# Managing inverter-based generation in the Australian power system

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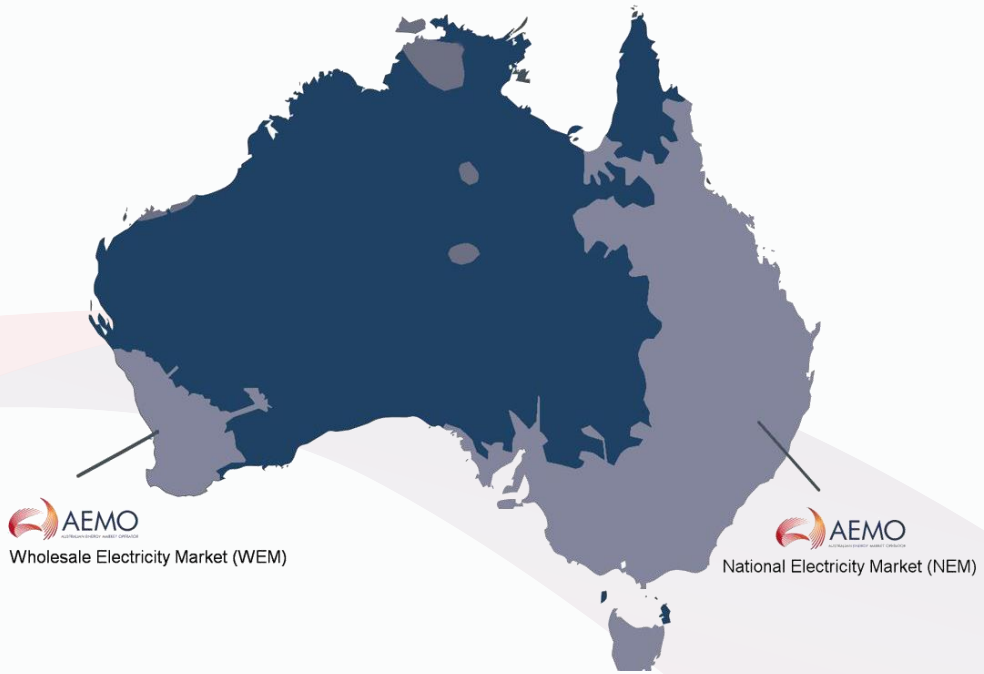
Australian Energy Market Operator

# Australia's electricity markets and AEMO role




One of the world's longest power systems with almost 50,000 km of transmission lines and cables (both the National Electricity Market (NEM) and the Southwest Interconnected System (SWIS))

AEMO is the independent system and market operator for the NEM and SWIS, operates gas markets in four south-eastern states, and undertakes electricity and gas planning functions

The NEM has an installed generation capacity of 61 GW and a peak demand of 36 GW

AEMO does not own any network or generation assets, nor makes power system or market rules

# Generation mix in Australia's National Electricity Market

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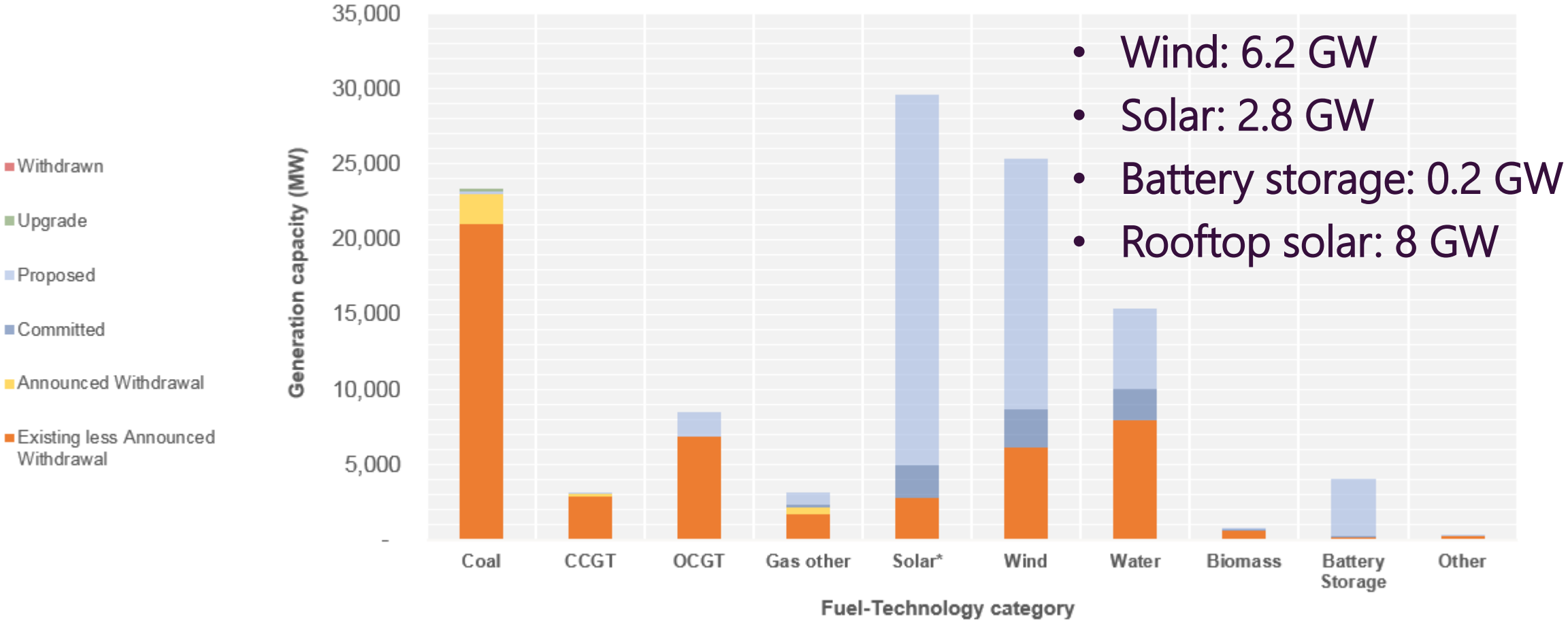
# Current and proposed generation summary in the NEM




- Wind: 6.2 GW
- Solar: 2.8 GW
- Battery storage: 0.2 GW
- Rooftop solar: 8 GW

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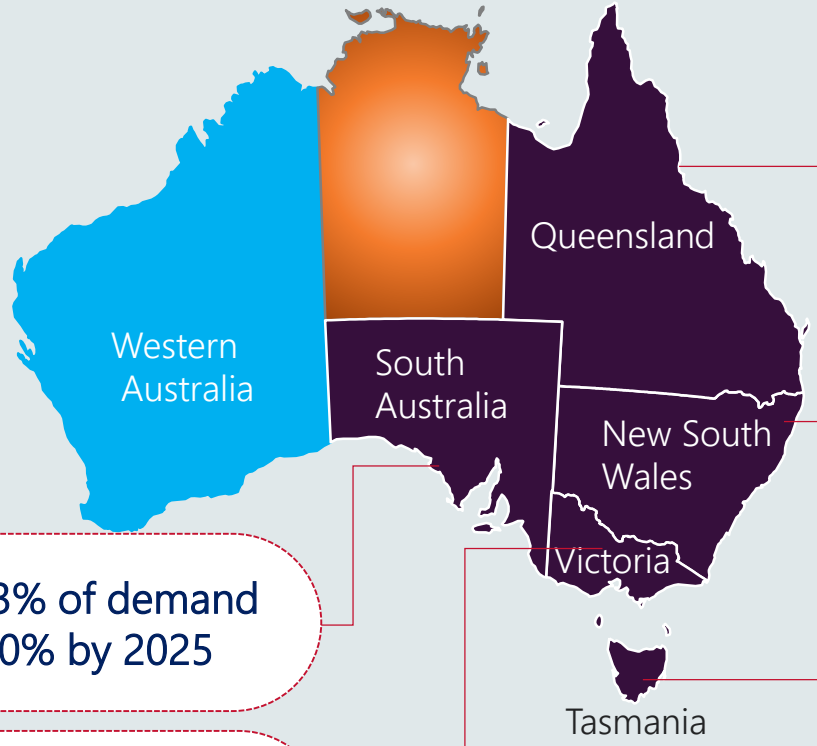
Approximately 10 MW of new generator connections every day

# Share of renewable generation in the NEM and future targets




- Renewable share in 2018: 10% of demand
- Renewable energy target: 50% by 2030

- Renewable share in 2018: 15% of demand
- Renewable energy target: none

- Renewable share in 2018: 96% of demand
- Renewable energy target: 100% by 2020

- Renewable share in 2018: 53% of demand
- Renewable energy target: 50% by 2025

- Renewable share in 2018: 21% of demand
- Renewable energy target: 40% by 2025

**Peak historical instantaneous penetration of renewables across the NEM is 31%**

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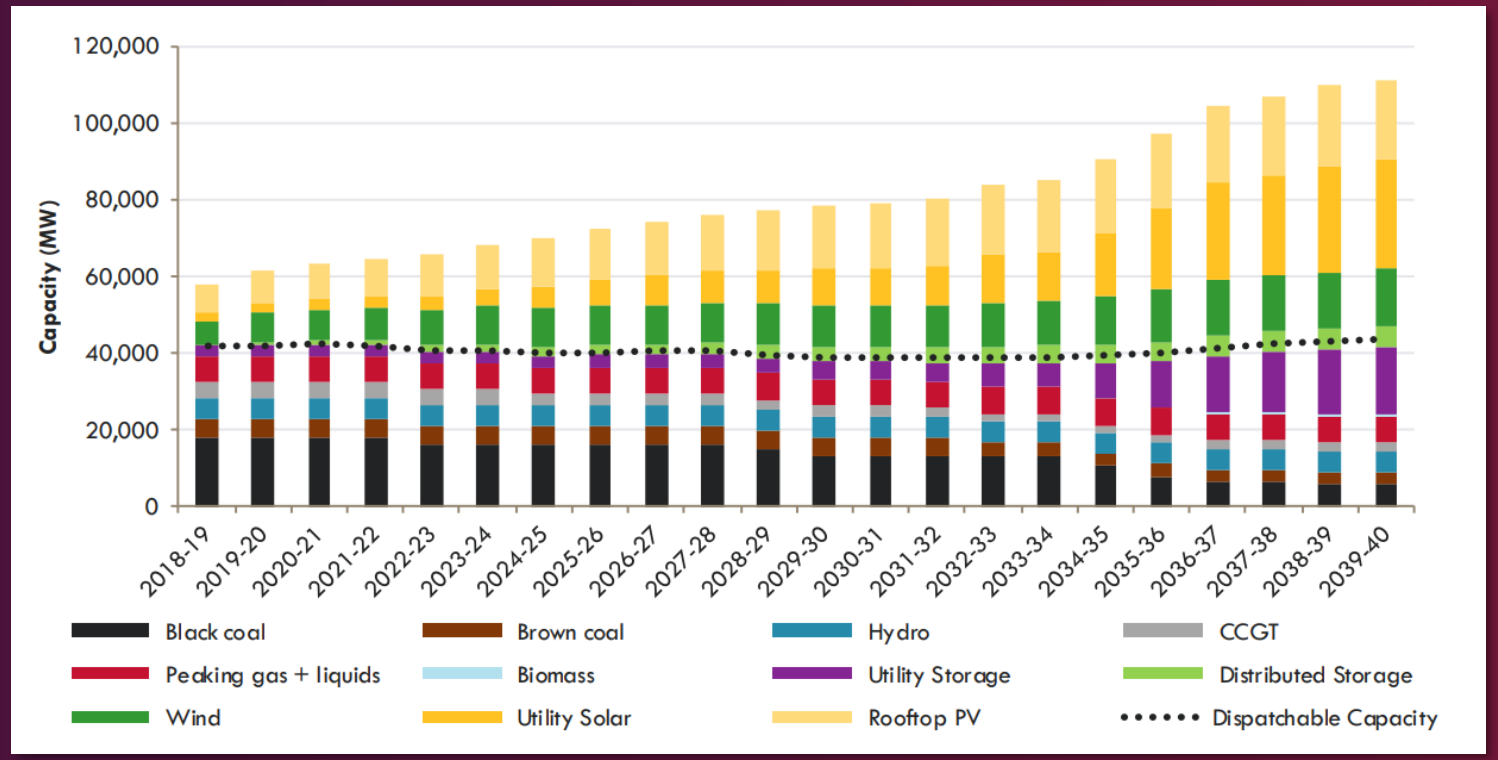
# Rapidly changing generation mix and technology




## Evolving technology/applications

- Application of batteries for system security enhancement (100 MW BESS in South Australia first of its kind)
- Grid forming inverters for grid-connected applications
- Increasing installation of hybrid wind/solar with batteries
- Increasing application of synchronous condensers

# Drawing parallels

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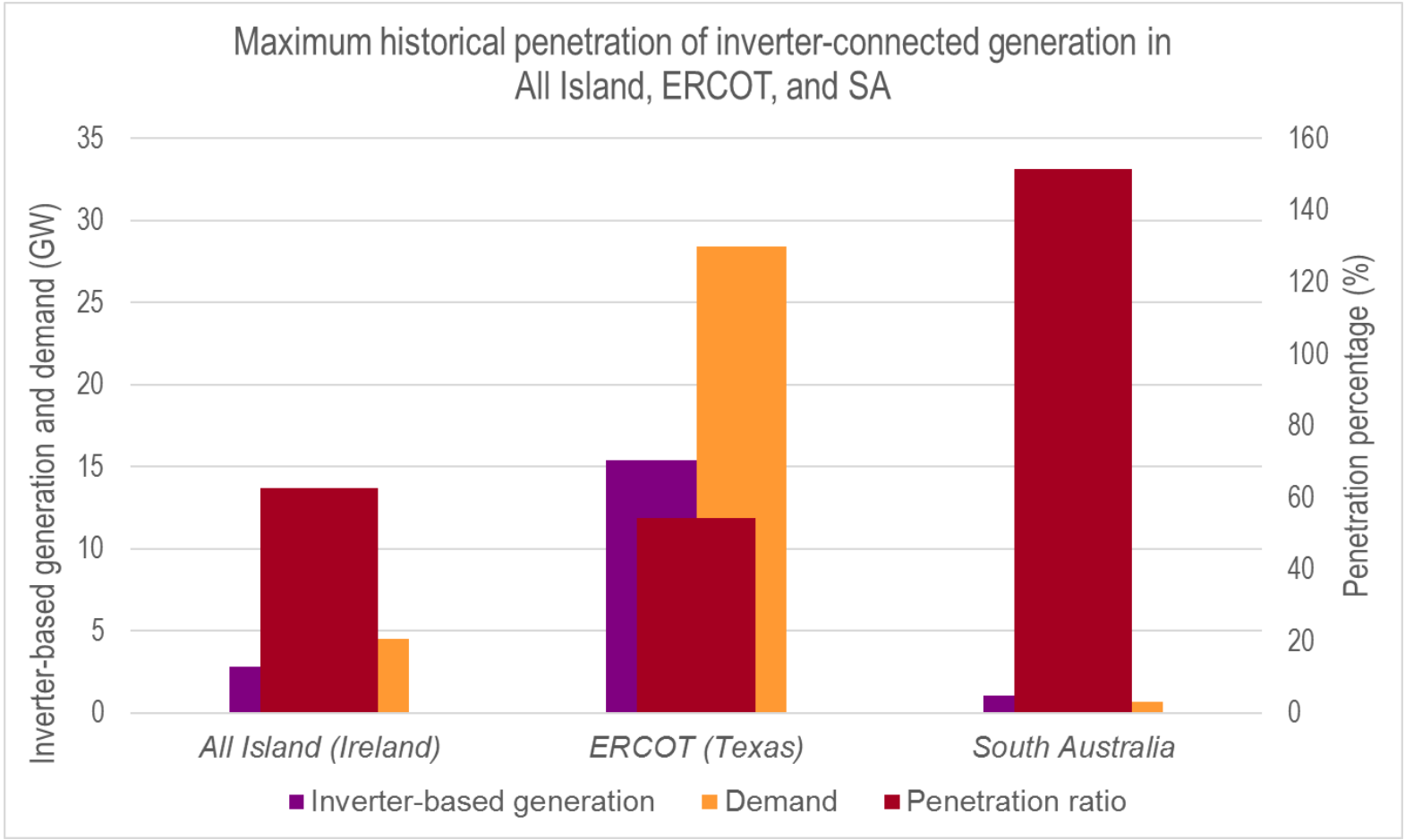
# Instantaneous penetration

- South Australia has one of the highest penetrations of inverter-based generation worldwide
- Instantaneous penetration is the most challenging aspect from a system security perspective
- This figure has increased by more than 20% over the past two years in South Australia




(excluding rooftop PV generation)

Ireland and Texas are among the pioneers of developing best practices for grid integration of inverter-based generation

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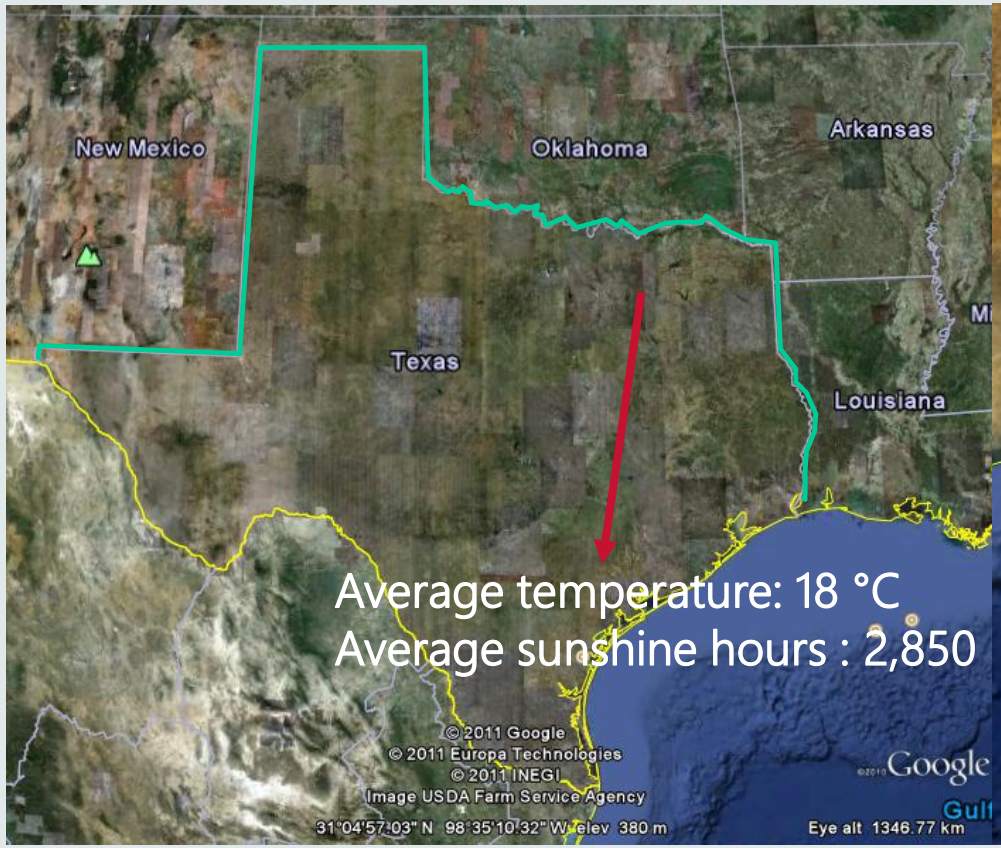
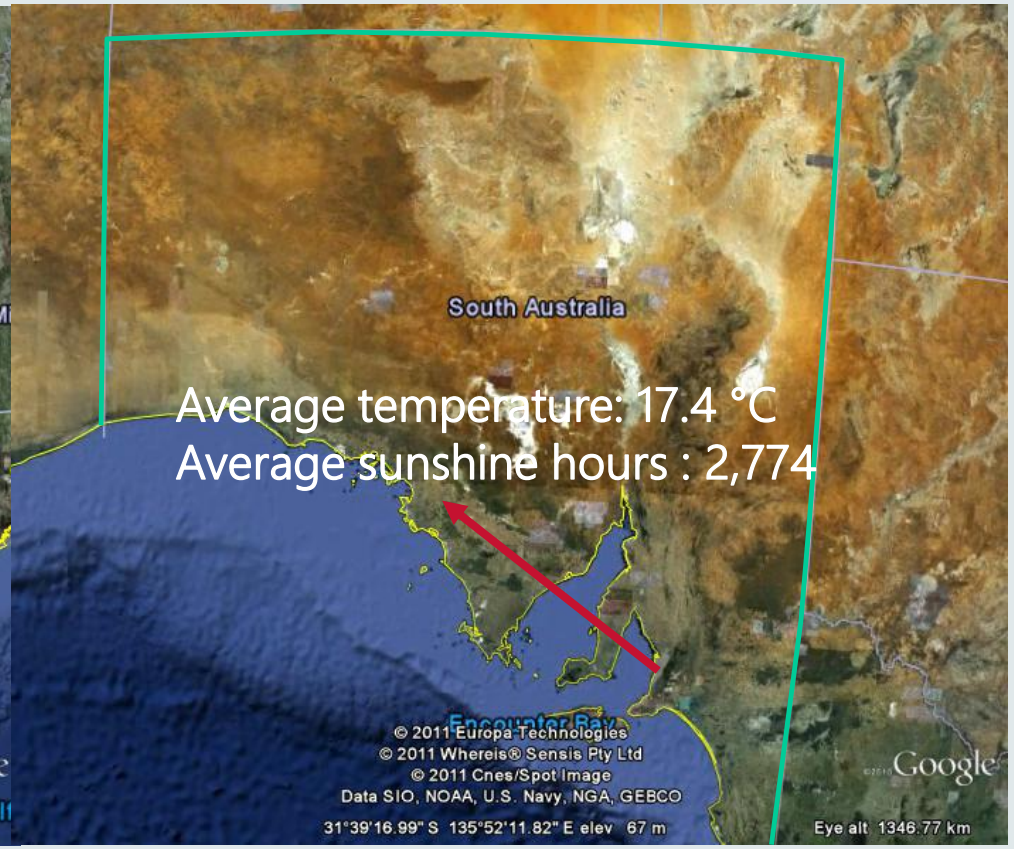
# South Australia compared to Texas

(Ref Google Maps)

695,662 km²
28.7 million population

984,377 km²
1.75 million population

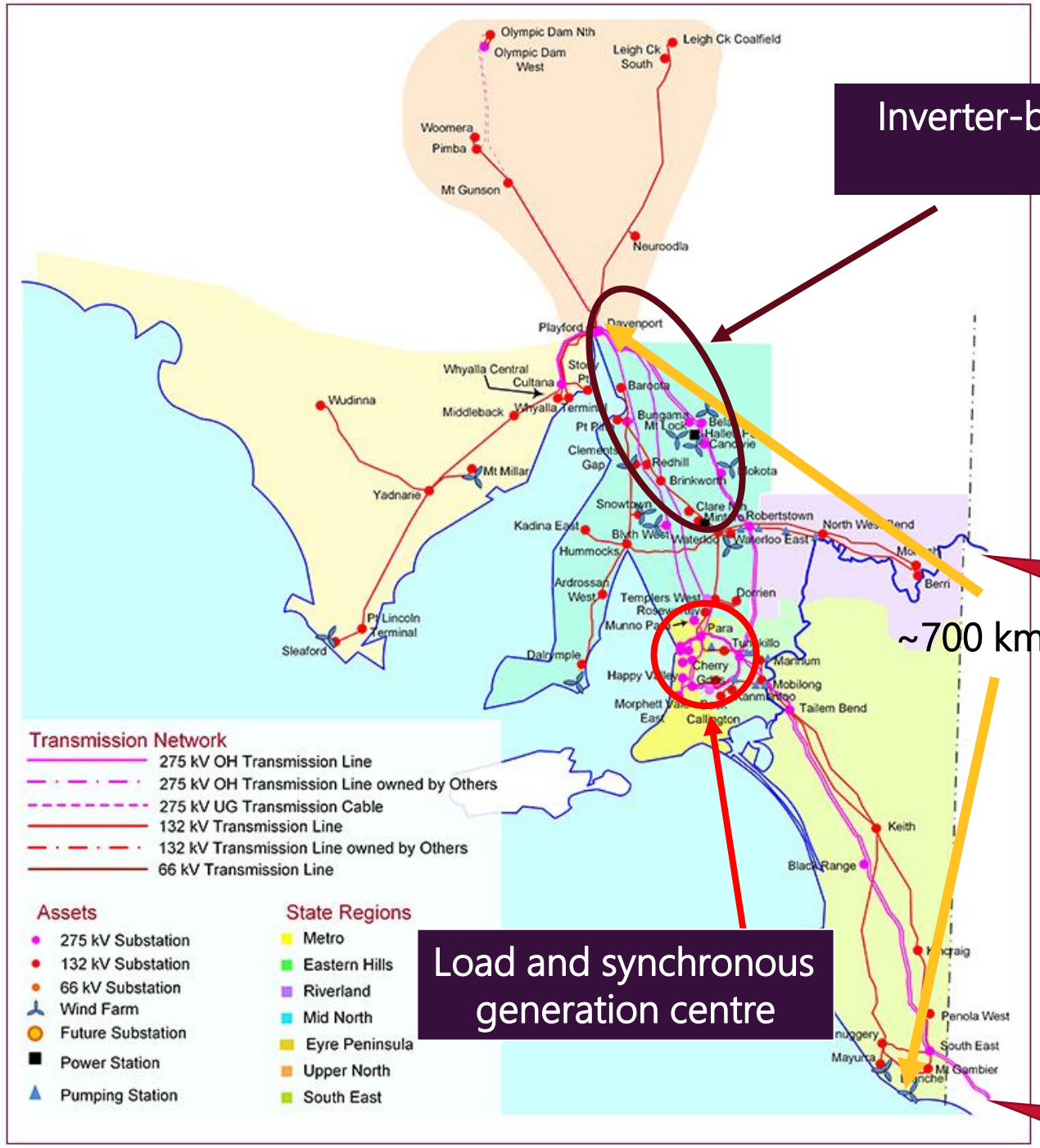



Large lands: Texas is larger than France, South Australia is equivalent to France + Germany

# South Australia power system

- Demand: ~600-3,100 MW with a 1,400 MW median
- Installed inverter-based generation: ~2,600 MW
- Rooftop PV in addition: ~1,100 MW
- Synchronous generators are primarily gas-fired (no hydro or coal), hence have the highest marginal cost
- These synchronous generators are sources of system strength for inverter-based generation

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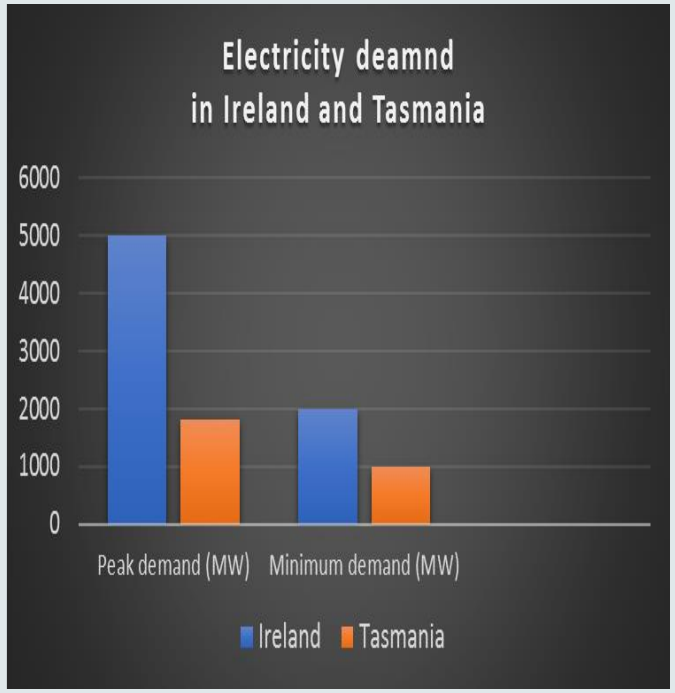
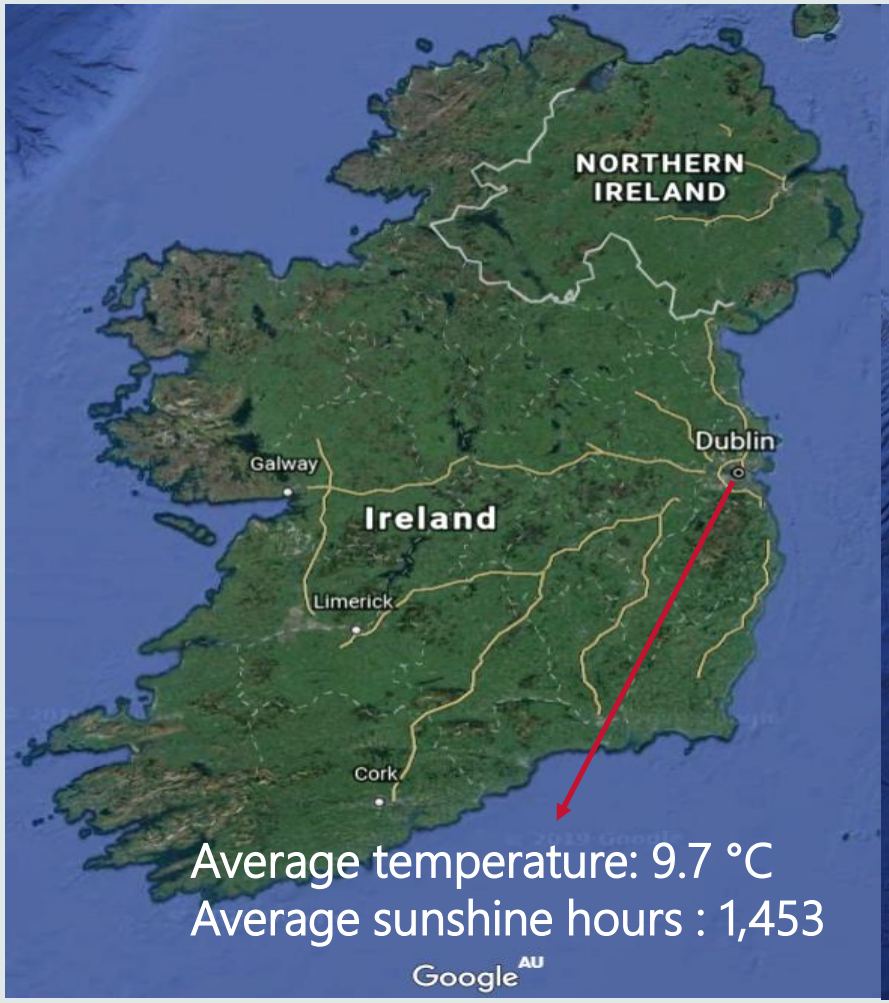
# Tasmania compared to Ireland

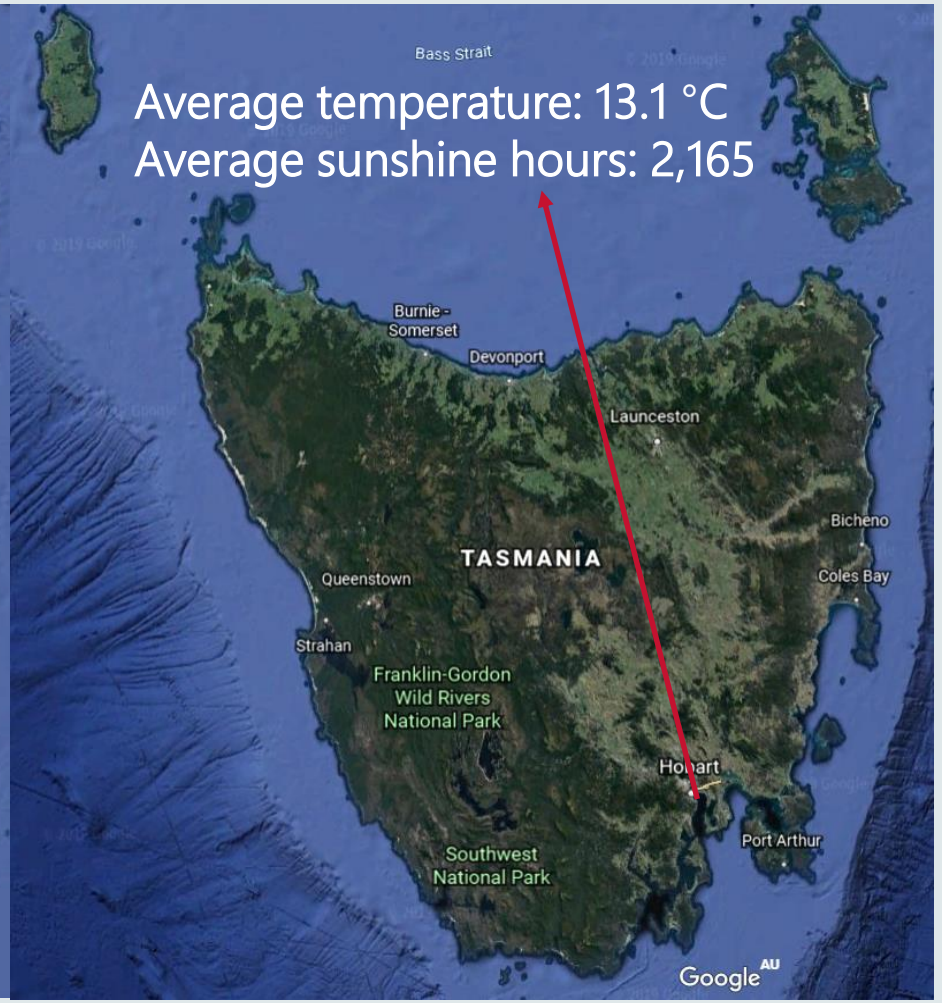
(Ref Google Maps)




70,273 km² (excluding Northern Ireland)




68,401 km²




Both are islanded from larger mainlands

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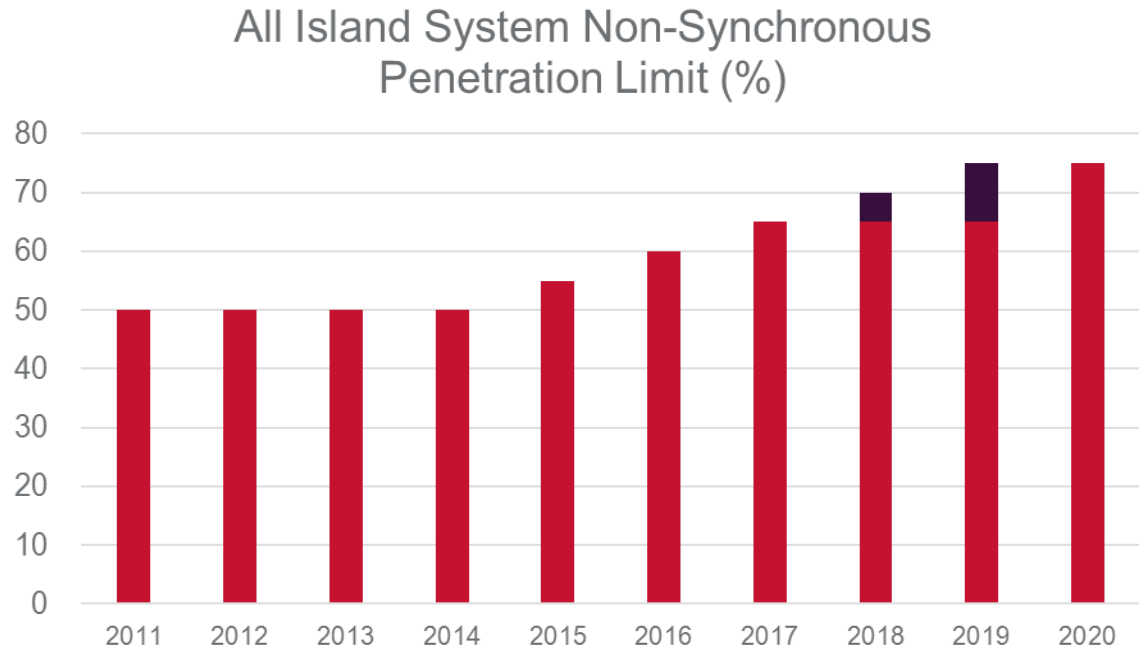
# Penetration ratio

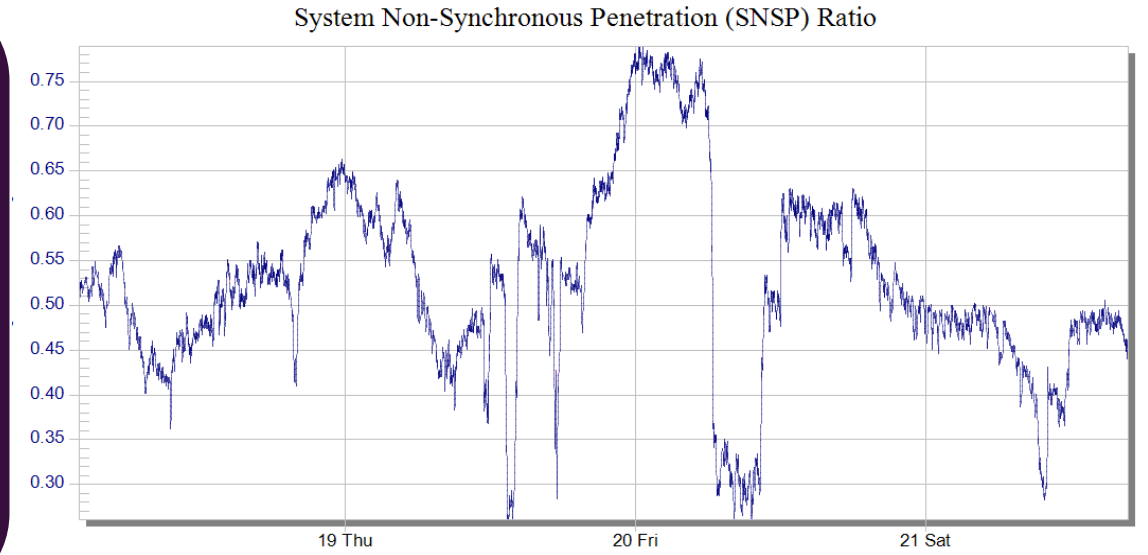
- System non-synchronous penetration (SNSP) is a metric pioneered by Erigrid for islanded power systems

- All Island (Ireland) has achieved a SNSP of slightly less than 65%
- Looking for up to 75% by 2020

*Source: Eirgrid*




- Tasmania has achieved a SNSP of 79%
- Can operate with SNSP of 100% by Q1 2020
- Operation of hydro units as synchronous condensers is a key differentiator with Ireland




*Source: TasNetworks*

# Challenges

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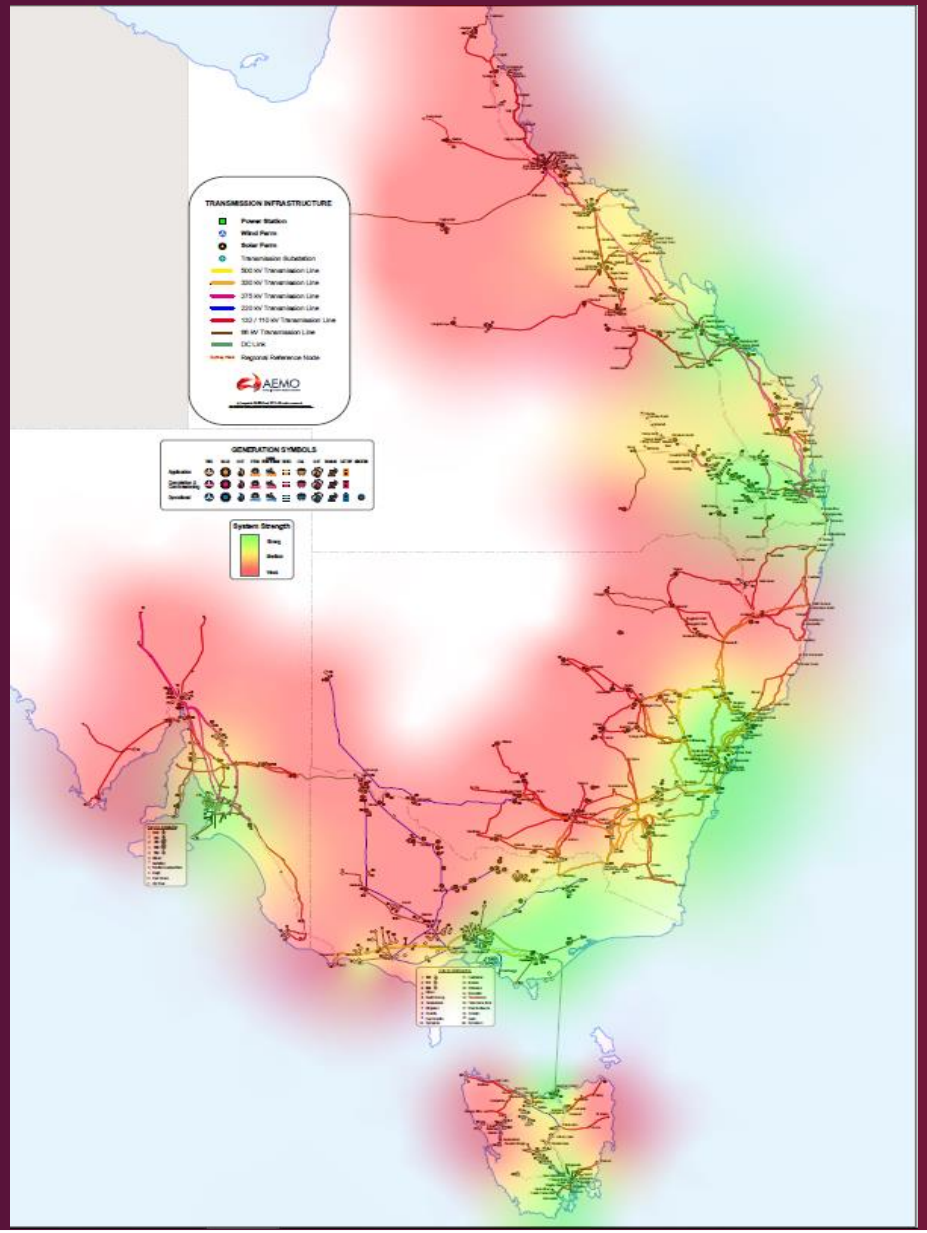
## Inverter-based generator connection sparsity

- Far from capable synchronous generators
- Close to other inverter-based generation

**Lack of system strength is one of the key challenges**

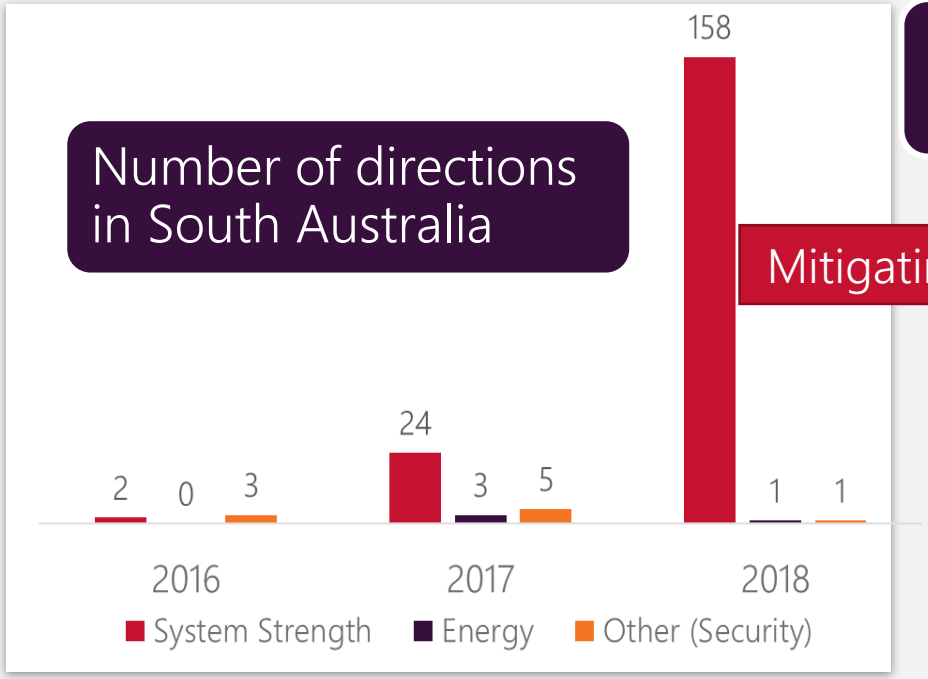



The need to design generating plant capable of operating in such networks

# Synchronous generator scarcity

- Synchronous generator retirement/de-commitment
- Aging synchronous plant also contributes to more frequent planned and forced outages

## Number of directions in South Australia




- Minimum synchronous generator requirements apply operationally to maintain sufficient system strength
- Synchronous generators do not tend to run at periods of low demand and low prices
- AEMO directs synchronous generators for system security purposes

## Mitigating directions

## Network synchronous condensers


*Source: ElectraNet*

# Moving forward

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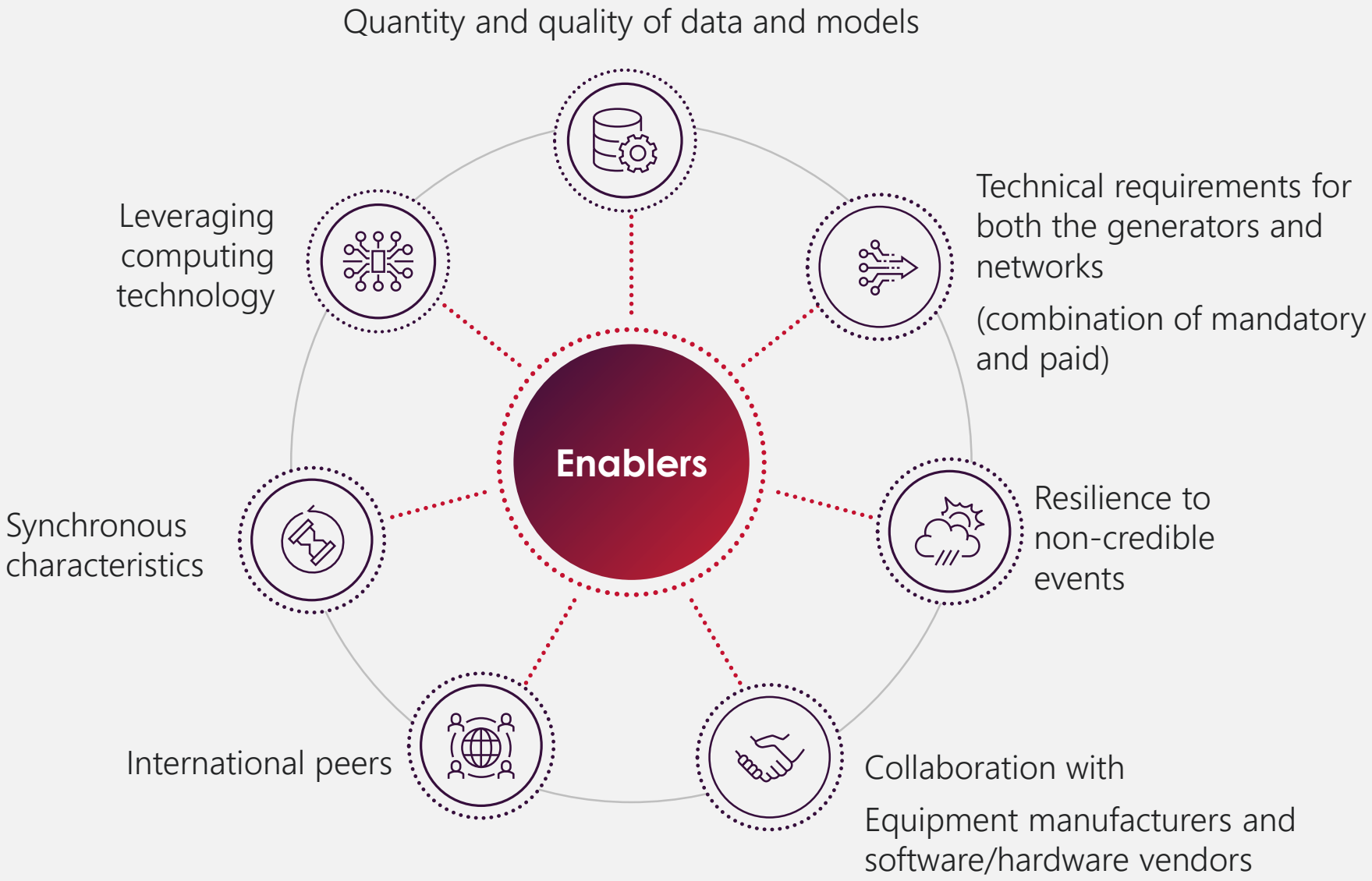
# Enablers for higher penetration of inverter-based generation



# What can AEMO share?

## Large-scale EMT modelling and simulation

- Lessons learned and value gained from developing a full-scale model of NEM power system in an electromagnetic transient (EMT) simulation tool

## System strength and inertia determinations

- An example of the use of detailed EMT models for determining requirements on networks and generators

## Operation of inverter-based generators

- Lessons learned from undesirable response of some of inverter-connected generators, and remediations applied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