



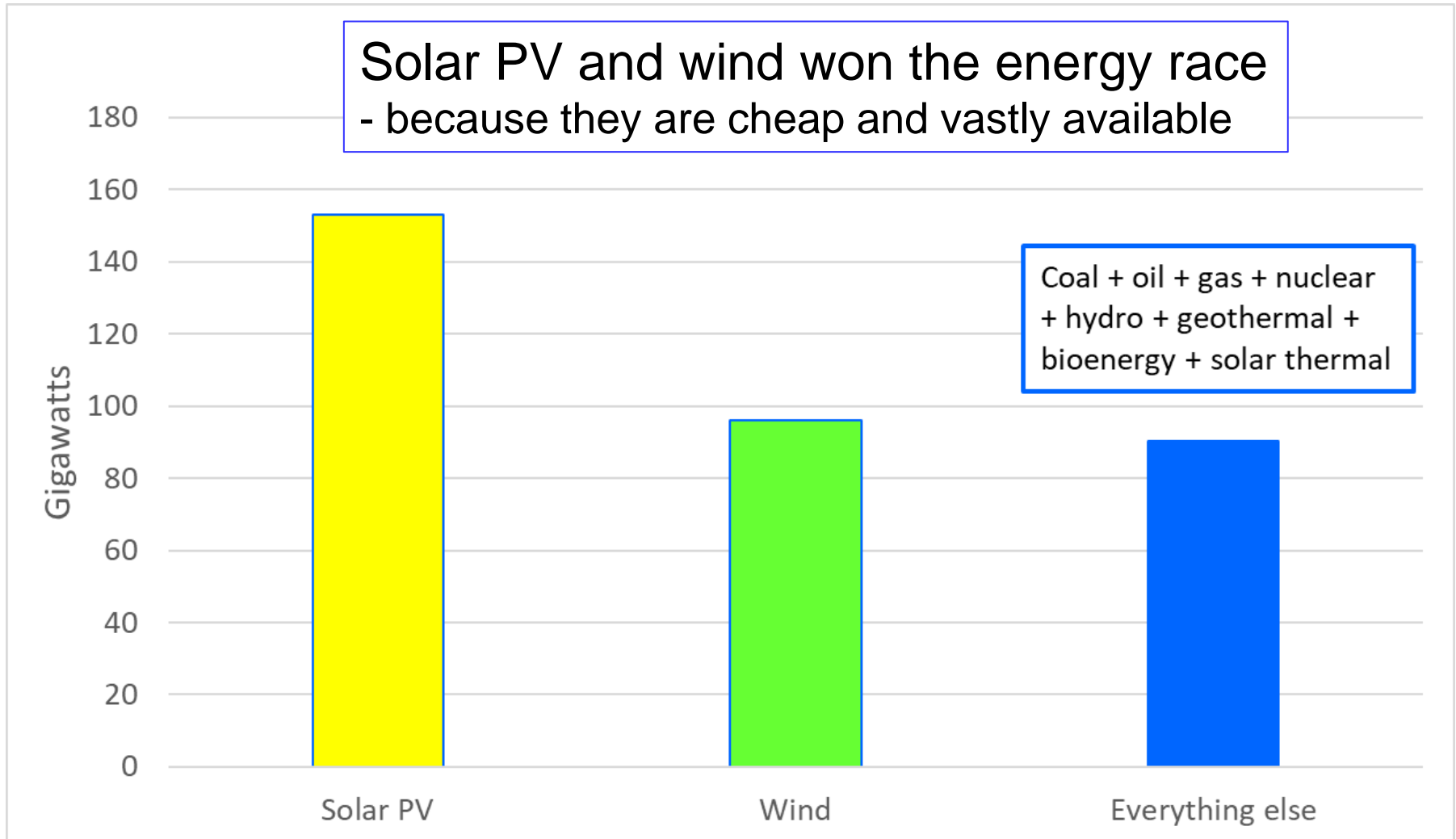
# **Storage and transmission to support rapid growth of renewable energy**

Andrew Blakers

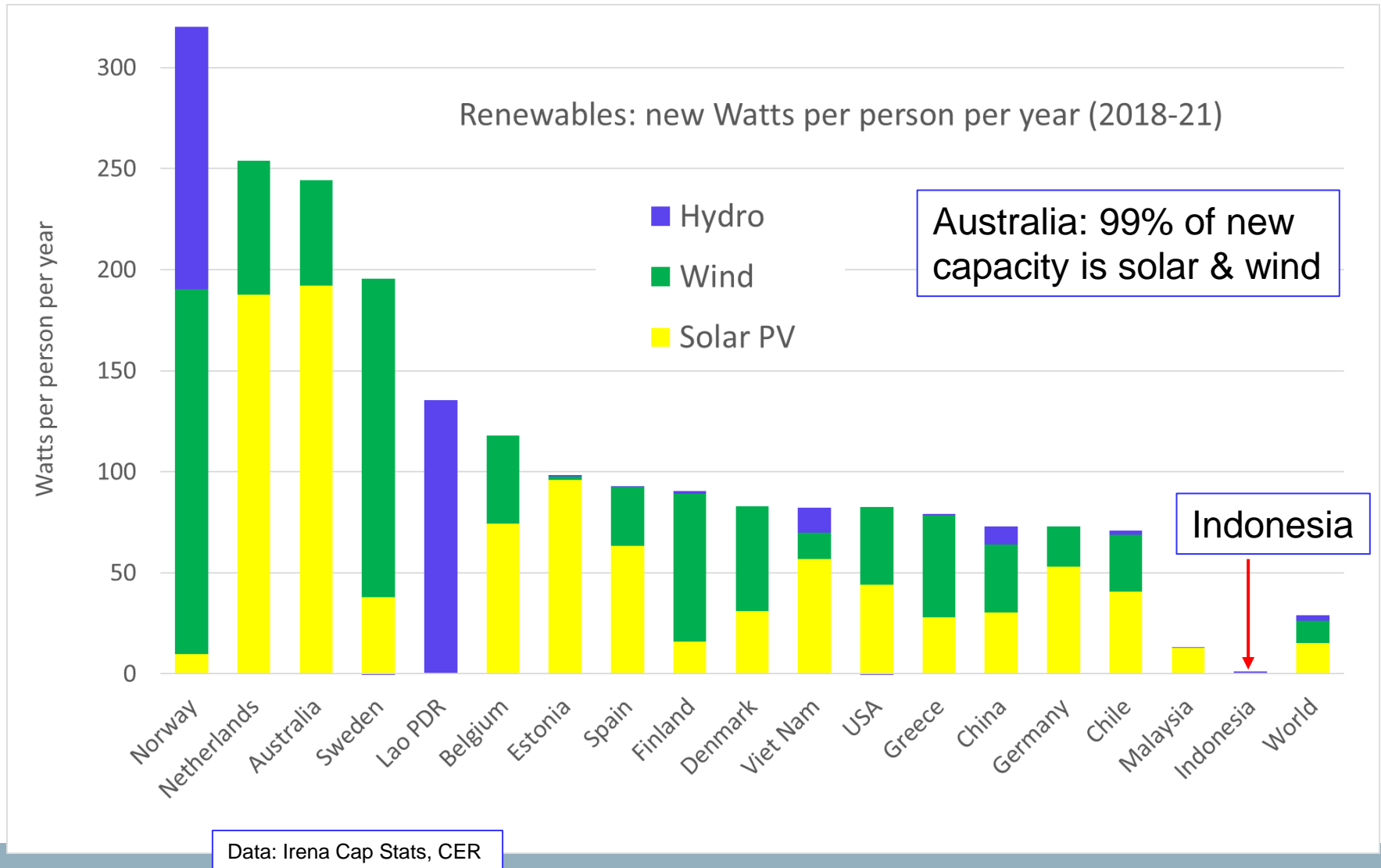
Australian National University

<http://re100.eng.anu.edu.au/>

# Global net new generation capacity in 2021



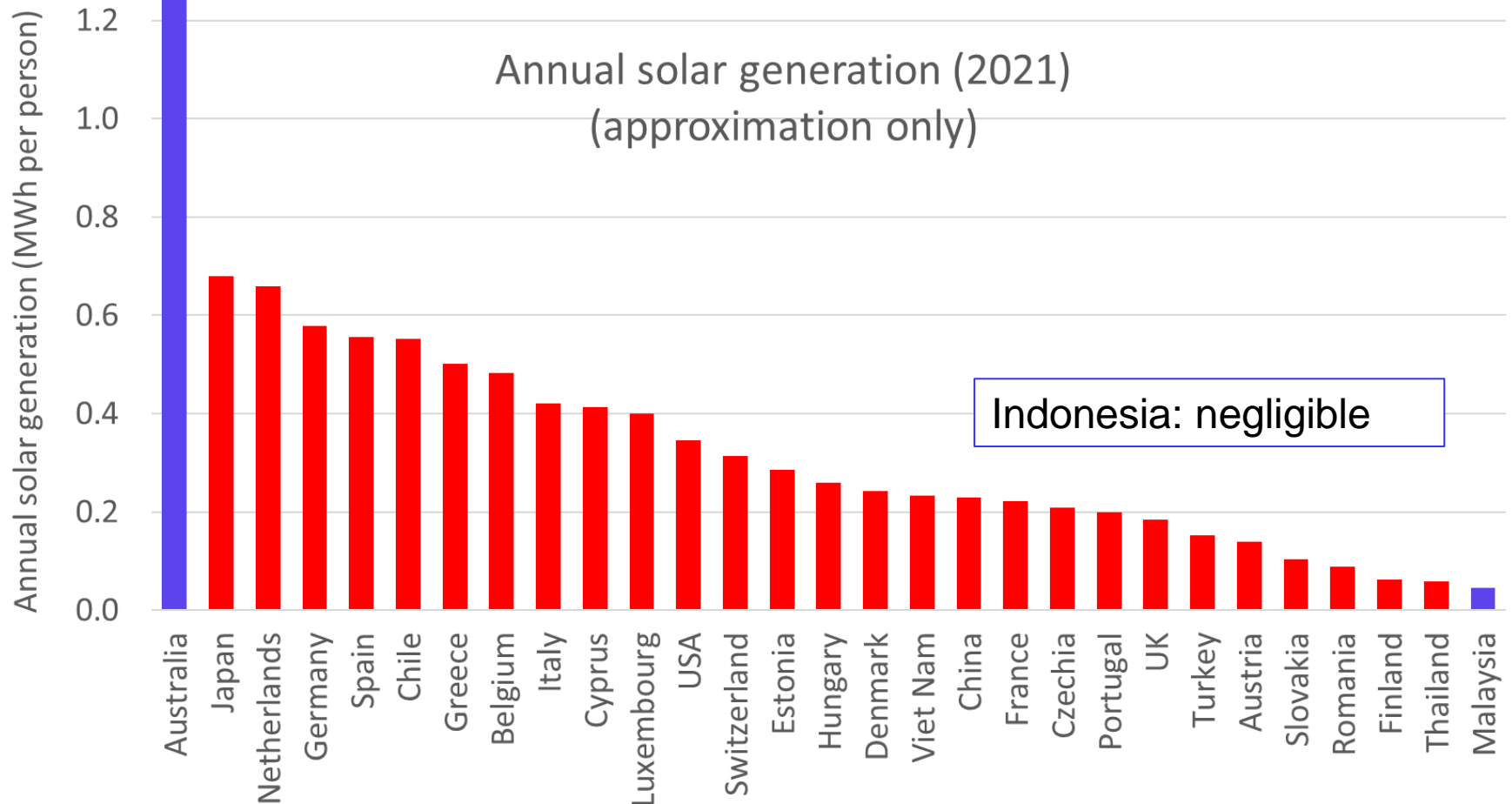
# Renewables deployment speed per person



# Solar generation per person per year

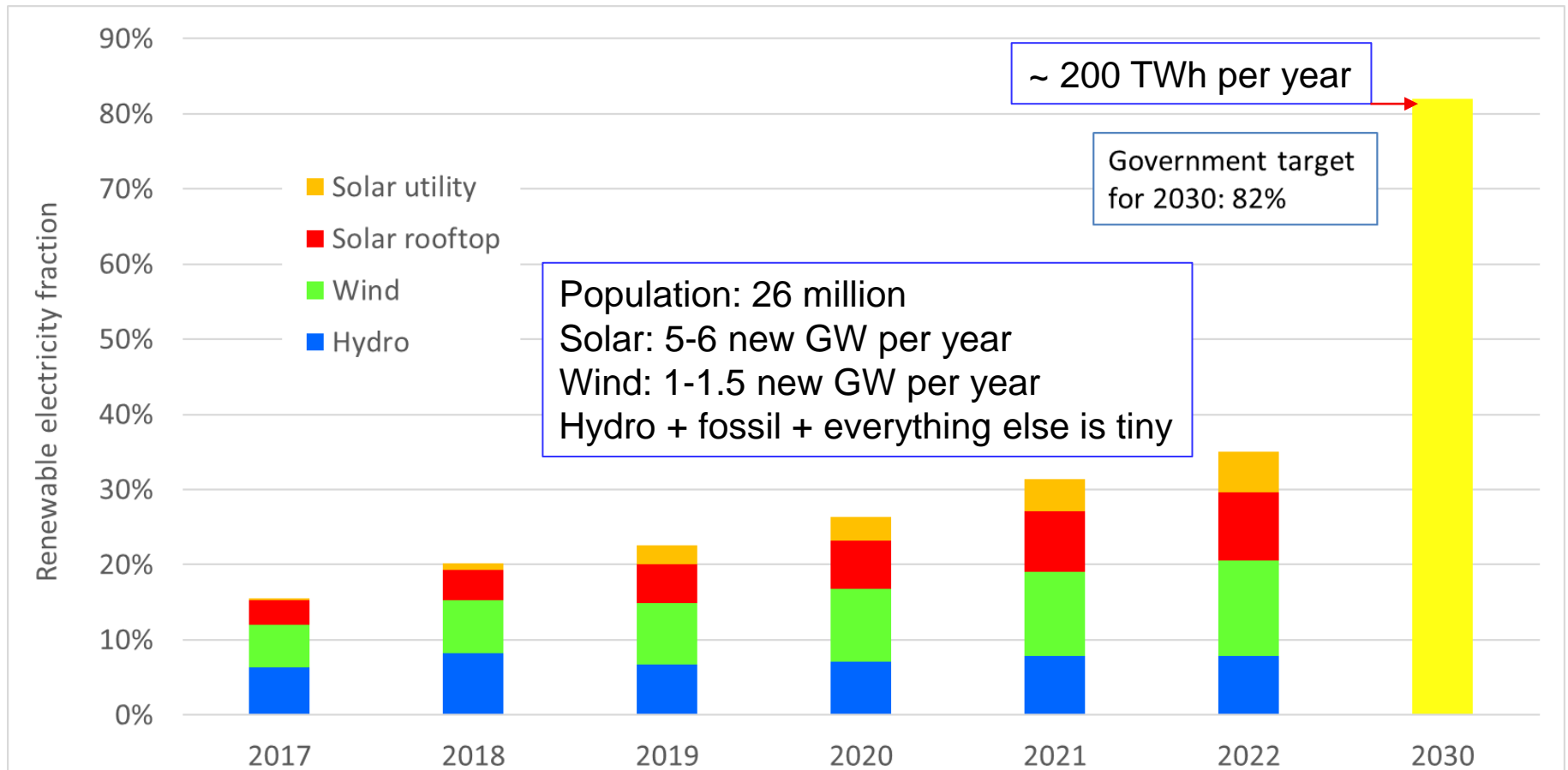
Australia: global solar pathfinder

Annual solar generation (2021)  
(approximation only)



Indonesia: negligible

# Australian renewable electricity fraction



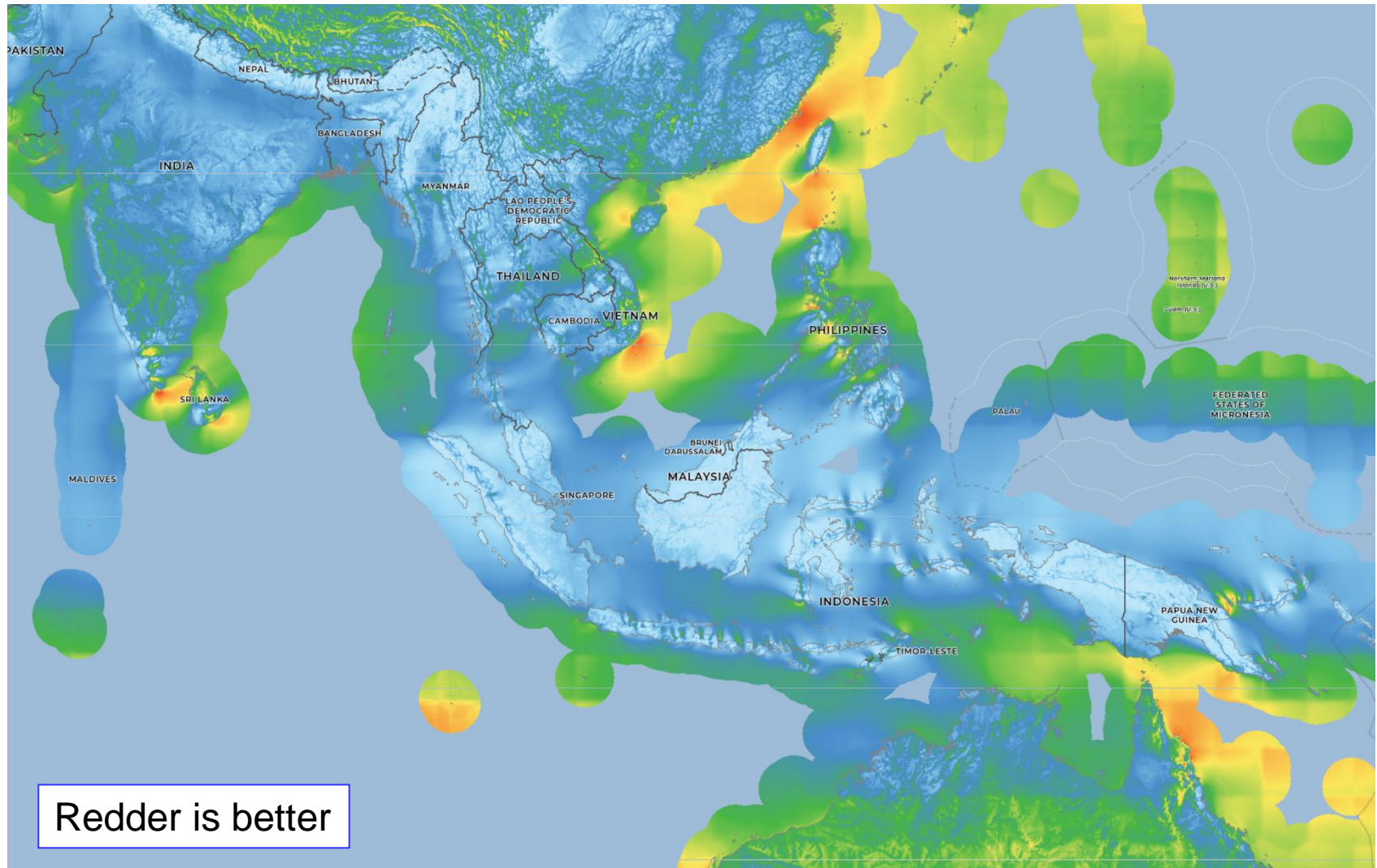


Bigger than all utility batteries  
in the world put together

## Facts on the ground: new Australian energy infrastructure

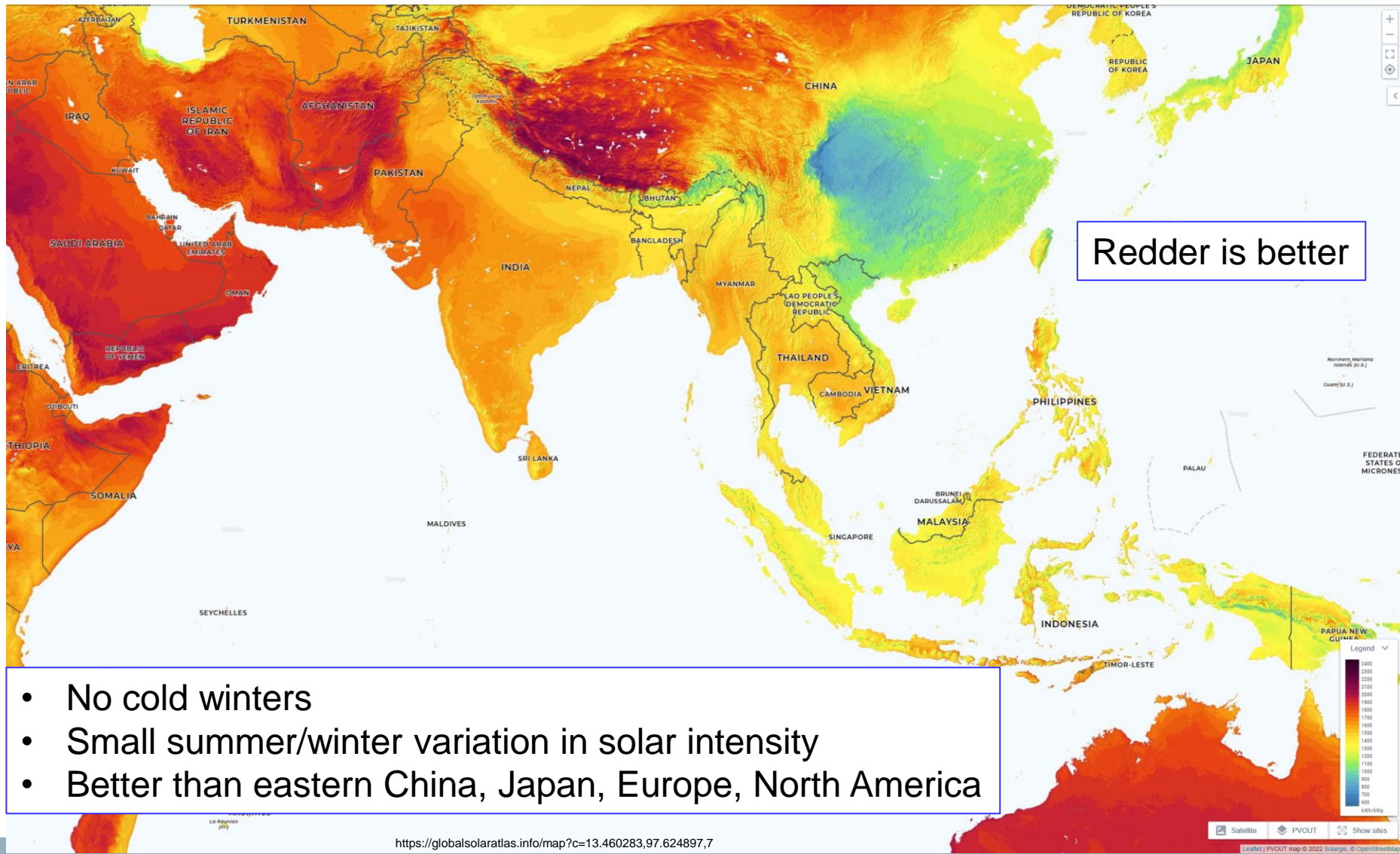
	Technology	Power (GW)	Energy (GWh)	Comments
<u>Tumut 3</u>	Pumped hydro	0.6/1.8	60	Existing
<u>Kangaroo Valley</u>	Pumped hydro	0.2	<1	Existing
<u>Wivenhoe</u>	Pumped hydro	0.6	6	Existing
<u>Snowy 2.0</u>	Pumped hydro	2.0	350	Under construction
<u>Kidston</u>	Pumped hydro	0.3	2	Under construction
<u>Battery of the Nation</u>	Pumped hydro	0.6-2.5	6-25	Detailed planning
Baroota, Borumba, Lake Lyell, Oven Mtn, Yetholme, Cultana, Dungowan, Fassifern, Highbury, Goat Hill, Kanmantoo, Middleback Ranges	Pumped hydro	0.1-1 each	1-10 each	Feasibility studies and detailed planning
No new dams on rivers				
<u>Utility combined</u>	Batteries	2.0	2	Existing
<u>Household combined</u>	Batteries	-	1	Existing
<u>EV combined</u>	Batteries	-	1	Existing
<u>Marinus Link</u>	Transmission	1.5	-	Detailed planning
<u>Energy Connect</u>	Transmission	0.8	-	Approved
HumeLink, QNI, VNI, VNI-West, Central-West Orana REZ, Snowy 2.0 connection and others	Transmission			Feasibility studies and detailed planning

# Indonesia has small wind potential



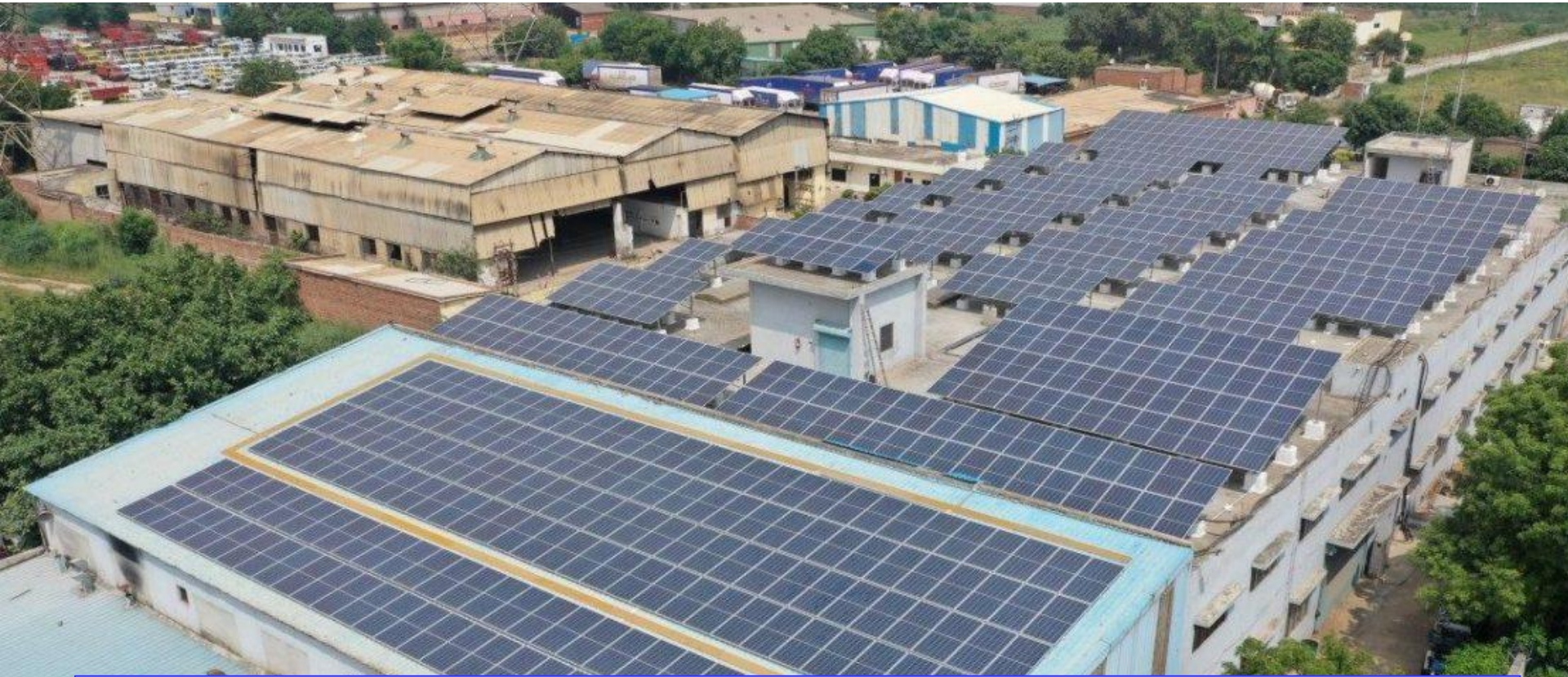


# ASEAN's large solar resource





# Solar panels on rooftops of houses and commercial buildings



- Australia (population 26 million) has 3 million solar rooftops
- 3-4 GW per year of new rooftop solar systems
- Cost of electricity: **US\$30-40/MWh** [one quarter of retail tariffs]



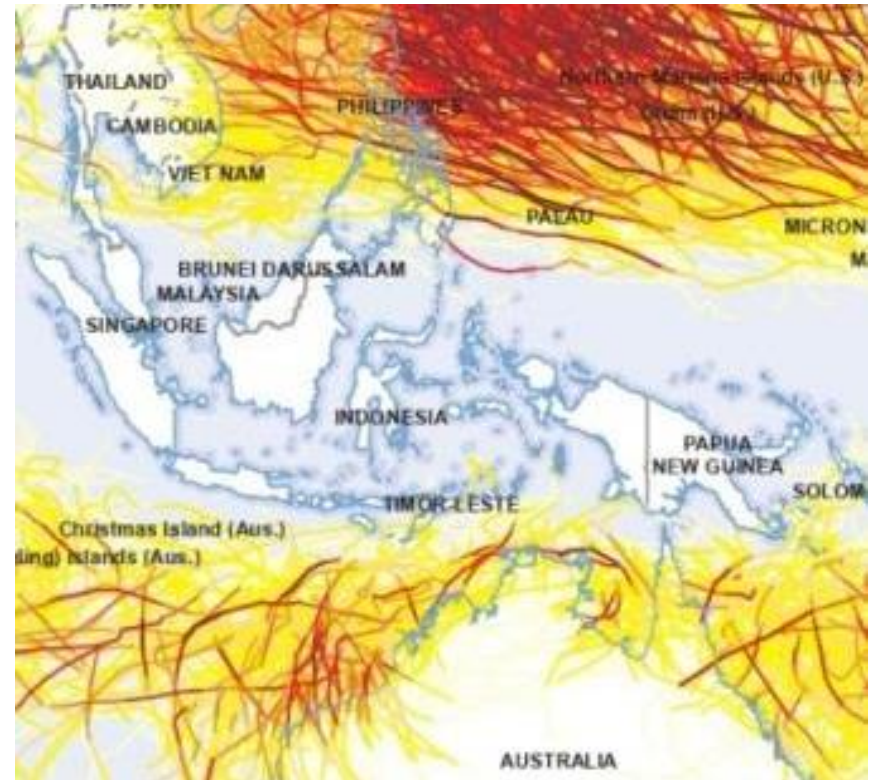
# Agrivoltaics

- Billions of solar panels in agricultural regions
- A few percent shading of crops and pasture  
→ small loss of food production



# Floating solar

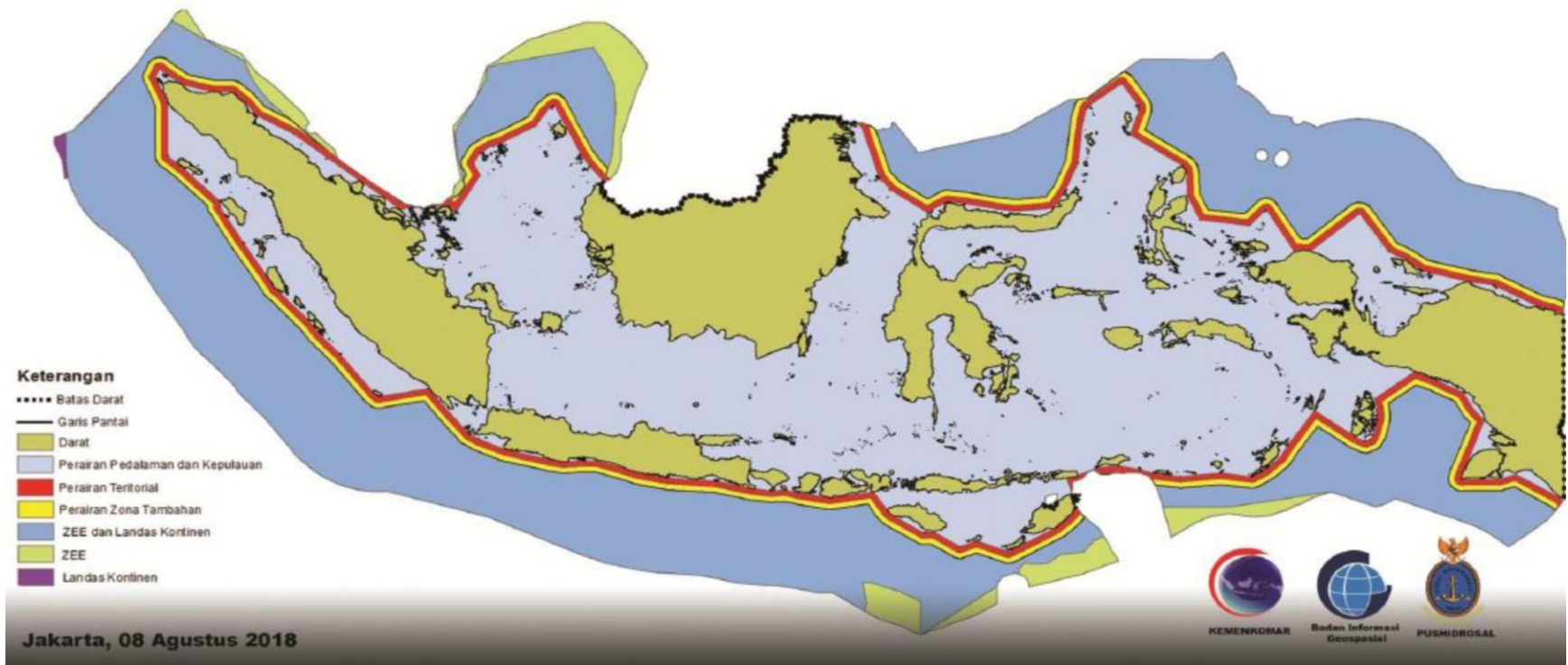
- Onshore
- Offshore





# Indonesia's vast floating solar resource

- Enough calm tropical sea to power the entire world
- 140,000 Gigawatts and 180,000 Terawatt-hours



# Off-river pumped hydro energy storage

Head: 500 m

Water volume: 6 Gigalitres

Combined reservoir area: 1 km<sup>2</sup>

1 GW power rating (6 hours)

Upper reservoir

Lower reservoir

Presenzano, Italy

Google Earth





# ANU's global **off-river** pumped hydro atlas

<http://re100.eng.anu.edu.au/global/index.php>

616,000 off-river sites (60°N to 56°S)

23 million Gigawatt-hours (1 million GW \* 23 hours)

All outside national parks & urban areas

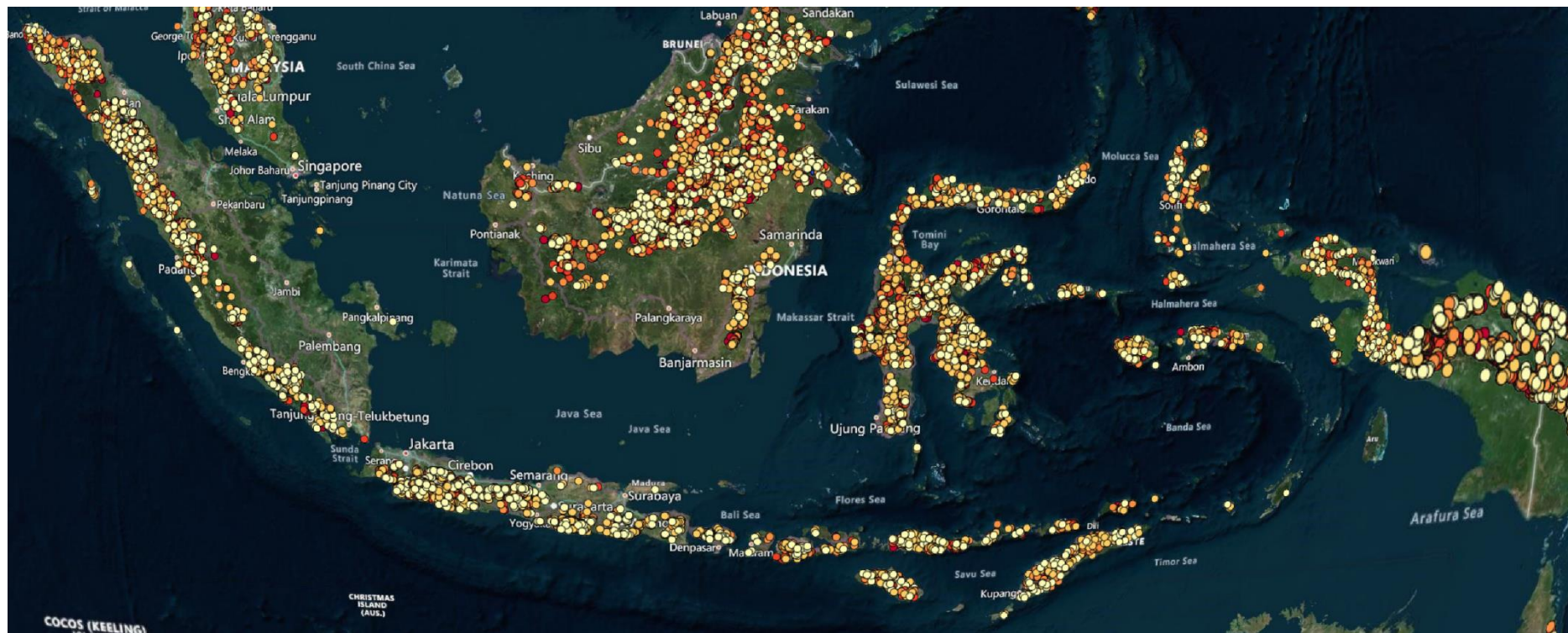




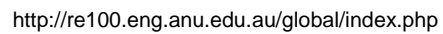
# Pumped hydro storage in Indonesia

26,000 sites, 821 Terawatt-hours

**100X** more than needed to support 100% renewable electricity









# 3-D image + information pop-up



# Key points

- Solar PV will dominate global and Indonesian energy
- Overnight storage is a solved problem
  - pumped hydro
  - batteries
- Indonesia
  - unlimited solar
  - unlimited pumped hydro storage
- Australia is the global solar pathfinder
  - Indonesia can rapidly follow Australia