Storage and transmission to support rapid growth of renewable energy

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http://re100.eng.anu.edu.au/
Global net new generation capacity in 2021

Solar PV and wind won the energy race - because they are cheap and vastly available

Coal + oil + gas + nuclear + hydro + geothermal + bioenergy + solar thermal

Renewables deployment speed per person

Renewables: new Watts per person per year (2018-21)

Australia: 99% of new capacity is solar & wind

Data: Irena Cap Stats, CER
Solar generation per person per year

Australia: global solar pathfinder

Annual solar generation (2021)
(approximation only)

Indonesia: negligible
Australian renewable electricity fraction

Population: 26 million
Solar: 5-6 new GW per year
Wind: 1-1.5 new GW per year
Hydro + fossil + everything else is tiny

Clean Energy Regulator

Government target for 2030: 82%

~ 200 TWh per year
### Facts on the ground: new Australian energy infrastructure

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<th>Technology</th>
<th>Power (GW)</th>
<th>Energy (GWh)</th>
<th>Comments</th>
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<tr>
<td>Tumut 3</td>
<td>Pumped hydro</td>
<td>0.6/1.8</td>
<td>Existing</td>
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<tr>
<td>Kangaroo Valley</td>
<td>Pumped hydro</td>
<td>0.2</td>
<td>Existing</td>
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<tr>
<td>Wivenhoe</td>
<td>Pumped hydro</td>
<td>0.6</td>
<td>Existing</td>
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<tr>
<td>Snowy 2.0</td>
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<td>2.0</td>
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<tr>
<td>Kidston</td>
<td>Pumped hydro</td>
<td>0.3</td>
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<td>Battery of the Nation</td>
<td>Pumped hydro</td>
<td>0.6-2.5</td>
<td>Detailed planning</td>
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<td>Baroota, Borumba, Lake Lyell, Oven Mtn, Yetholme, Cultana, Dungowan, Fassifern, Highbury, Goat Hill, Kanmantoo, Middleback Ranges</td>
<td>Pumped hydro</td>
<td>0.1-1 each</td>
<td>Feasibility studies and detailed planning</td>
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<tr>
<td>Utility combined</td>
<td>Batteries</td>
<td>2.0</td>
<td>Existing</td>
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<tr>
<td>Household combined</td>
<td>Batteries</td>
<td>-</td>
<td>Existing</td>
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<td>EV combined</td>
<td>Batteries</td>
<td>-</td>
<td>Existing</td>
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<tr>
<td>Mariner Link</td>
<td>Transmission</td>
<td>1.5</td>
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<tr>
<td>Energy Connect</td>
<td>Transmission</td>
<td>0.8</td>
<td>Approved</td>
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<tr>
<td>HumeLink, QNI, VNI, VNI-West, Central-West Orana REZ, Snowy 2.0 connection and others</td>
<td>Transmission</td>
<td>-</td>
<td>Feasibility studies and detailed planning</td>
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</tbody>
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*Bigger than all utility batteries in the world put together*

*No new dams on rivers*
Indonesia has small wind potential

Redder is better

https://globalwindatlas.info/
ASEAN’s large solar resource

- No cold winters
- Small summer/winter variation in solar intensity
- Better than eastern China, Japan, Europe, North America
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 km²
1 GW power rating (6 hours)

Presenzano, Italy
ANU’s global off-river pumped hydro atlas


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

Zooming in

50 GWh sites

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