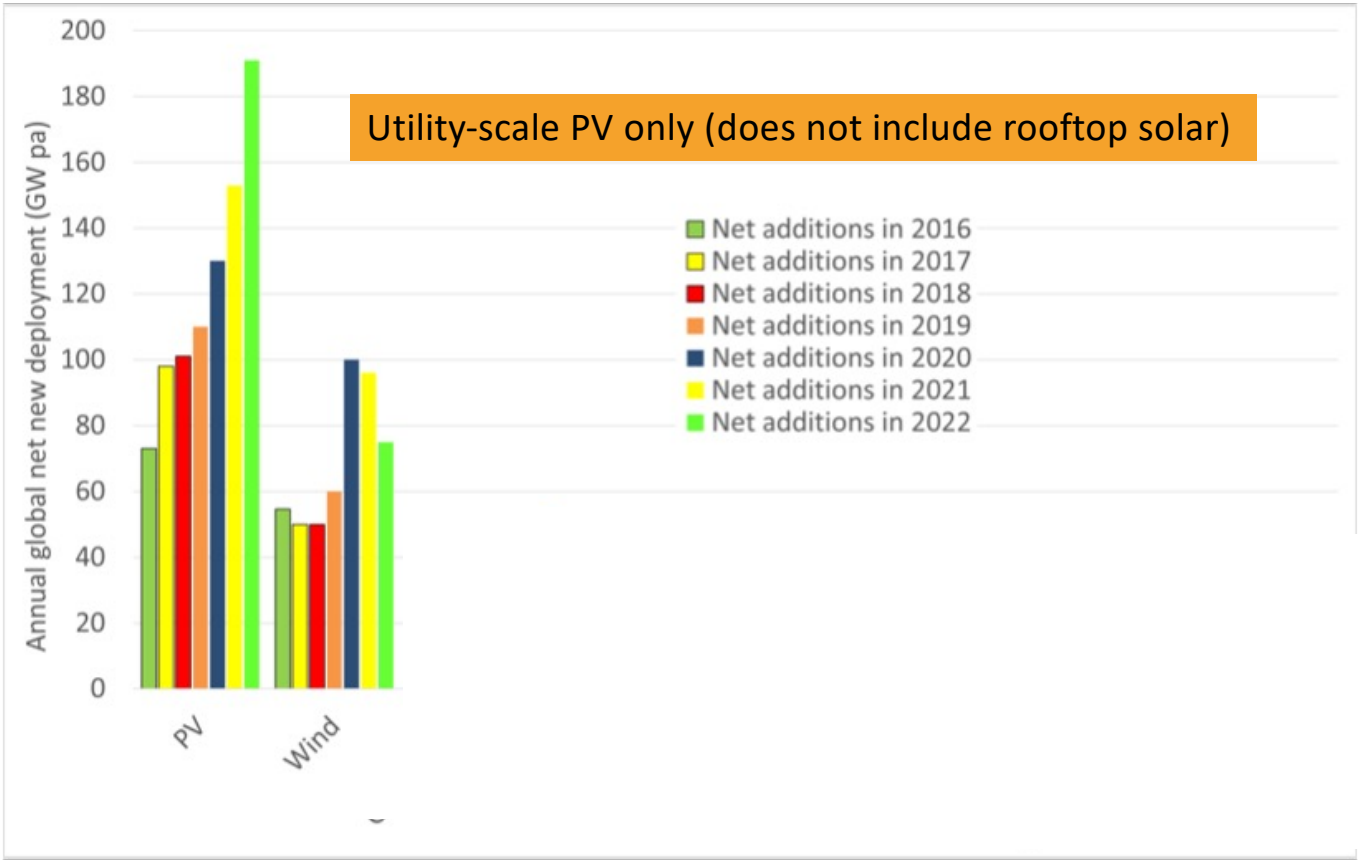

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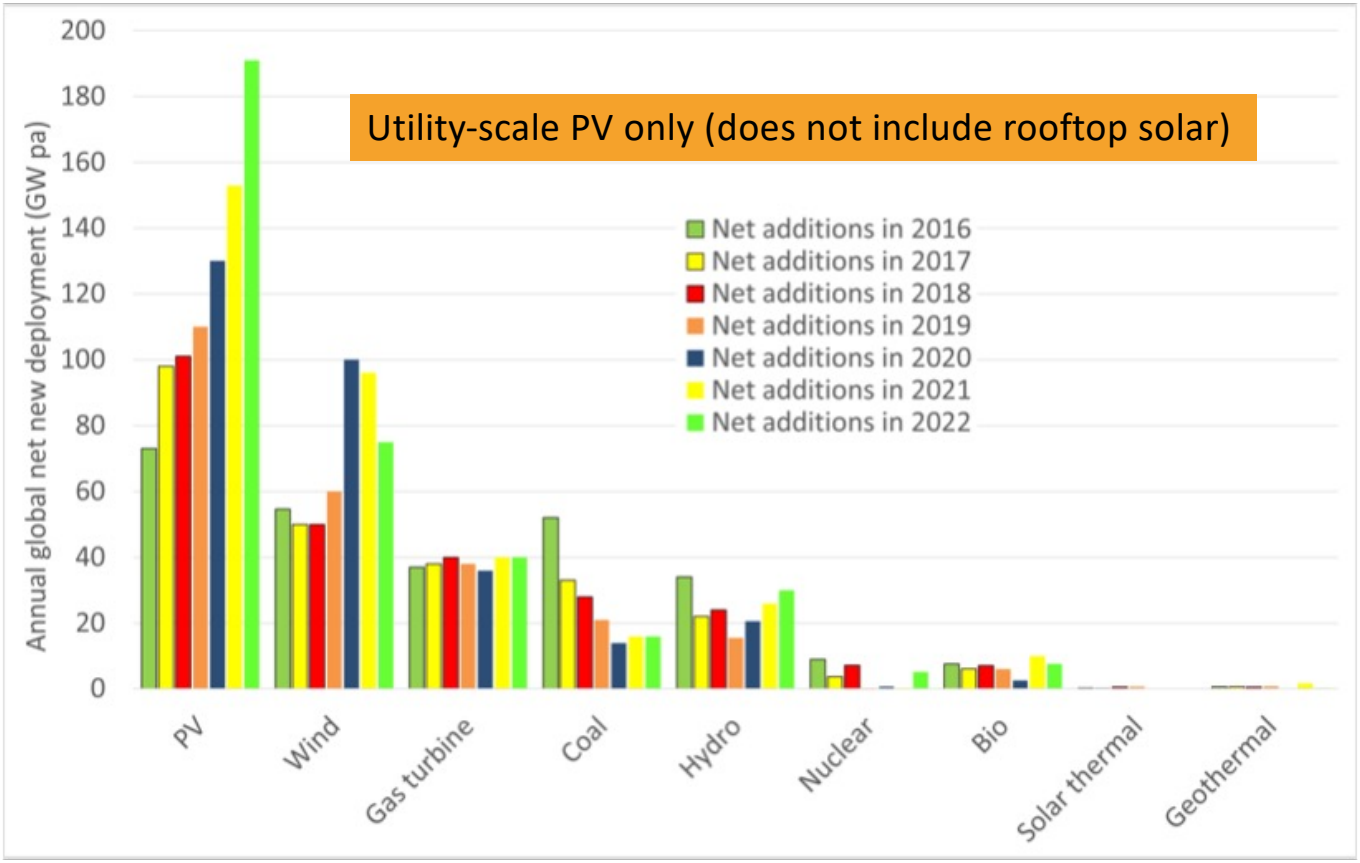

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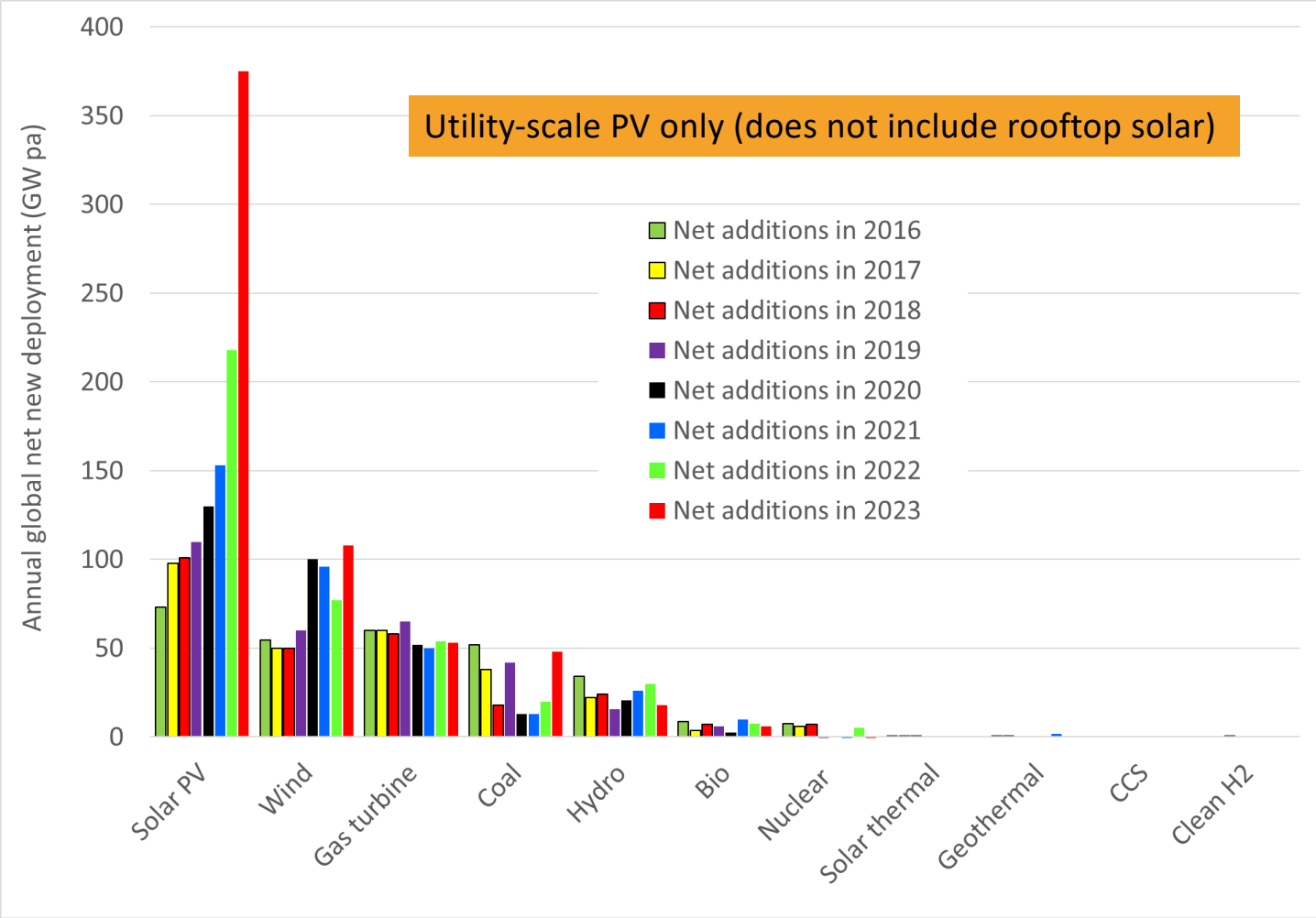

Figure 1: Global net capacity additions 2016-23 (IRENA, IEA, GEM, WNA, GWEC)

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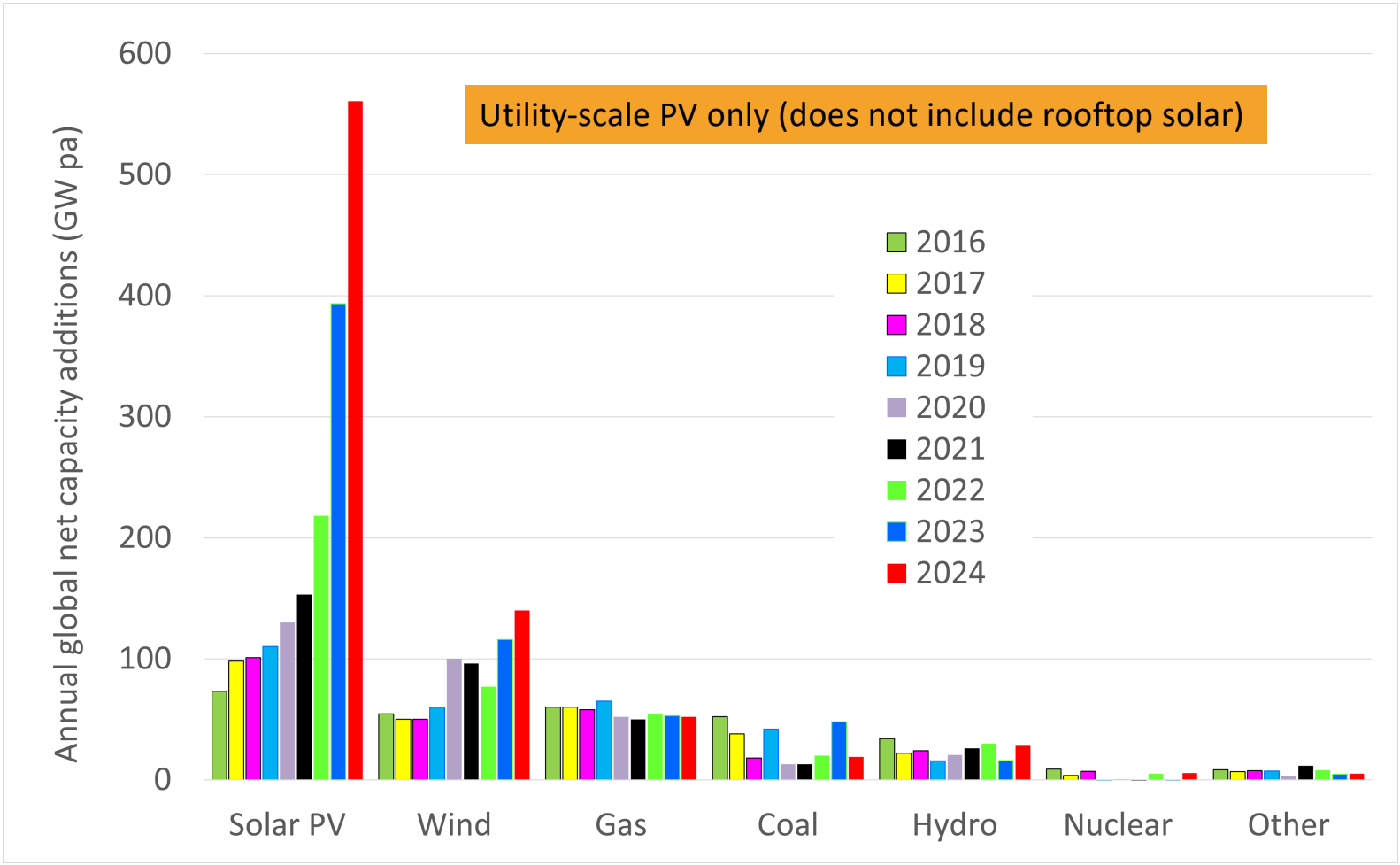

Global net capacity additions 2016-24 (IRENA, IEA, GEM, WNA, GWEC)

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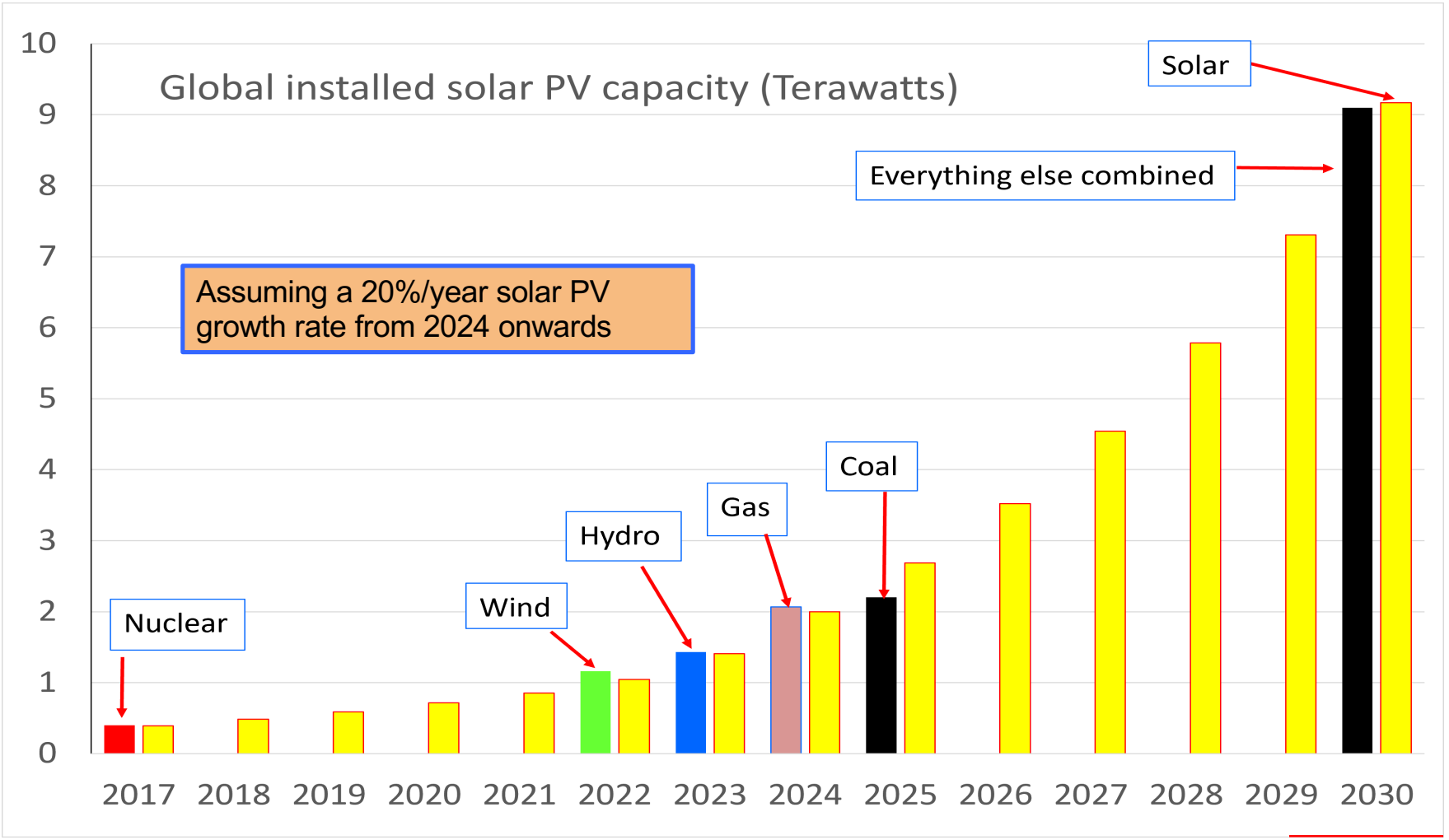

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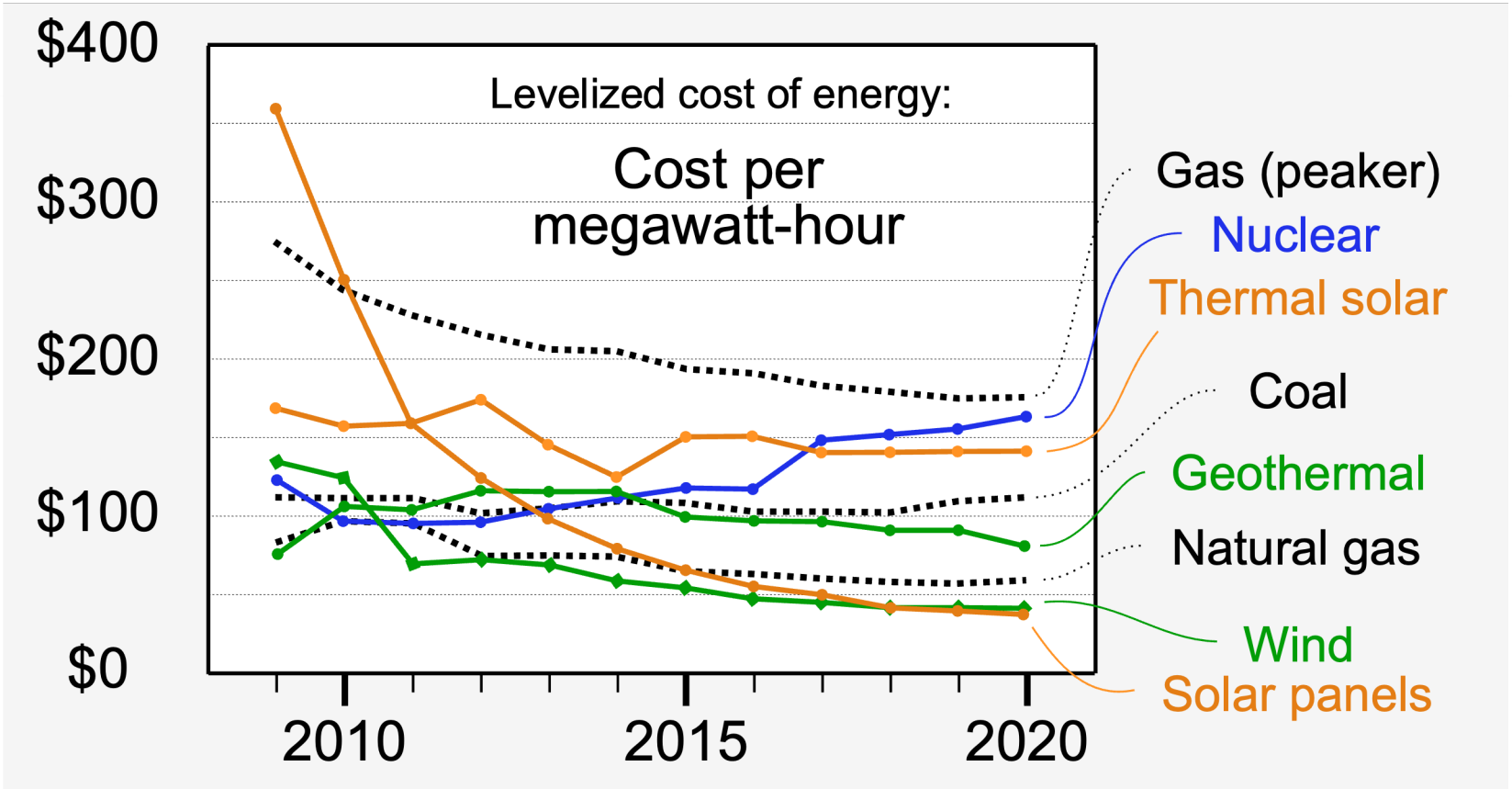
COST REDUCTION IS KEY

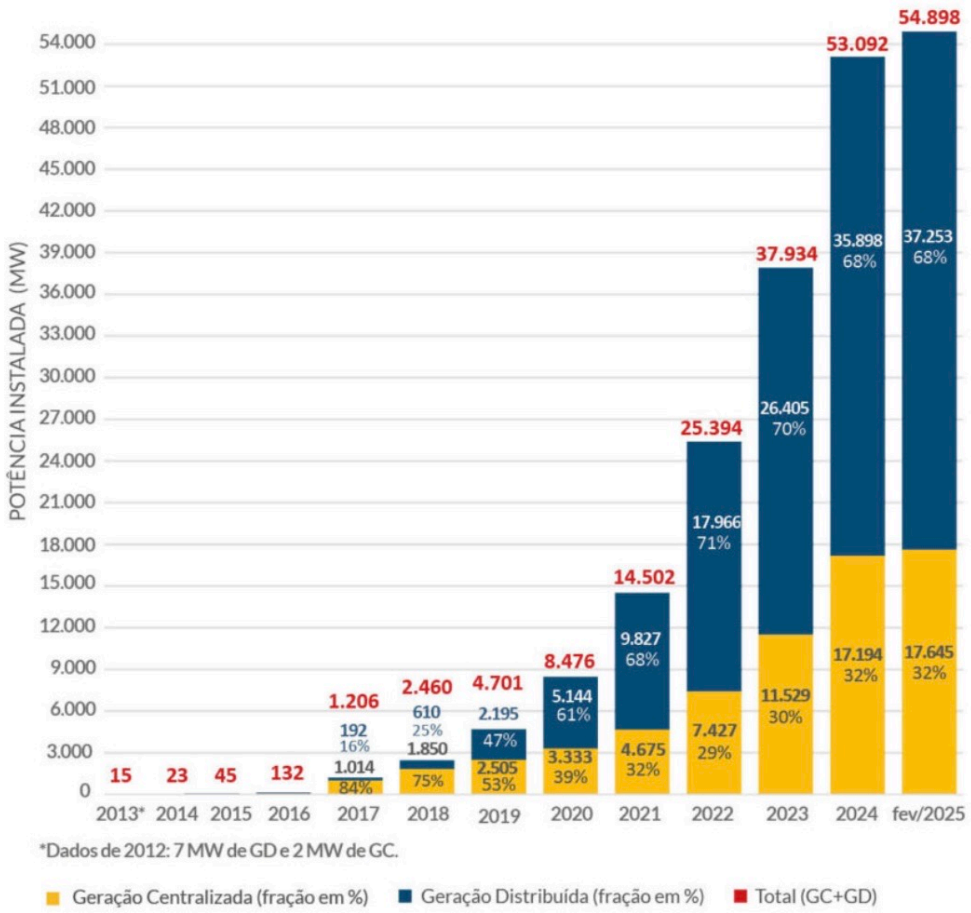


https://en.wikipedia.org/wiki/Cost_of_electricity_by_source

SOLAR PV GROWTH IN BRASIL

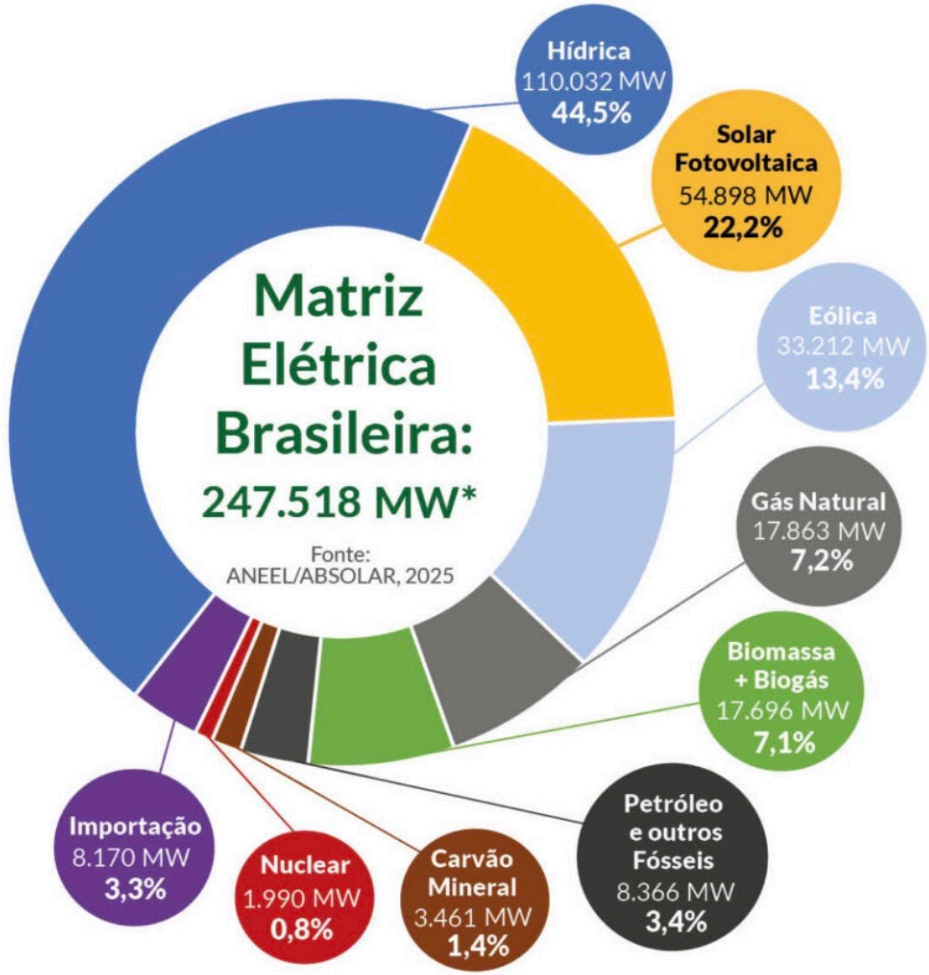
Evolução da Fonte Solar Fotovoltaica no Brasil

Fonte: ANEEL/ABSOLAR, 2025.



*Dados de 2012: 7 MW de GD e 2 MW de GC.

Geração Centralizada (fração em %) | Geração Distribuída (fração em %) | Total (GC+GD)

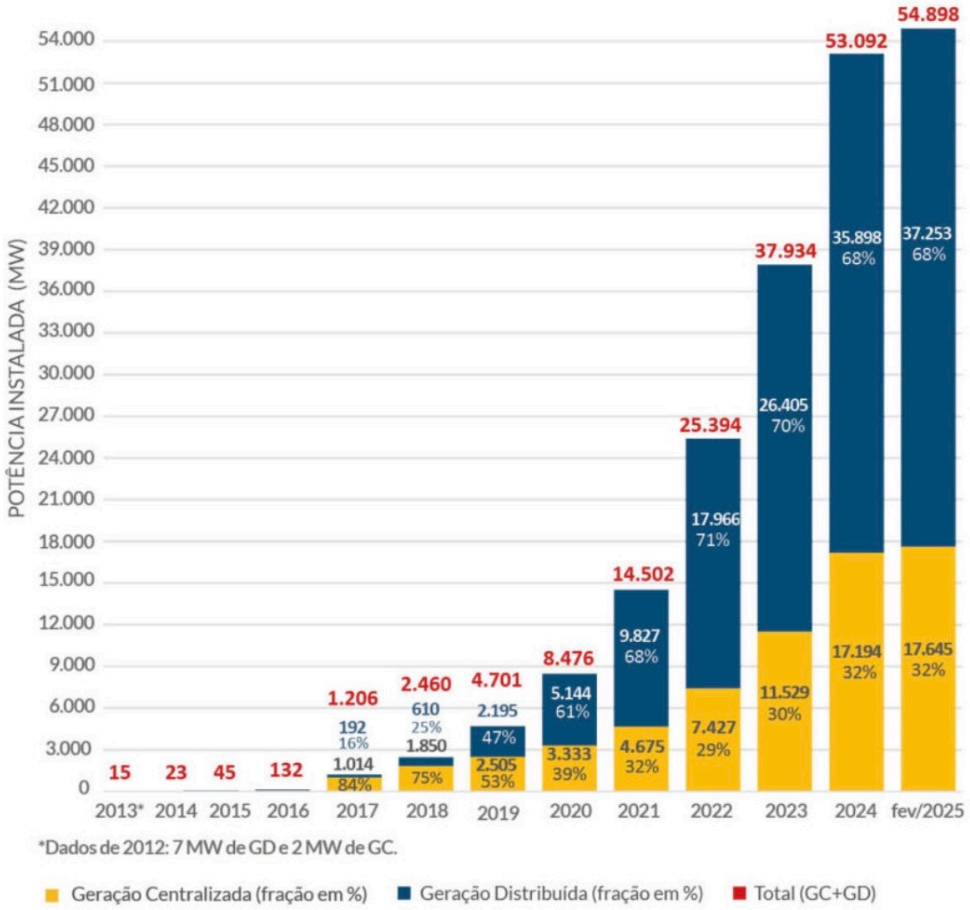


*A potência total da matriz não inclui a importação e segue critério aplicado pelo MME, que adiciona, nos valores de capacidade instalada, as quantidades de mini e microgeração distribuída associadas a cada tipo de fonte.

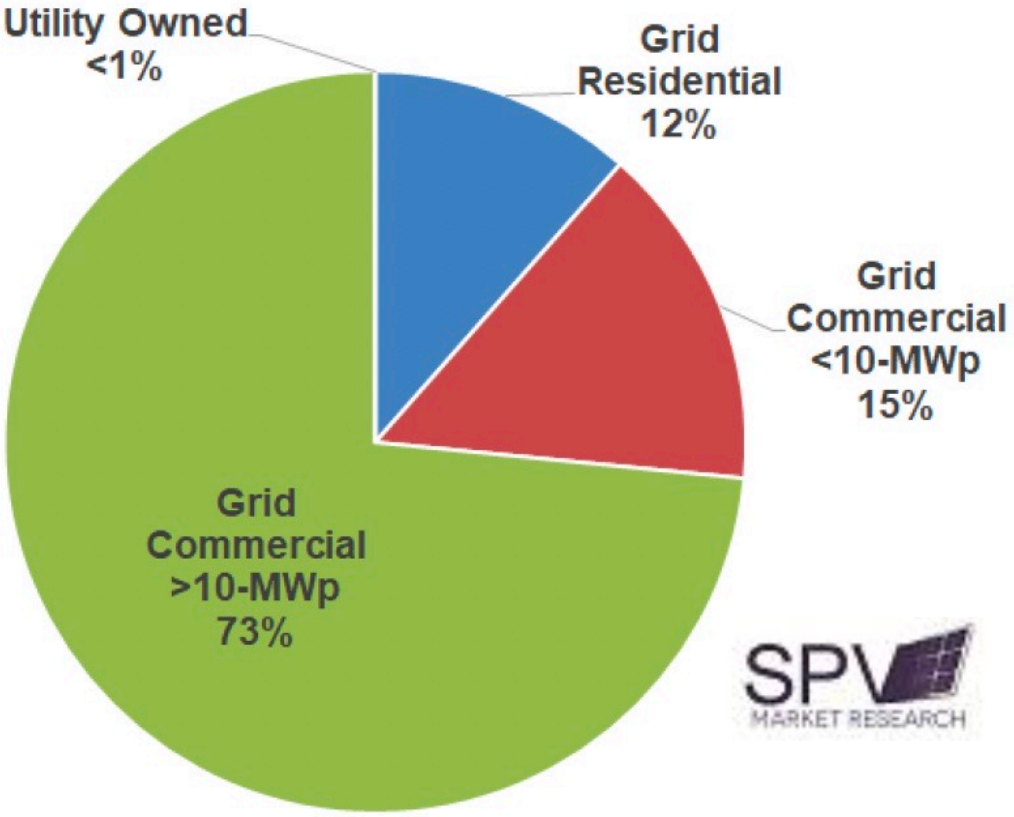
DISTRIBUTED X CENTRALISED PV DEPLOYMENT

Evolução da Fonte Solar Fotovoltaica no Brasil

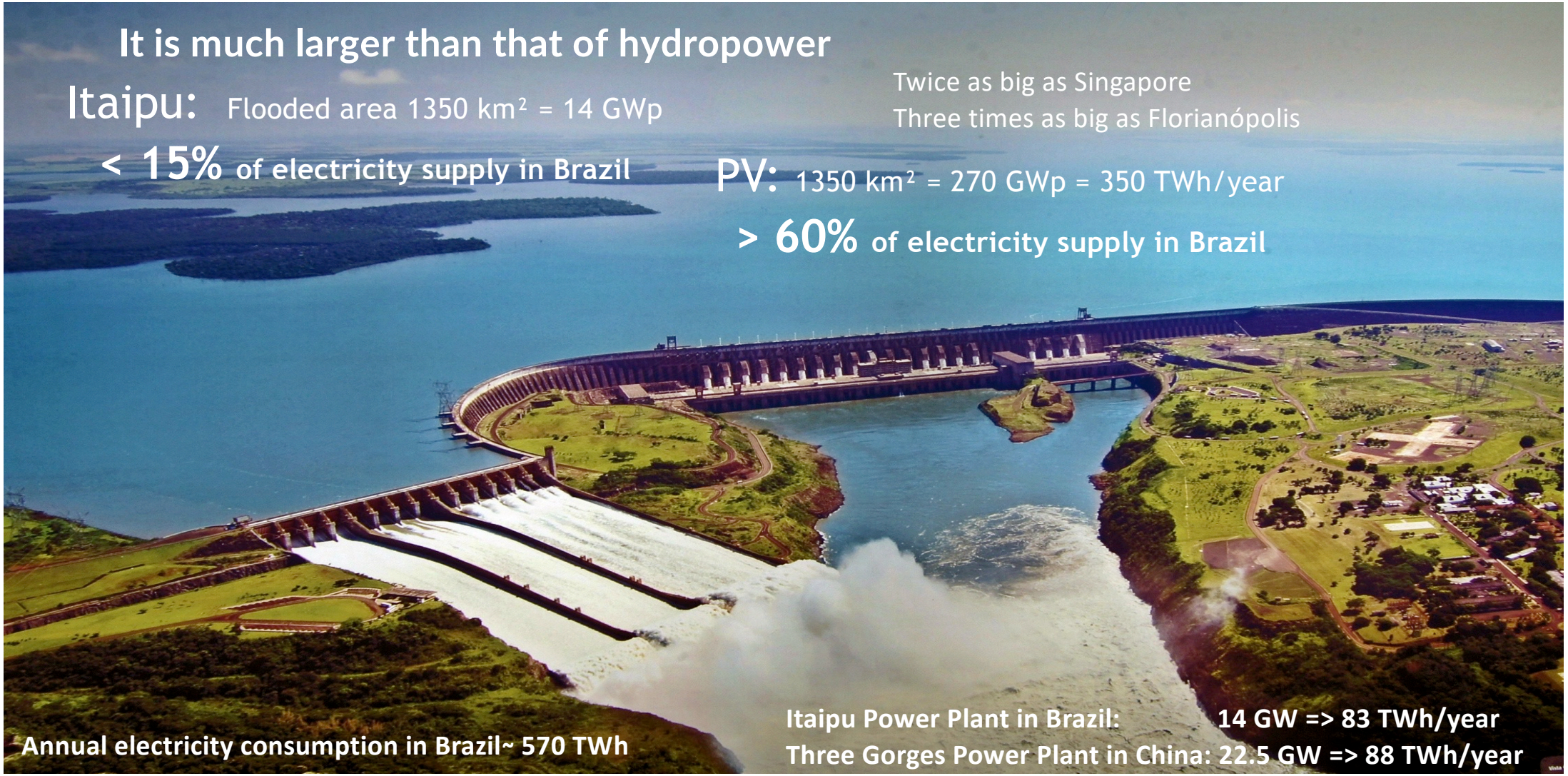
Fonte: ANEEL/ABSOLAR, 2025.



Grid Connected Sub Applications 562.8-GWp 2023



WHAT IS THE SOLAR PHOTOVOLTAICS POTENTIAL?



THE TRENDS IN PHOTOVOLTAICS

Hydropower installed capacity in Brazil: ~ 110 GW
Flooded area of all hydropower plants in Brazil combined: 40.000 km^2
How much PV can we fit in this area: 8.000 GWp (8 TWp) !!! (World 2 TWp)

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PHOTOVOLTAICS EVERYWHERE

A hybrid wind and solar power station near Zhangjiakou in Hebei province, northwestern China. Credit: Chen Xiaodong/VCG via Getty

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PHOTOVOLTAICS EVERYWHERE !

VERY BIG PHOTOVOLTAICS EVERYWHERE !

https://bolandnewenergy.com/qinghai-talatan-solar-power-station/

Largest PV power plant

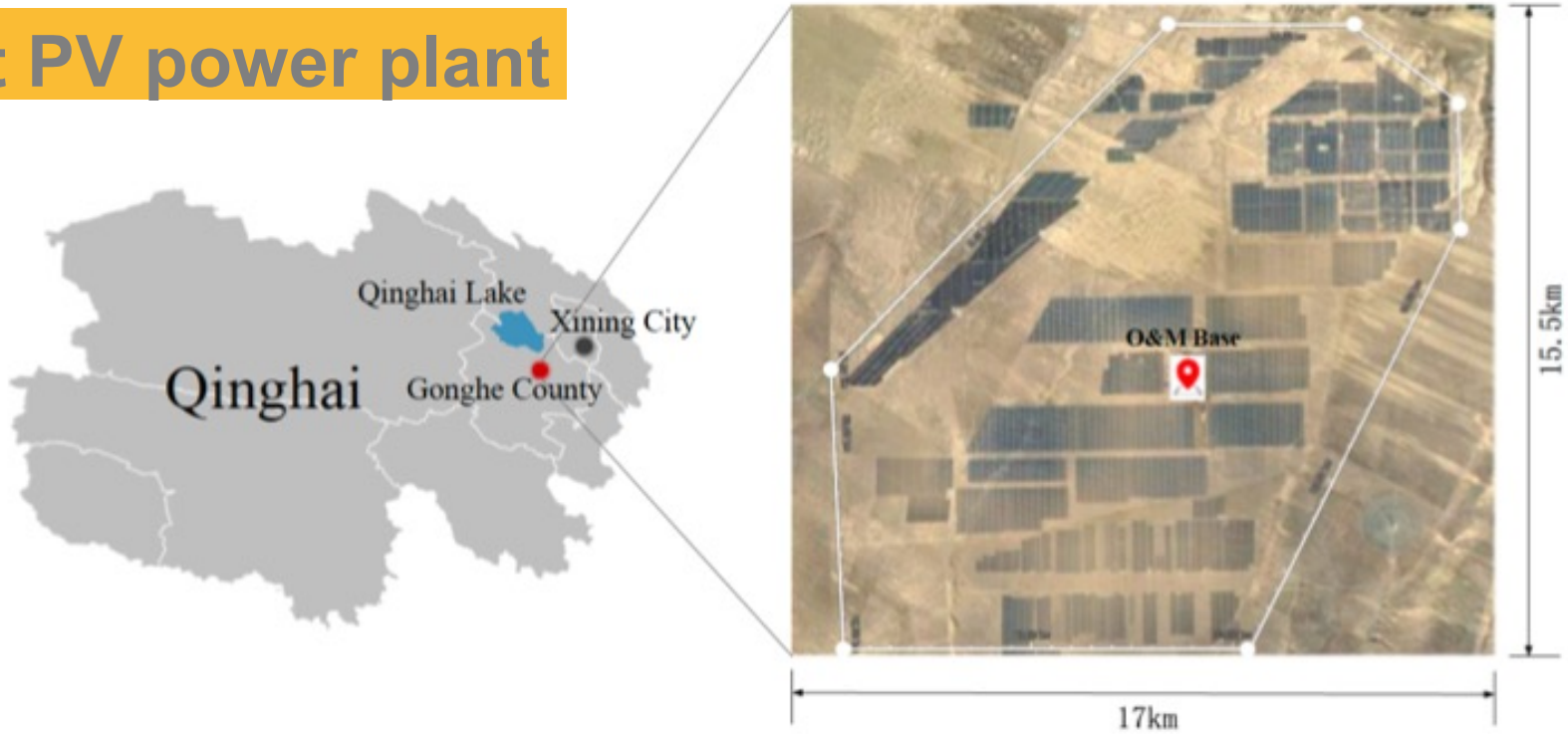


Fig. 7. Satellite image of the Talatan PV power plant.

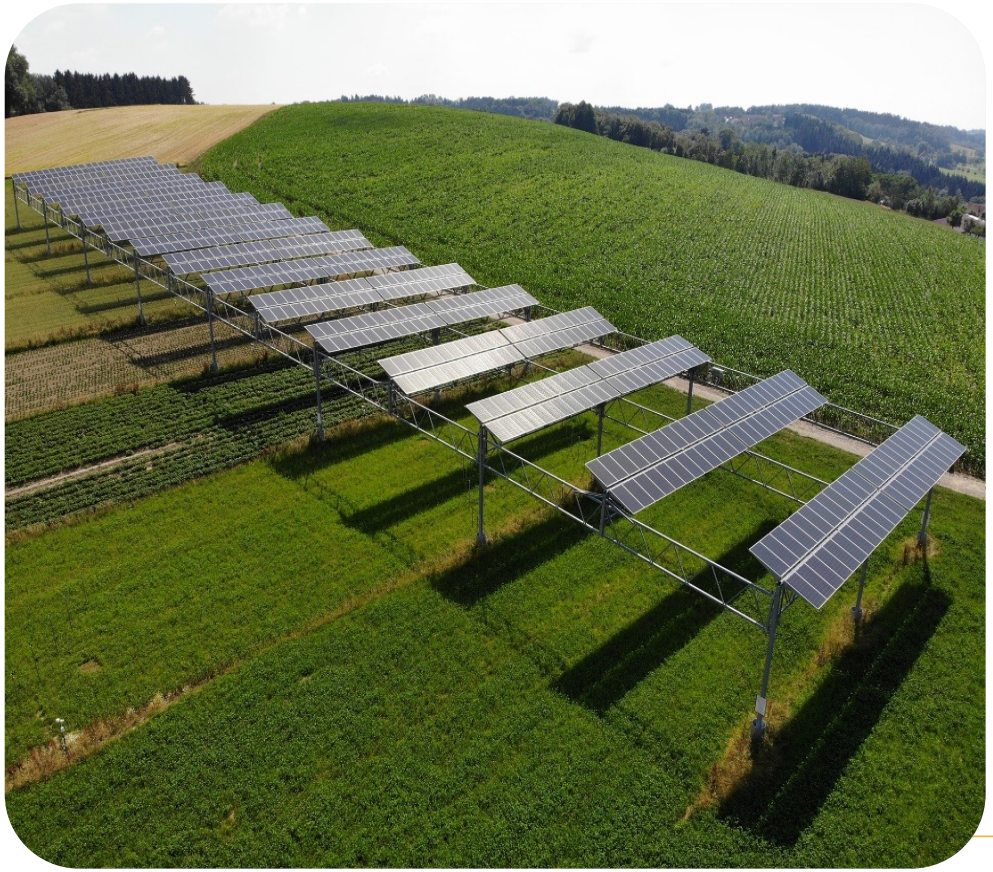
https://www.youtube.com/watch?v=UO1D5V8Aowg

Talatan PV power plant in China: 15.6 GW Total area: 15000 hectares = 150 km^2 More than 7 million PV modules

THE TRENDS IN PHOTOVOLTAICS

AgriPhotovoltaics

Simultaneous use of the land for agriculture and solar PV generation



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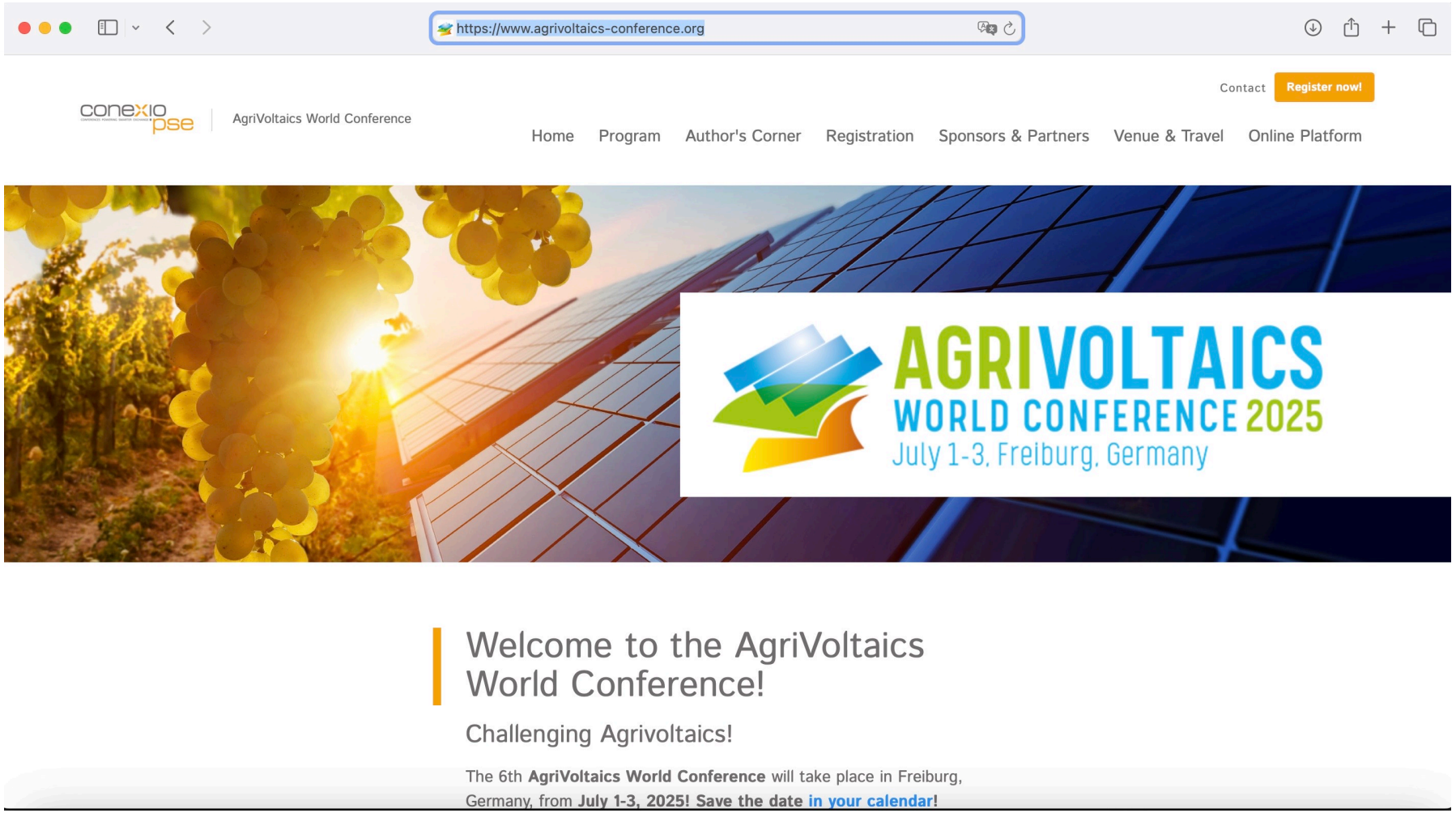
THE TRENDS IN PHOTOVOLTAICS

AgriPhotovoltaics – AgriVoltaics - AgriPV



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THE TRENDS IN PHOTOVOLTAICS

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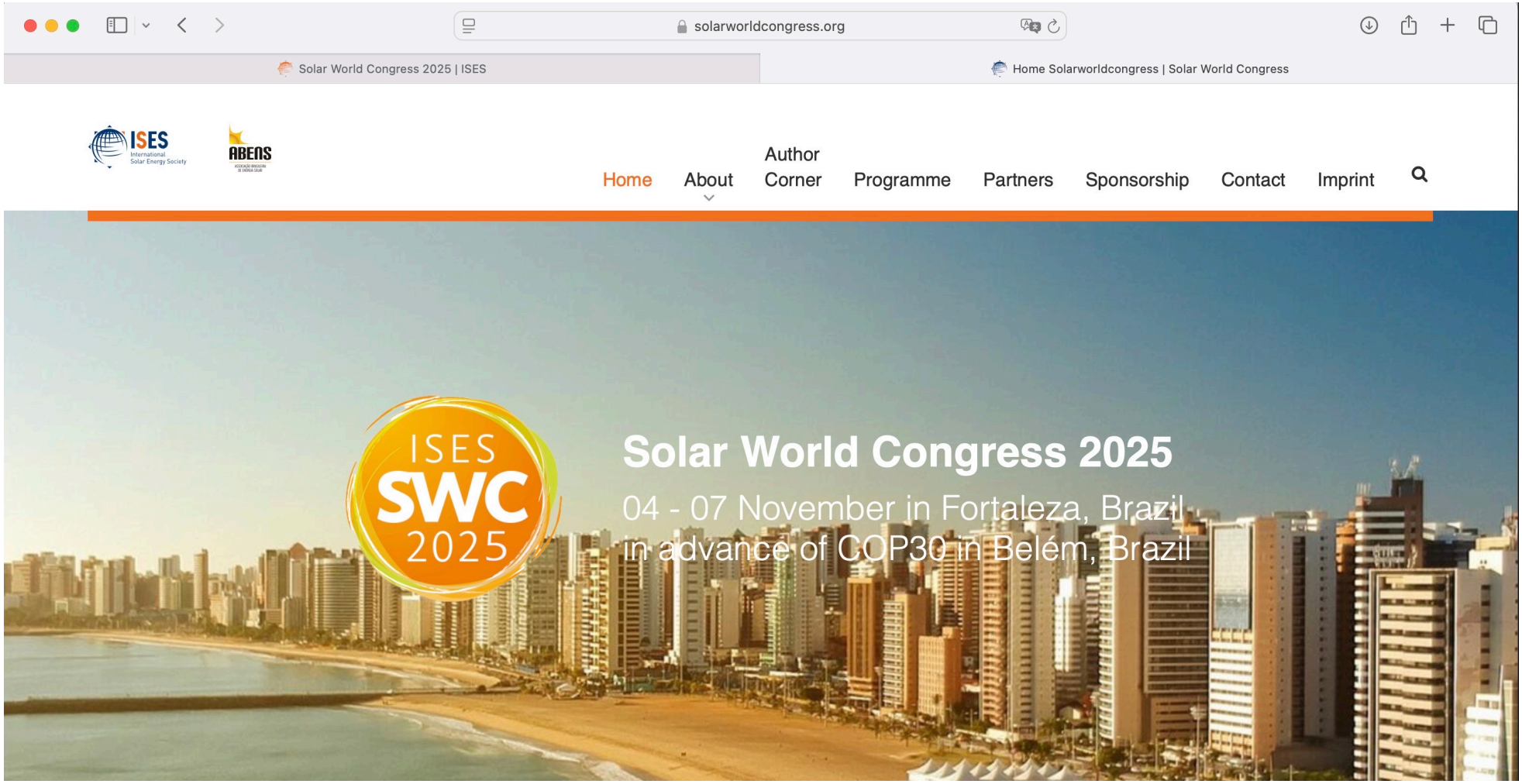

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ELECTRICAL MOBILITY
&
ENERGY STORAGE

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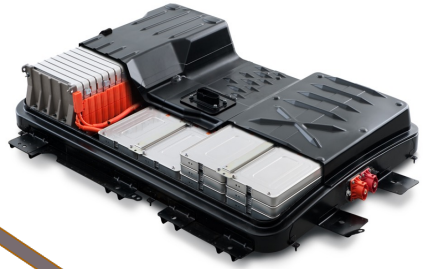
LI-ION BATTERIES: ELECTROMOBILITY + STATIONARY APPLICATIONS

Electromobility



Discard ??

Stationary use in second-life

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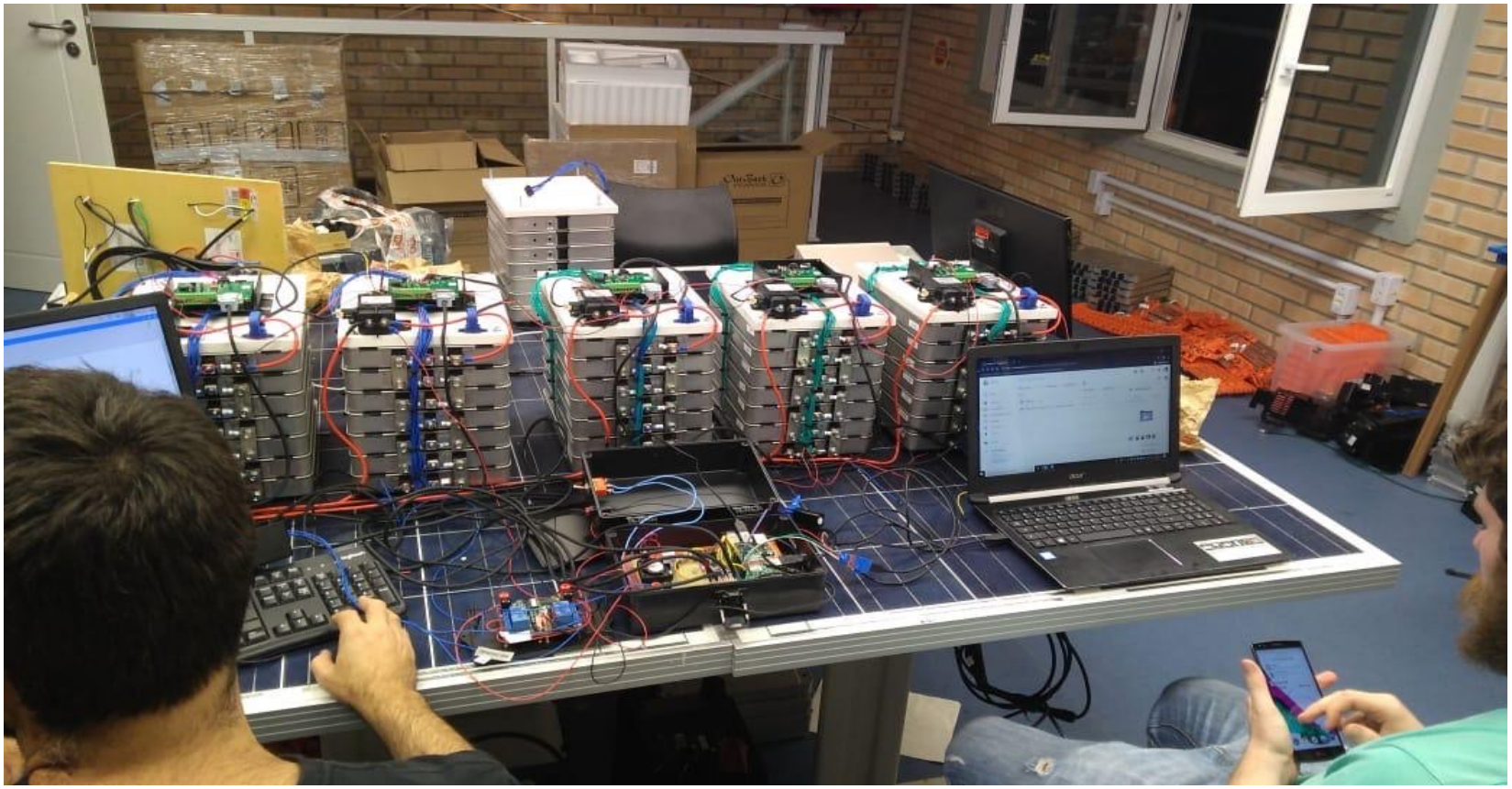
Electric Vehicle (EV) Li-ion Second Life Batteries

25 kWh Nissan Leaf Li-ion battery pack being repurposed for second life, stationary applications at the Fotovoltaica/UFSC Solar Energy Research Laboratory

LI-ION SECOND LIFE BATTERIES

Second-life Li-ion batteries, recycled from electric vehicles, repurposed for stationary applications at the Fotovoltaica/UFSCLaboratory



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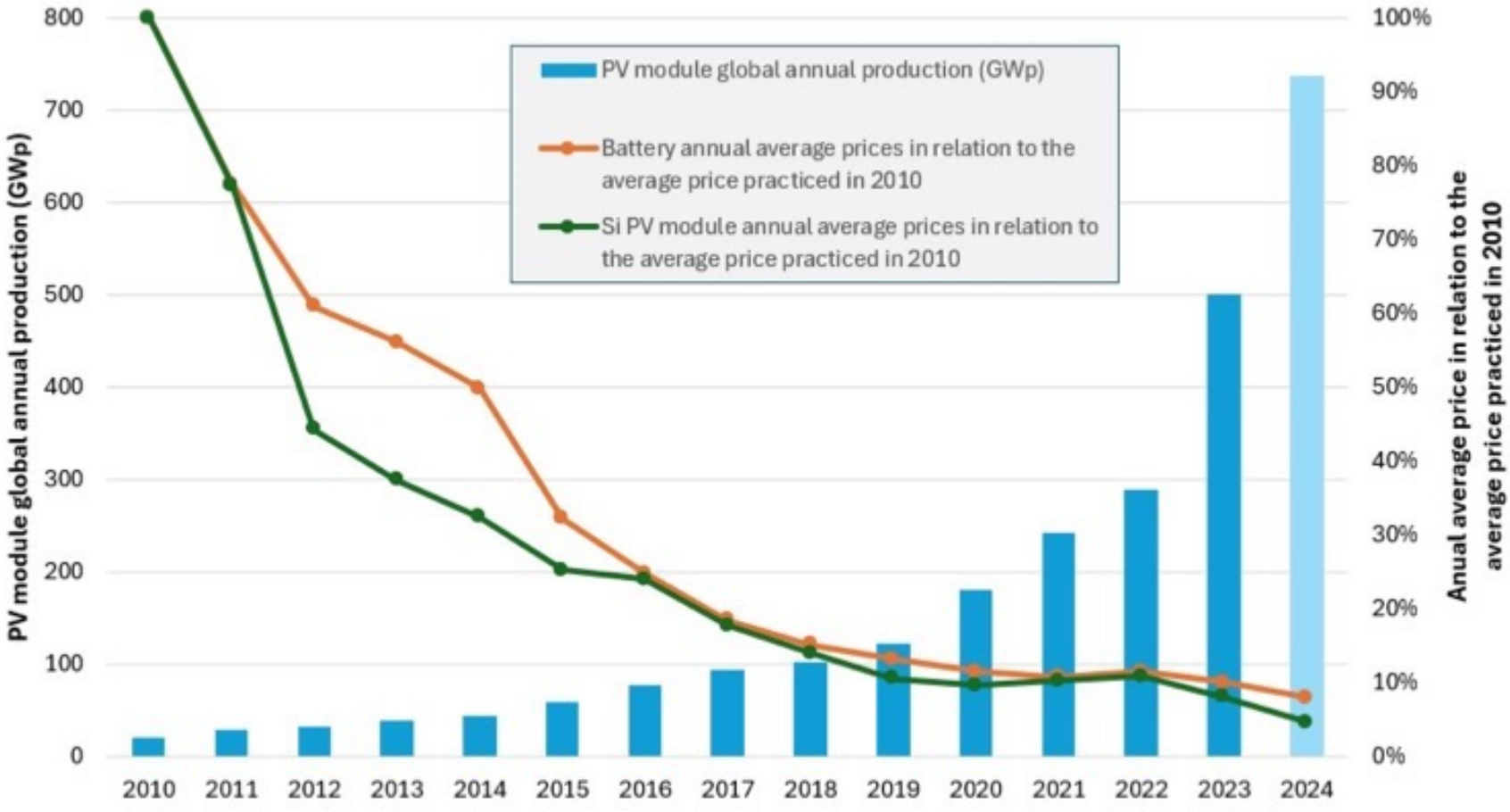
LI-ION BATTERIES: ELECTROMOBILITY + STATIONARY APPLICATIONS

1. Vehicle Charger
   - 7.4 kW
2. Hybrid Inverter
   - 8kW
   - 11 kWp
3. Second Life Battery
   - 24 kWh
   - 48 V
   - 14S16P
4. Rooftop PV carport

BATTERIES ARE COMING DOWN IN PRICE AS FAST AS SOLAR PHOTOVOLTAICS



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https://www.bloomberg.com/professional/insights/commodities/race-to-net-zero-pressures-of-the-battery-boom-in-five-charts/
https://about.bnef.com/blog/3q-2024-global-pv-market-outlook/
https://reneweconomy.com.au/mind-blowing-battery-cell-prices-plunge-in-chinas-biggest-energy-storage-auction/

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GREEN HYDROGEN

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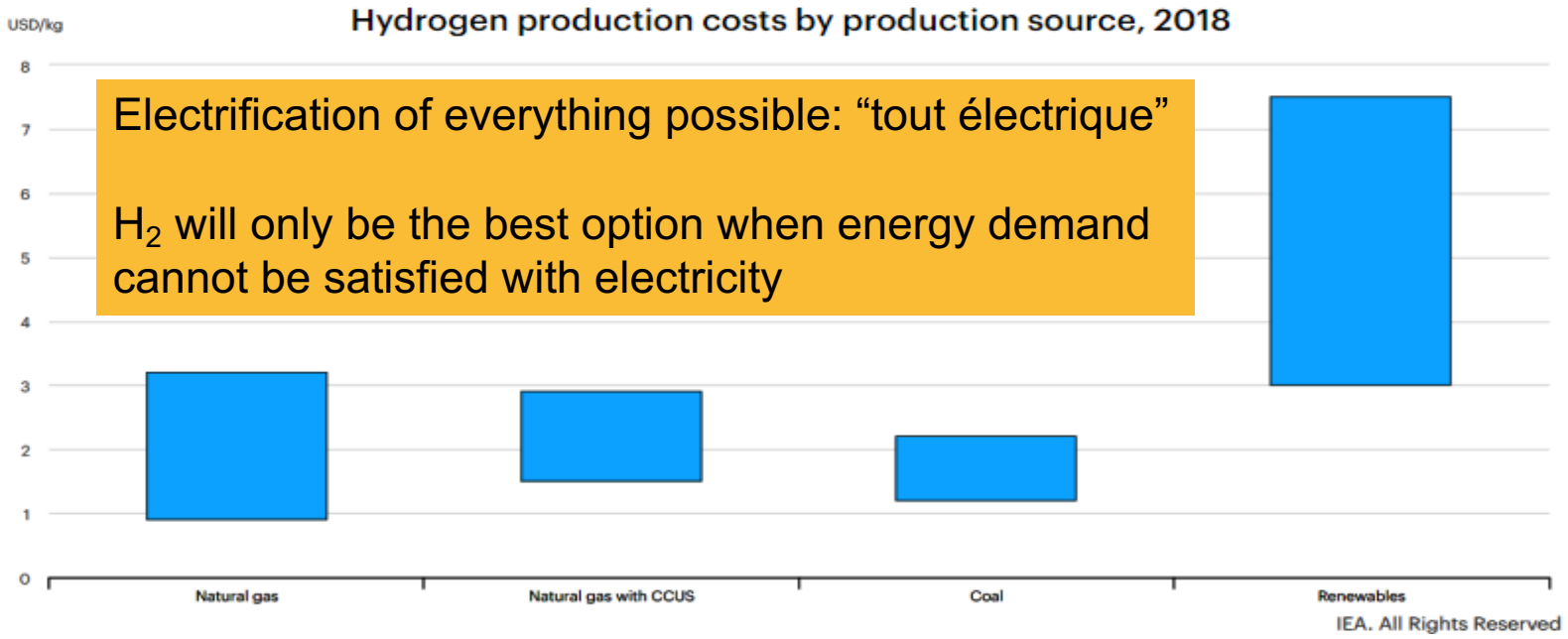
GREEN HYDROGEN: HOW EXPENSIVE?



Electrification of everything possible: “tout électrique”

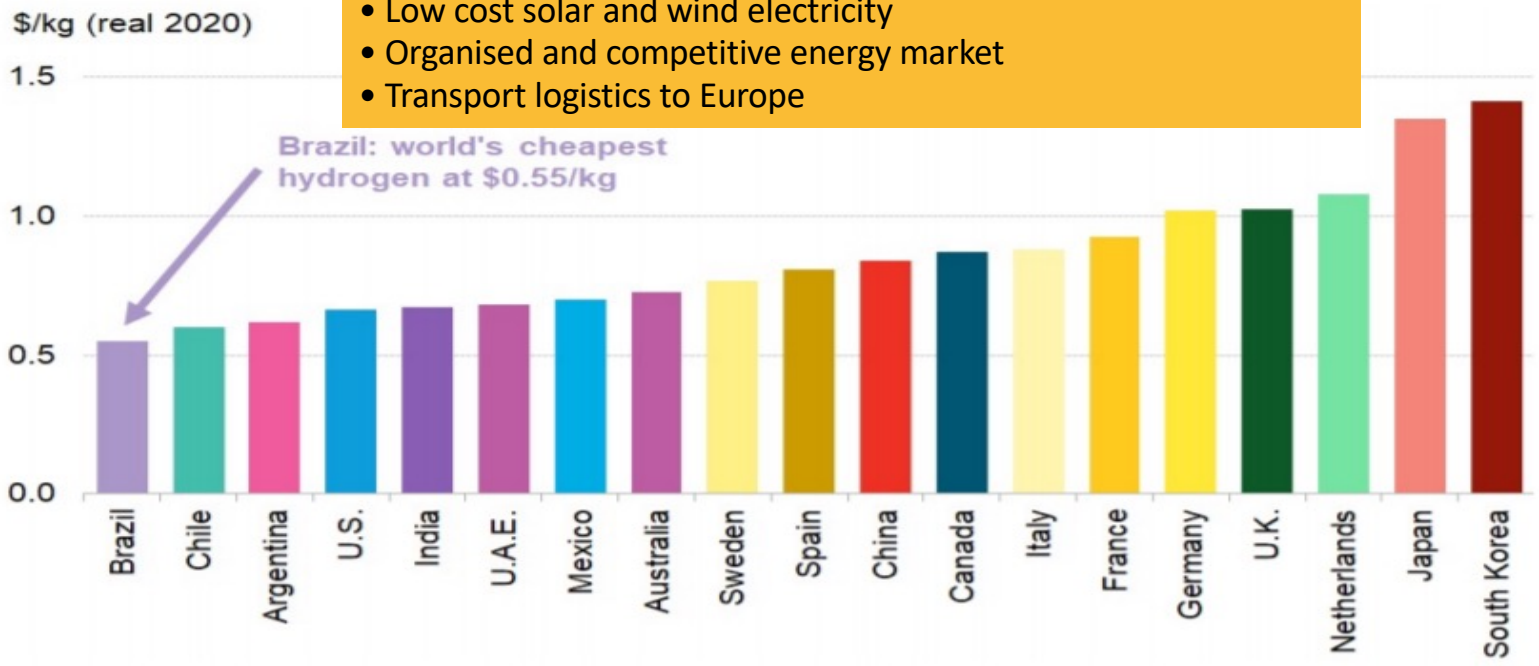
H_2 will only be the best option when energy demand cannot be satisfied with electricity

- Hydrogen was a fad in the early 2000’s: expensive and energy intensive
- Solar and wind cost reduction + environmental concerns, comeback in 2021
- Green hydrogen needs a lot of solar/wind electricity and pure water

GREEN H2: HOW MUCH WILL IT COST?

Levelized cost of hydrogen production from renewables, 2050

- Low cost solar and wind electricity
- Organised and competitive energy market
- Transport logistics to Europe

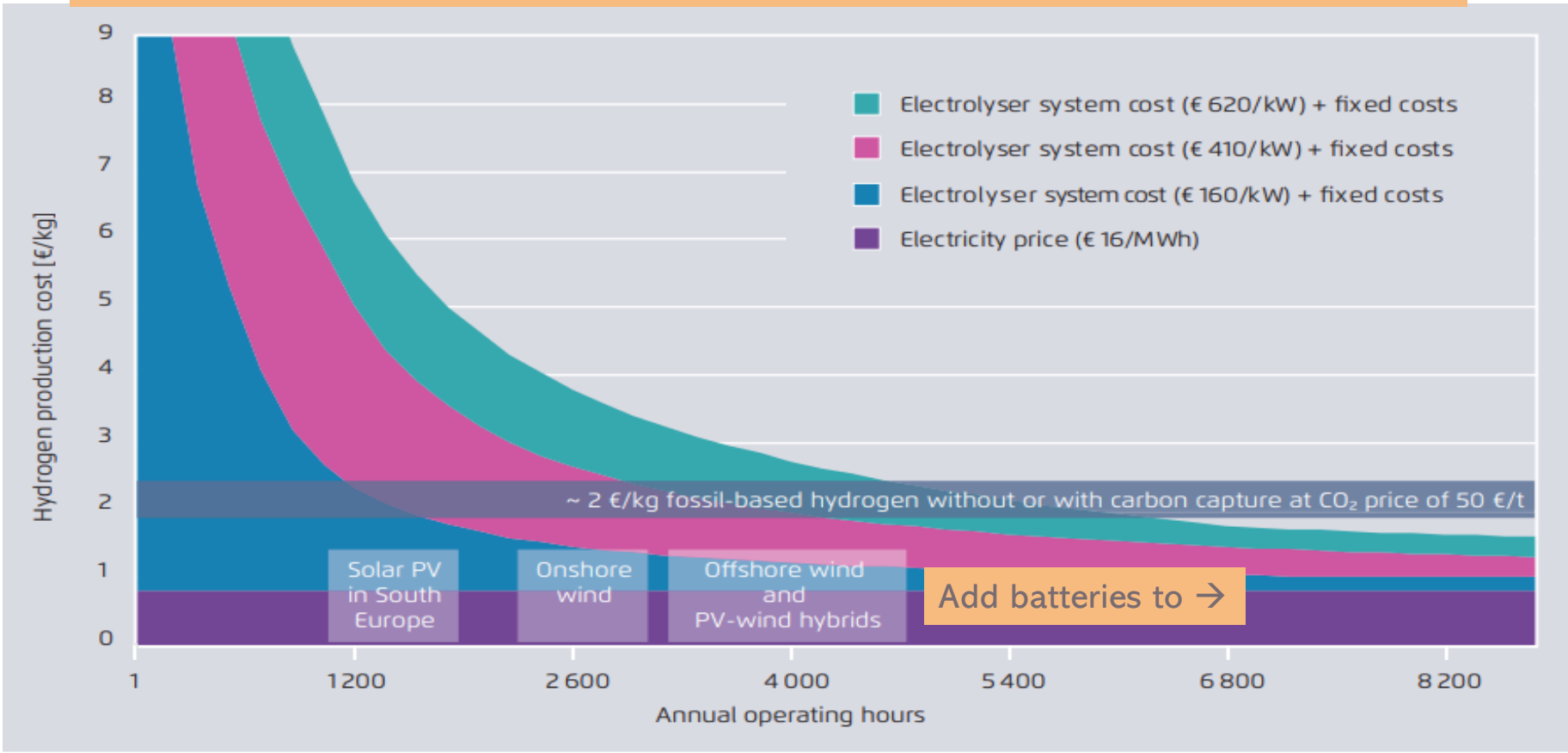


Source: BloombergNEF

Note: Assumes our optimistic alkaline electrolyzer cost scenario and the u
either solar PV or onshore wind electricity, whichever leads to the cheape
hydrogen production cost.

PRODUCTION COST OF GREEN H2
IMPACT OF CAPEX, FULL LOAD HOURS AND COST OF ELECTRICITY

PRODUCTION COSTS OF GREEN H2 AS A FUNCTION OF OPERATING HOURS



Source: Agora Energiewende, Making renewable hydrogen cost-competitive, 2021, p.12/fig.2.

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AGRIVOLTAICS
OR
AGRIPHOTOVOLTAICS
OR
AGRIPV

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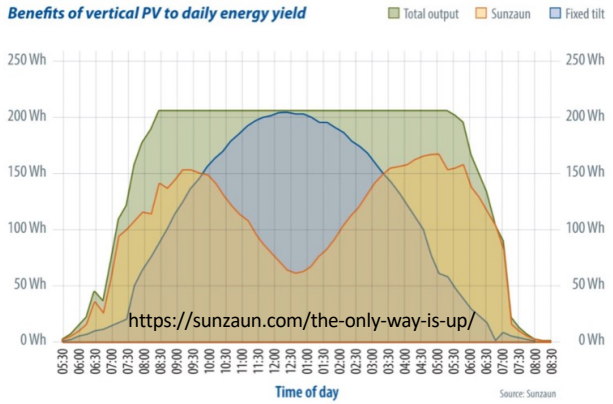
AgriPhotovoltaics

REPSOL

AgriPV Power Plant



https://sunzaun.com/the-only-way-is-up/

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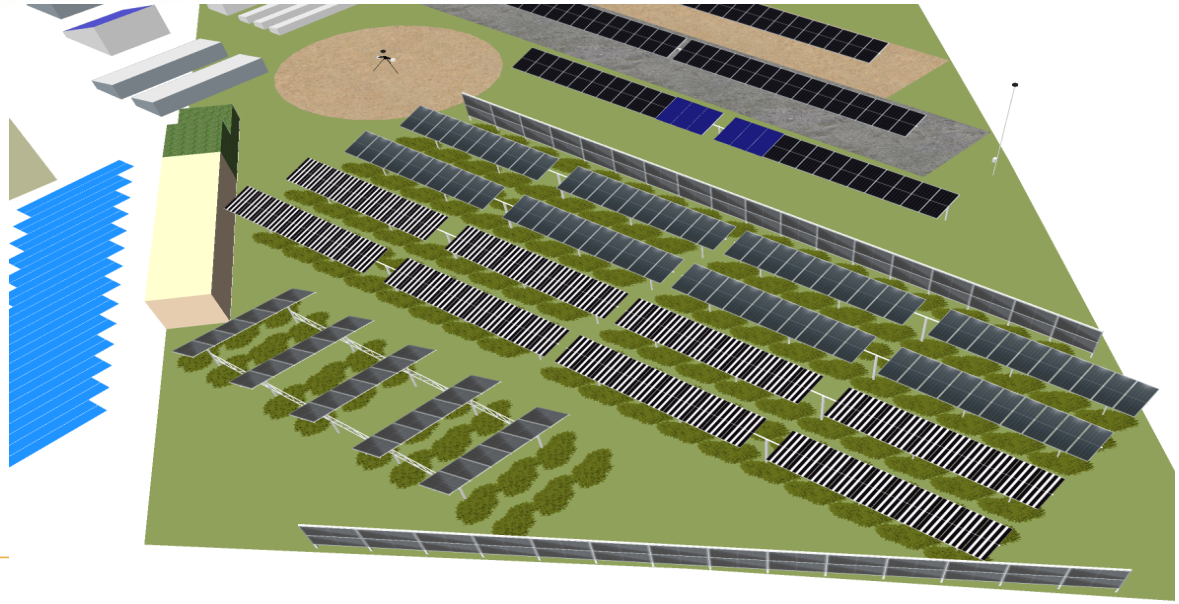
journal homepage: www.elsevier.com/locate/apenergy

An evaluation of the potential of agrivoltaic systems in Brazil

Laís Cassanta Vidotto [a,*], Kathlen Schneider [a,1], Ramom Weinz Morato [b], Lucas Rafael do Nascimento [a], Ricardo Rüther [a]

[a] Solar Energy Research Laboratory Fotovoltaica/UFSC, Universidade Federal de Santa Catarina, 88056-000 Florianópolis, SC, Brazil
[b] Associação Maniva de Certificação Participativa - Opac Maniva, 69058-250 Manaus, AM, Brazil



Ammonium sulfate $(NH_4)_2SO_4$ => Fertiliser for AgriPhotovoltaics
Made with 100% rainwater and solar electricity

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SOLAR ENERGY RESEARCH LABORATORY – FOTOVOLTAICA/UFSC

• PHOTOVOLTAICS • ENERGY STORAGE • SECOND LIFE LI-ION BATTERIES

• ELECTRIC VEHICLES • GREEN HYDROGEN. • AGRIPHOTOVOLTAICS

Everything onsite: From solar electricity + rainwater = green fertiliser

The building itself is an equipment:

1) Hosts electrolyser and Haber-Bosch reactor
2) Collects rainwater for electrolysis
3) Generates solar power to run electrolyser and Haber-Bosch reactor

cooperação alemã DEUTSCHE ZUSAMMENARBEIT

Por meio da giz

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Solar photovoltaics, energy storage, electrical mobility, green hydrogen and agrivoltaics

Prof. Ricardo Rüther - Universidade Federal de Santa Catarina - Laboratório Fotovoltaica/UFSC
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