



Sandia National Laboratories



Energy Transformation: It Can Happen Faster Than You Think!

South Australia as a Case Study

Abraham Ellis | June 27, 2023



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- ❖ The case study describes the ongoing rapid energy transition in South Australia.
- ❖ Many of the illustrations were compiled from presentations given at the 2022 IRED conference in Adelaide, accessible here: <https://research.csiro.au/ired2022/>



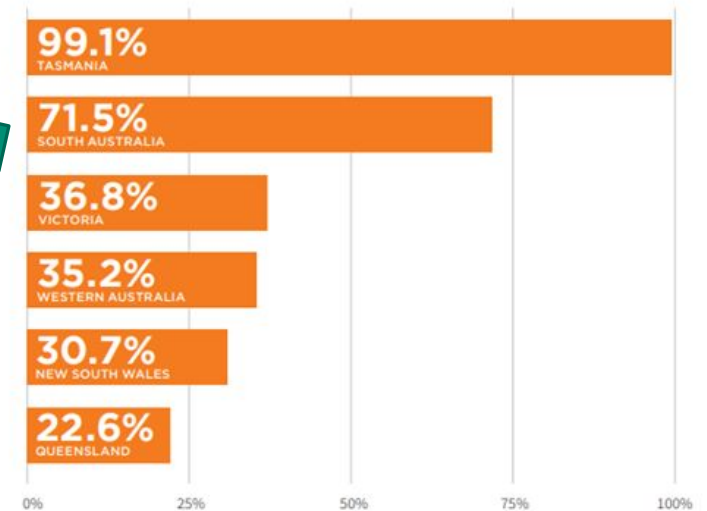
- ❖ Alaska is charting its own path to energy transformation that reflects unique challenges and opportunities

Province of South Australia



- ❖ Area is ~57% of the size of Alaska AK
- ❖ 1.8 million in 2020 (**2.5X** that of AK), highly concentrated in Adelaide (77%)
- ❖ Latitude: 26° to 38° S (Anchorage at ~61° N)
- ❖ Leads states in renewable energy generation
- ❖ State Target: 100% RE by 2030

Renewable energy
penetration by state as
proportion of generation

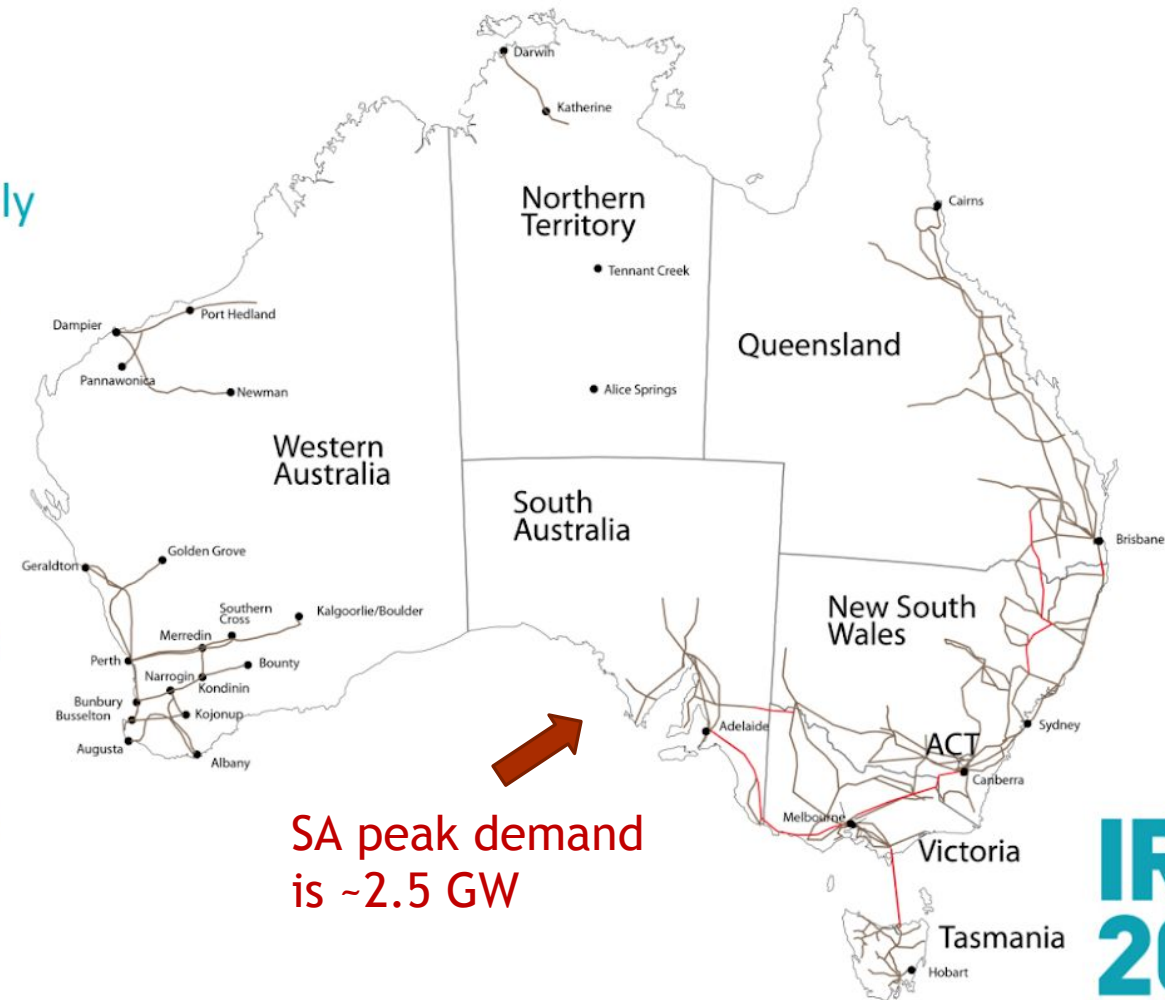


Source:
<https://assets.cleanenergycouncil.org.au/documents/Clean-Energy-Australia-Report-2023.pdf>

Australia's Electric Systems



- Eastern interconnection (NEM)
 - 56 GW of electricity generation capacity
 - 15 - 35 GW demand
 - 5 minute generation dispatch, Energy-Only market, since 1998
 - Security constrained economic dispatch, with co-optimised energy and ancillary services
- WEM for SWIS
 - 5.8GW of electricity generation capacity
 - comprises a wholesale electricity trading component and a capacity component.
- Significant increase in wind, solar and battery connections. (NEM: 15GW small solar, 7GW wind, 4GW large solar)

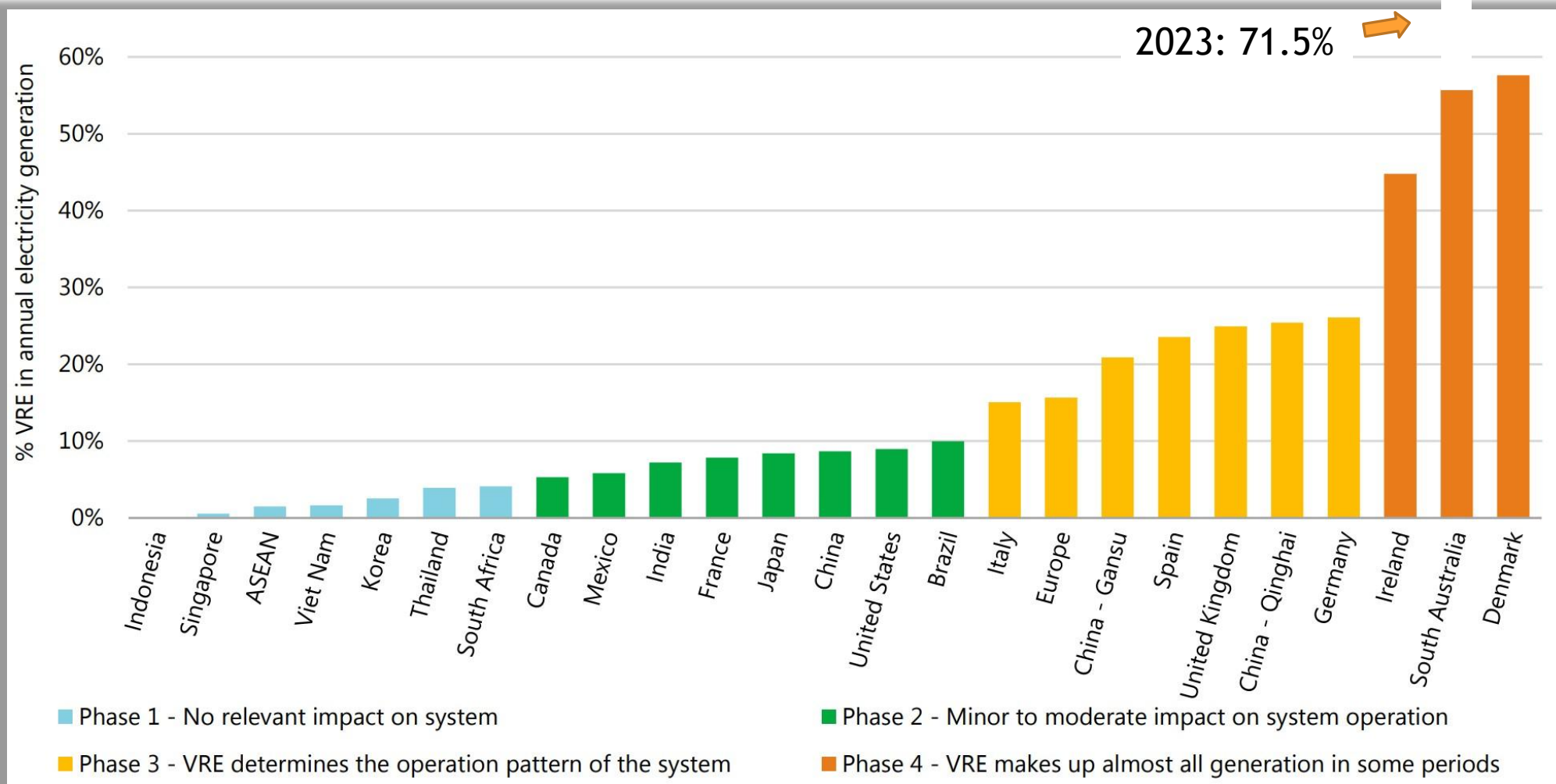


**IRED
2022**

9TH INTERNATIONAL CONFERENCE
INTEGRATION OF RENEWABLE
& DISTRIBUTED ENERGY RESOURCES

Source: CSIRO, John Hard, IRED 2022, 9th International Conference Integration or Renewable & Distributed Energy Resources

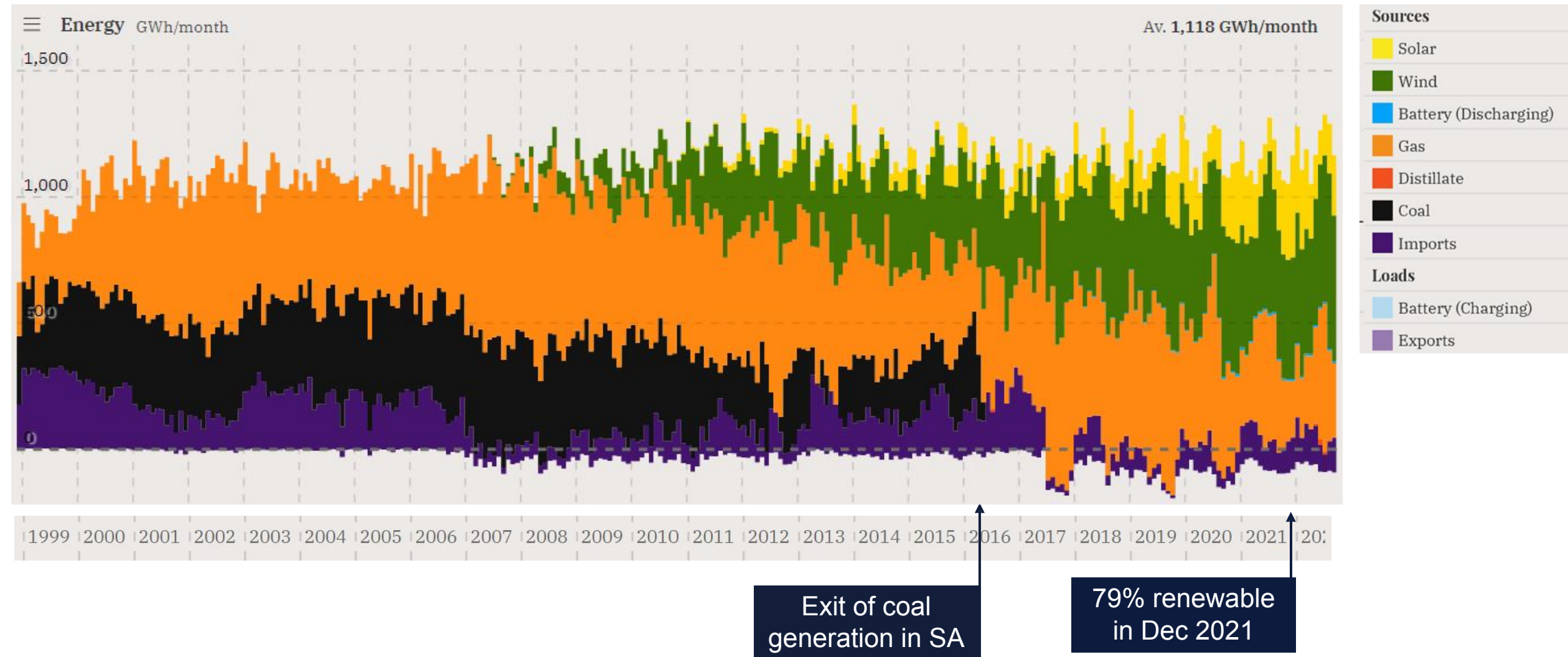
Pushing the limits on VRE penetration



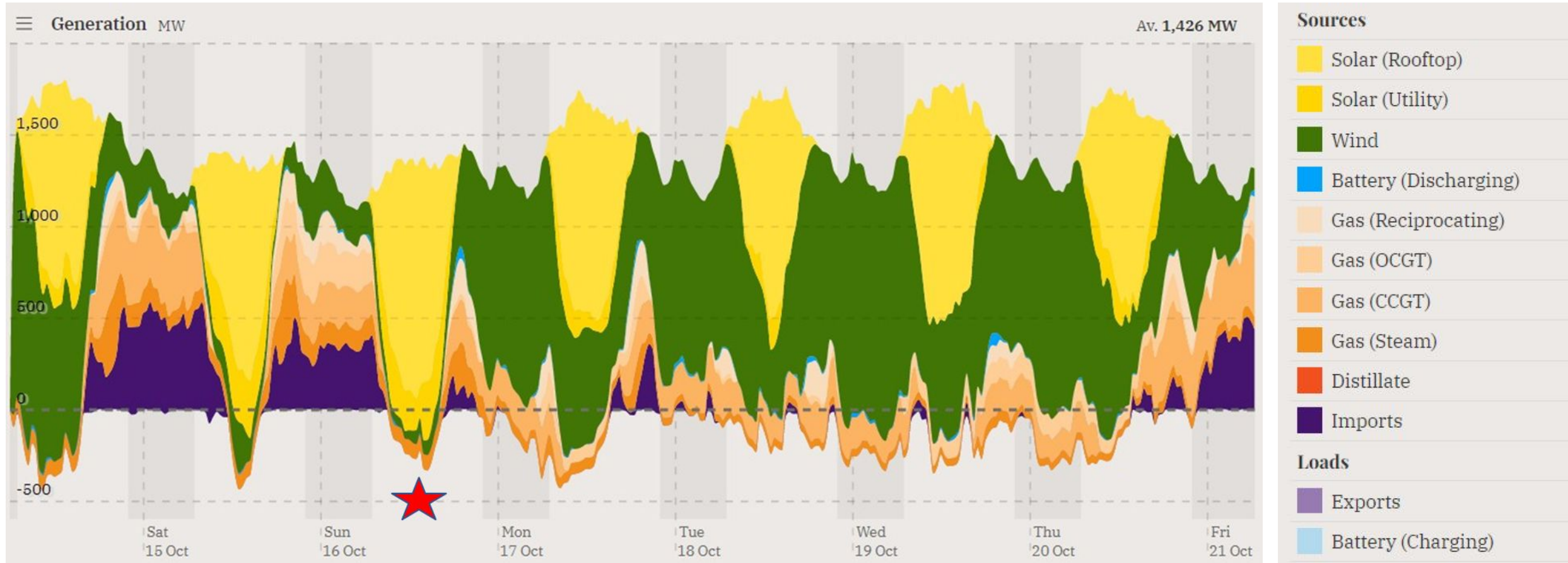
Source: IEA, Secure Energy Transitions in the Power Sector, 2021. Note China = The People's Republic of China

What can we learn from SA's experience?

It can happen fast!



Dealt with difficult operational challenges



Sunday 16 Oct 2022

- New minimum operational state demand record of 100MW (after rooftop solar), lowering last year's record by 4MW
- New solar PV generation record of 116.7% of state demand, beating last year's record of 110%
- 76.2% renewable energy generation for the week (note the record of 88.3%, 17 –23 January 2022)

Incentivized flexibility by wind/solar & storage

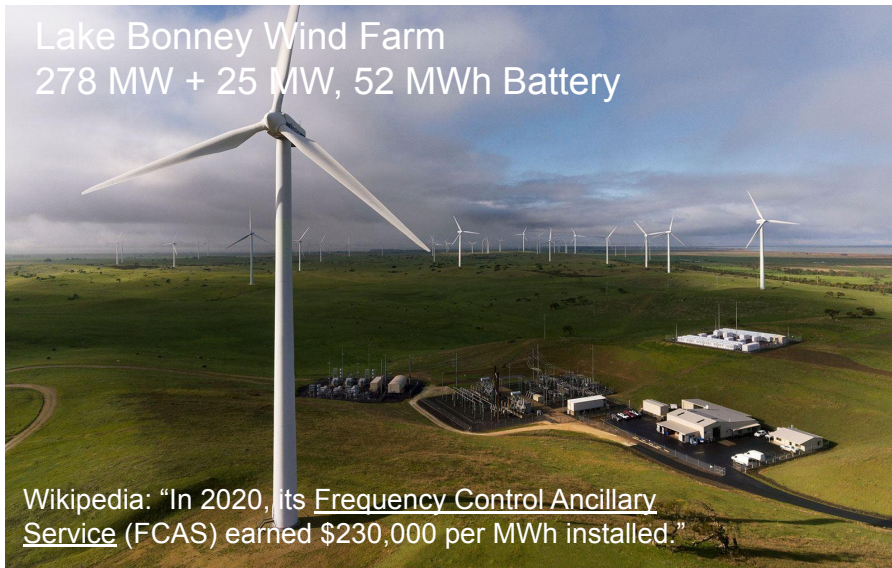


Tesla's Big Battery at Hornsdale Power Reserve
150 MW, 193.5 MWh

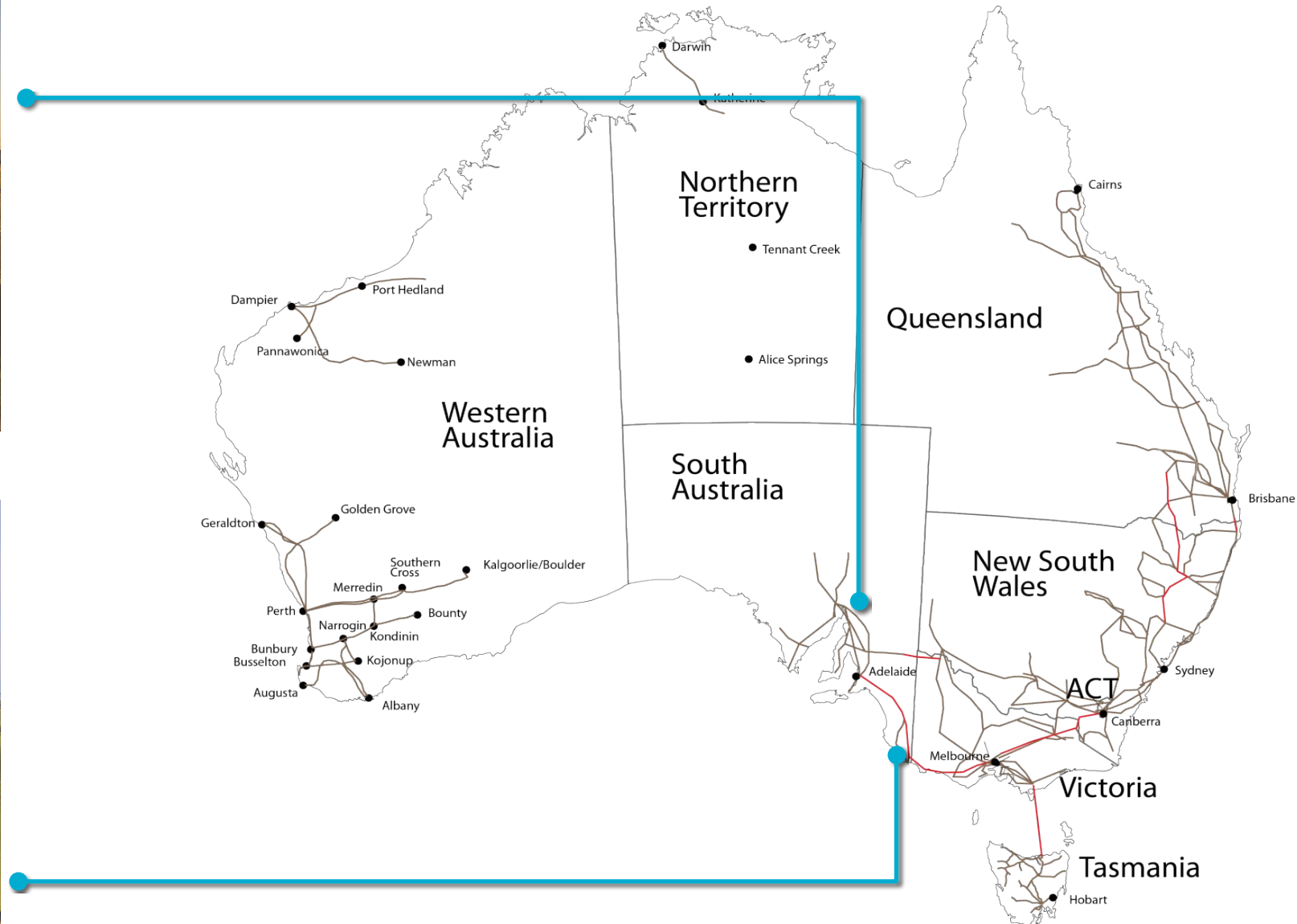


"70% of HPR's output is reserved to prevent load shedding and provide system security services." PV Magazine, Dec 5, 2018

Lake Bonney Wind Farm
278 MW + 25 MW, 52 MWh Battery



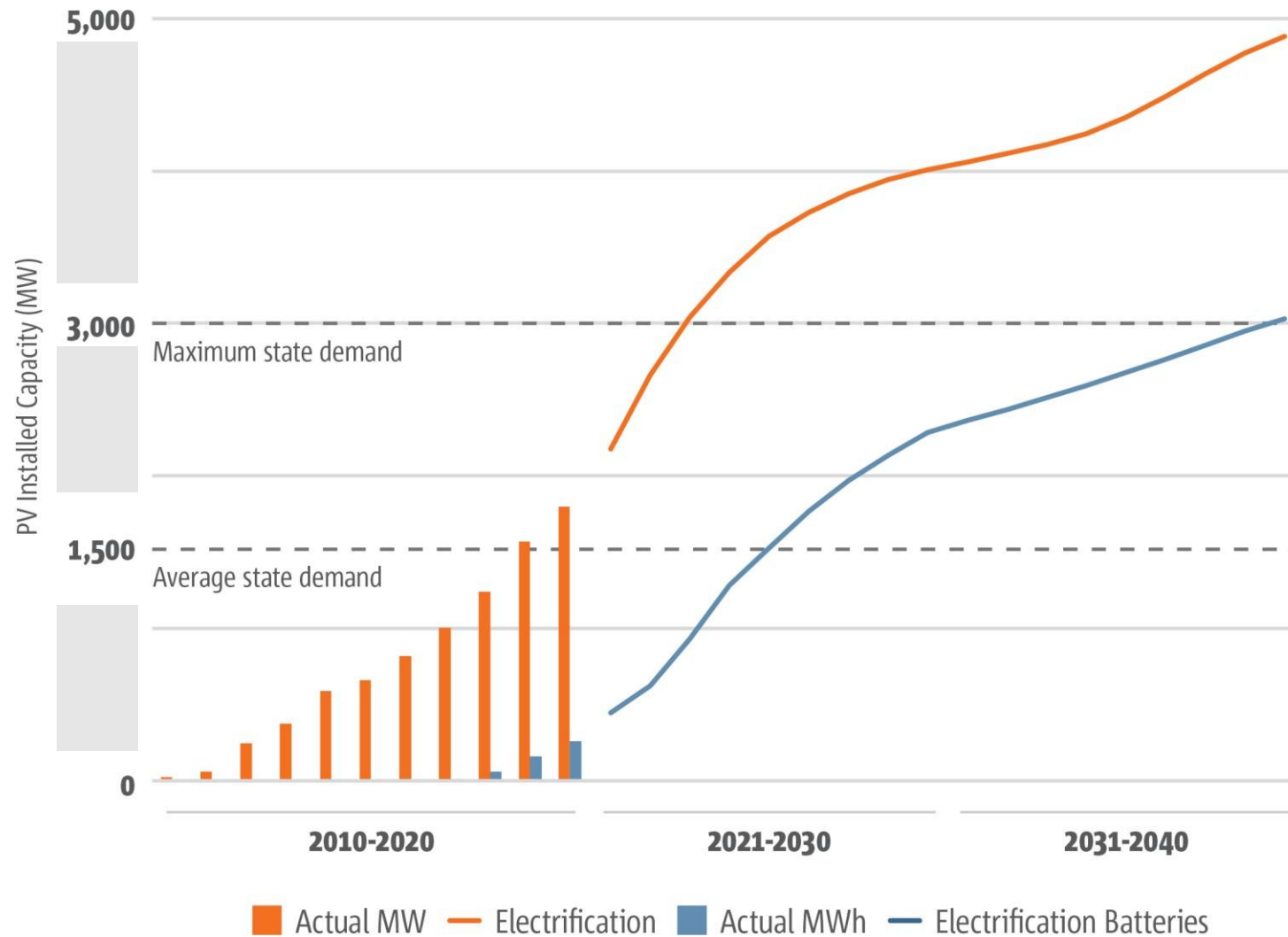
Wikipedia: "In 2020, its Frequency Control Ancillary Service (FCAS) earned \$230,000 per MWh installed."



... and also promoted grid-friendly DER!



SA Forecasts AEMO ESOO 2021



~300,000 Rooftop solar systems

>1 in 3 customers, world's highest

State's largest generator

Record growth continues

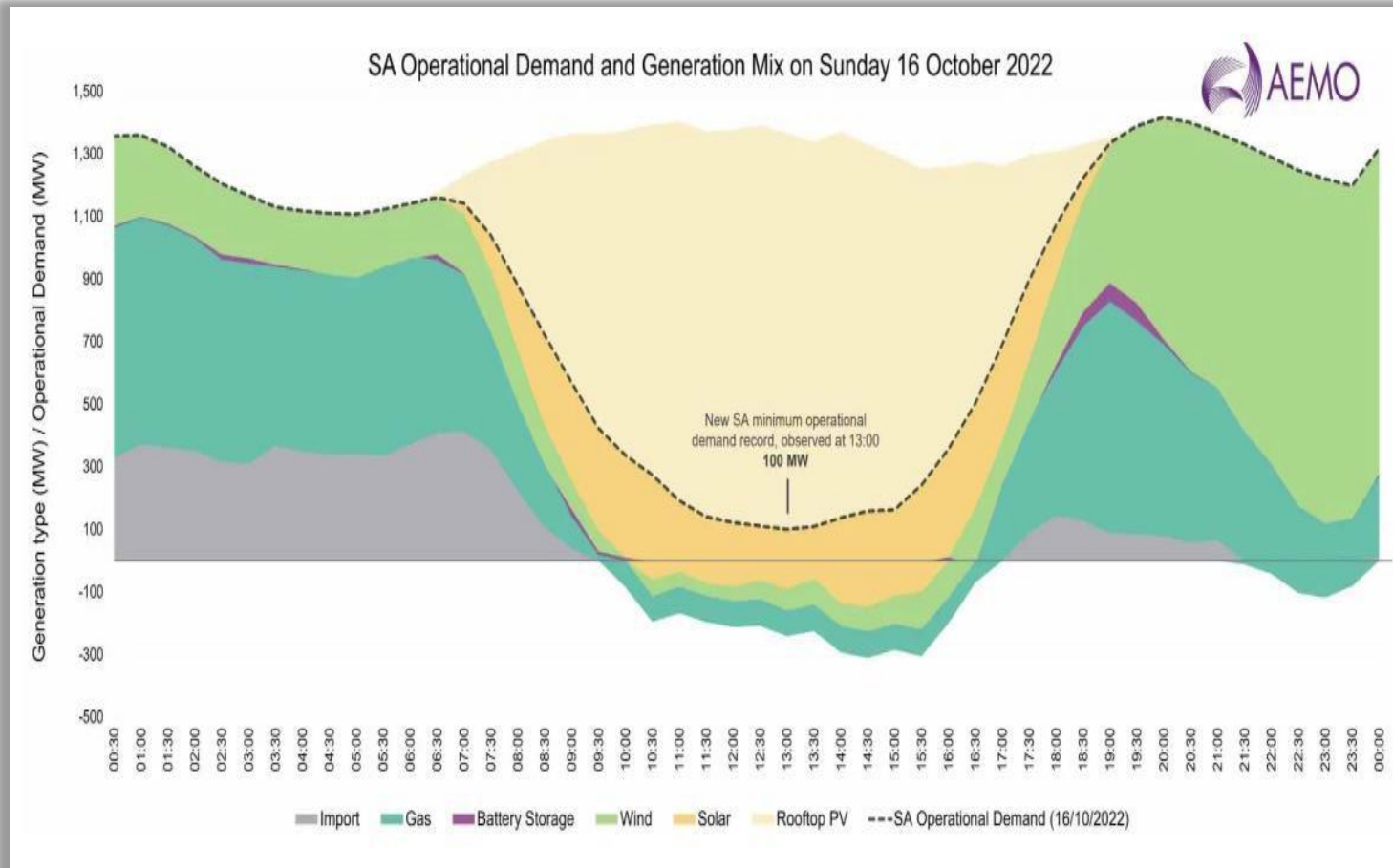


~30,000 Home batteries

9 Virtual Power Plants operating in SA

Source: SAPN

Supply flexibility is critical for security/reliability



Source: SAPN



It sure helps to have strong connections!



Source: Neoen



Source: SMA

Technology innovation has been key...

SA as a test bed for leading edge concepts



Source: ElectraNet



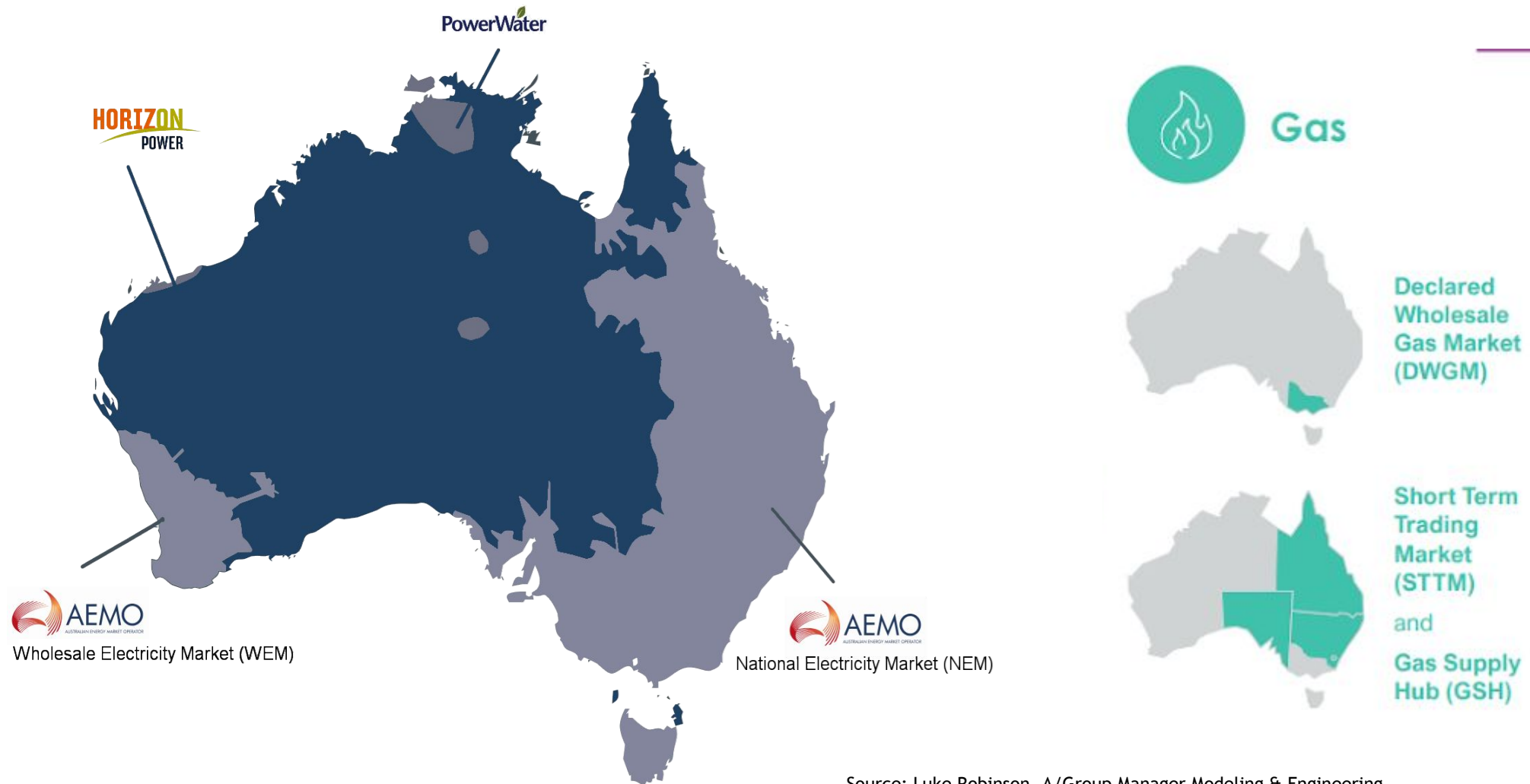
Source: Wärtsilä

- Grid scale batteries
- Home batteries & VPPs
- Synchronous condensers
- Fast gas

The institutional foundations are also critical



Decisive, well-functioning, innovation-friendly Policy, Regulatory & Market Constructs



Source: Luke Robinson. A/Group Manager Modeling & Engineering

Is RE increasing electricity costs?



It's complicated... Wholesale electricity prices are driven more by the cost of natural gas.

SA Inflation Adjusted Average Wholesale Electricity Prices
In Cents Per kWh & Percentage Of Renewable Generation



Average SA Wholesale Electricity Price In
Cents Per kWh & Gas Price In \$ Per GJ

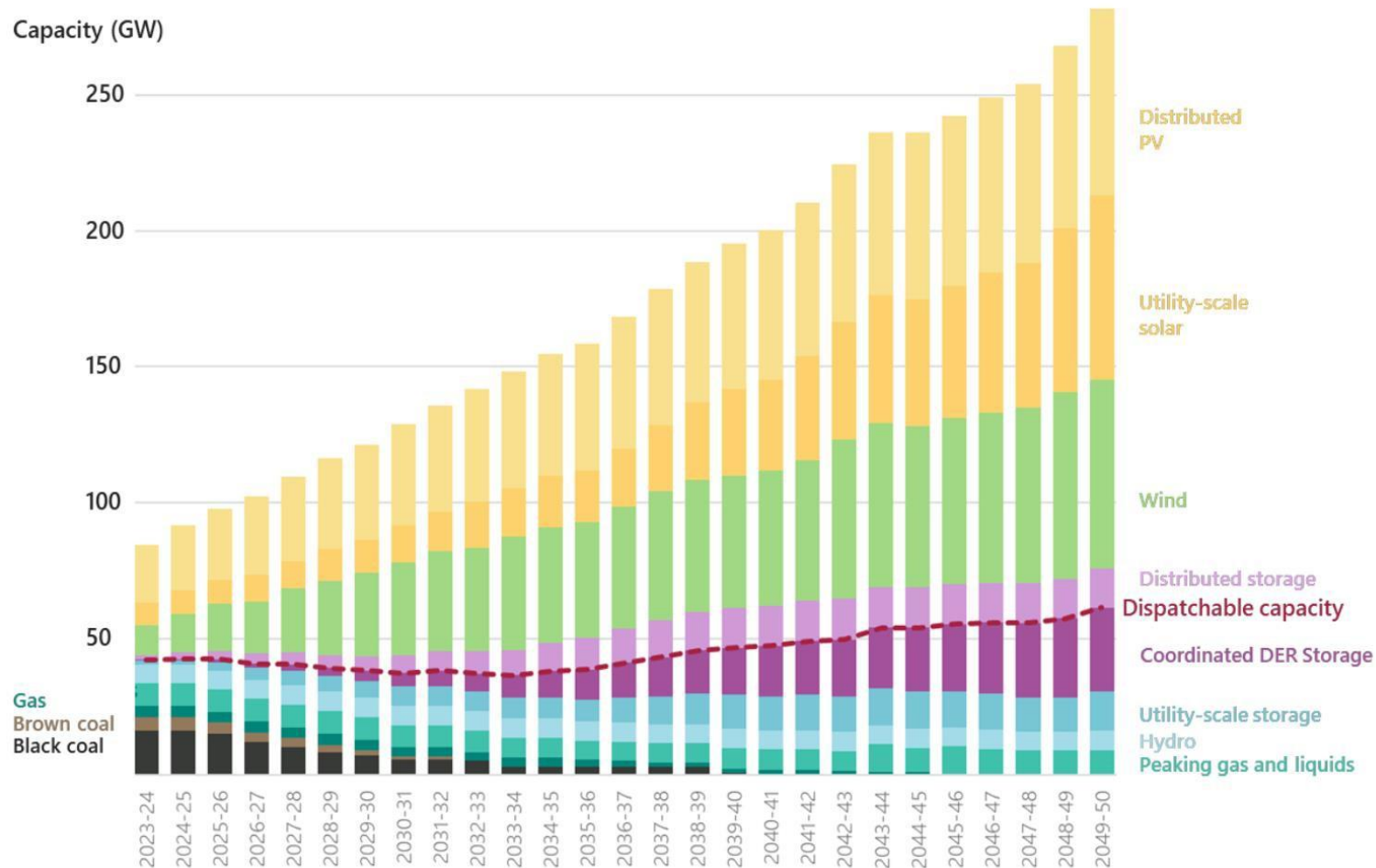


Source: <https://www.solarquotes.com.au/blog/cheap-renewables-expensive-electricity/>

What's next? More RE (mainly solar) and storage



Figure 1 Forecast NEM capacity to 2050, Step Change scenario, with transmission



AEMO ISP (2050):

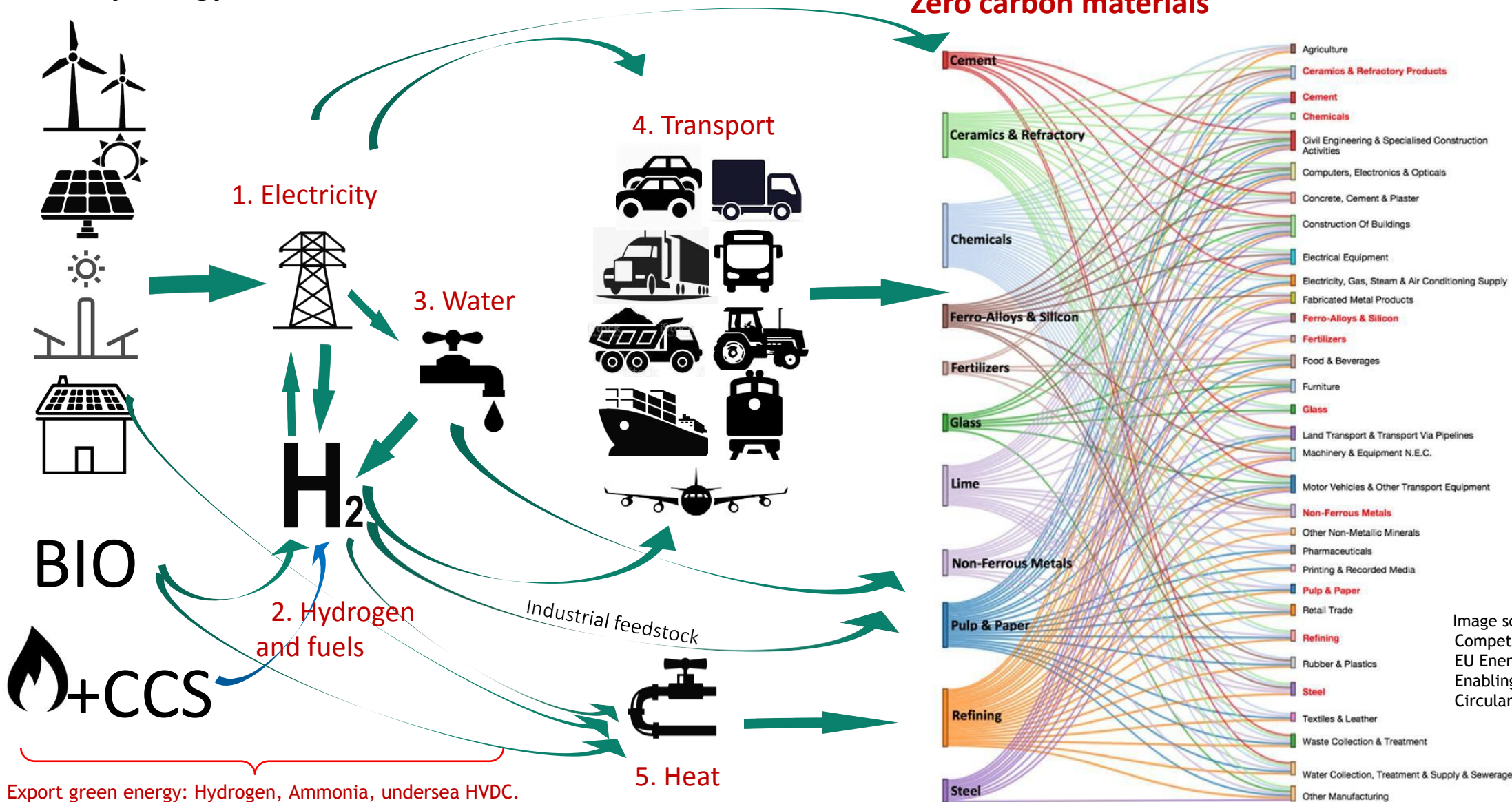
- **5x** Distributed Solar
- **9x** Large Scale Solar
- **30x** Storage
- **2x** Electricity usage !

Source: IRED 2022, 9th International Conference Integration of Renewable & Distributed Energy Resources

2X electricity usage by 2050.



Primary energy Energy carriers / fuel inputs into the economy Zero carbon materials Zero carbon industries & exports



Looking out for Consumers



“For the changes that we see as necessary to become reality, requires **a kind of grand bargain** between consumers and those who run the system.”

“Consumers care most about affordability.”

“Least cost also means unlocking the potential of the demand side.”

“Energy inclusion is essential to our energy transformation... The first thing is nobody gets left behind.”

“Delivering a transition with affordability for all requires optimizing consumer participation.”

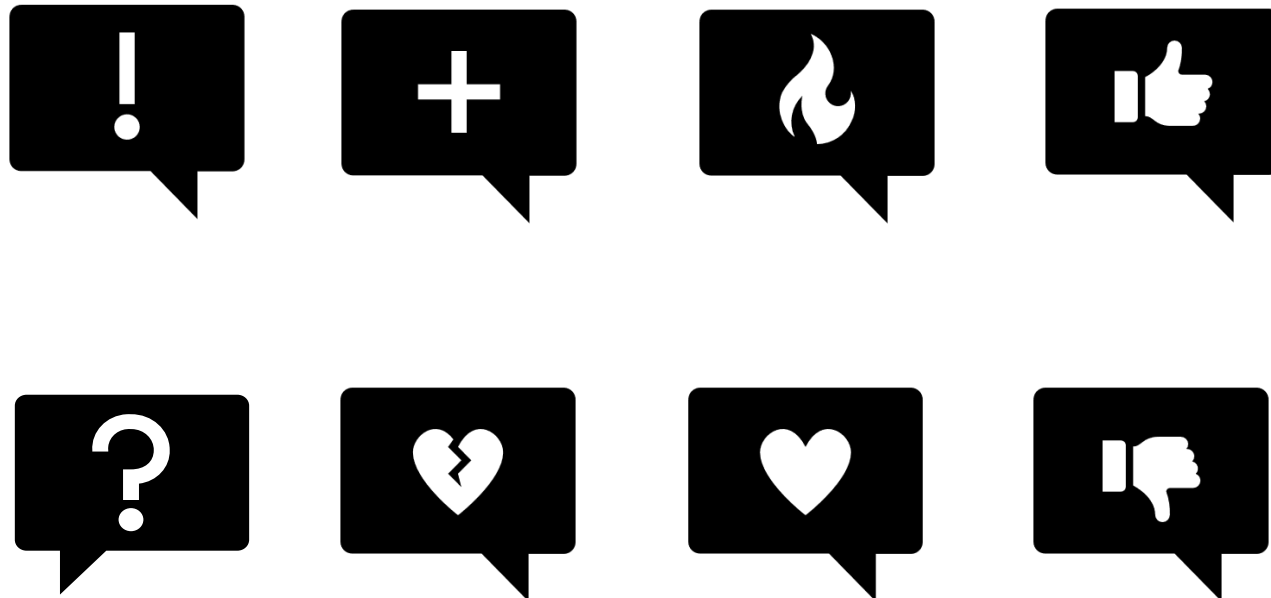
“And participation? Well, that requires trust.”

Credit: Lynn Galagher, “The Role of Consumers in the Energy Transformation”
Presentation at the IRED 2022 conference, Adelaide, Australia, October 2022





Discussion



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