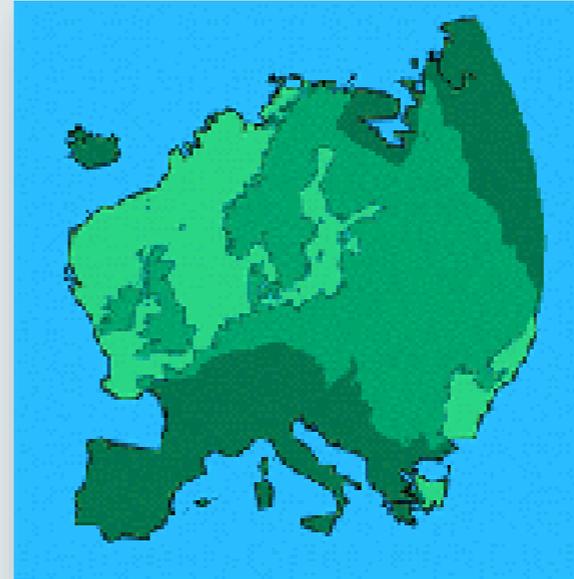


Preparing for a step change: Challenges of a fast transformation to a renewable future

2 October 2019

Australian Energy Market Operator



AEMO has a number of roles in the Australian Energy system, including:

- Electricity System Operator, NEM and WEM
- National Transmission Planner
- Operating gas markets:
 - Declared Wholesale Gas Market
 - Short Term Trading Market



Australia and climate change

AEMO is working with Australia's Bureau of Meteorology to improve understanding of climate change impacts on Australia's energy system.

Australia is a hot, dry continent – historically with rather extreme weather. Climate change will make it worse.

Impacts on electricity supply is significant, including:

- Extreme temperatures
 - Record high demands
 - Power stations and networks de-rated (thermal/PV)
 - High temperature cut-out
- Bushfires (disrupting transmission lines)
- More intense cyclones/storms/tornadoes
- Extended drought
 - Thermal cooling water restrictions
 - Reduced hydro power generation
- Industry sector impacts
 - Increased irrigation (or decline in agriculture load)
 - Increased desalination plant load

Integrated System Plan 2018

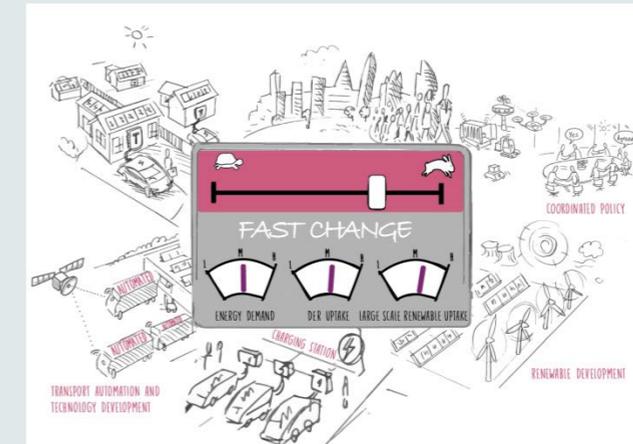
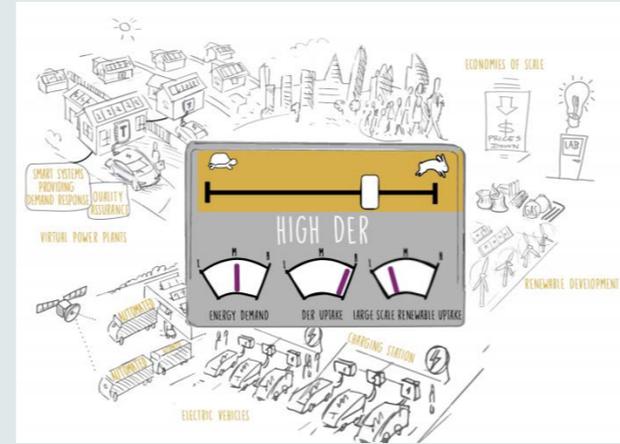
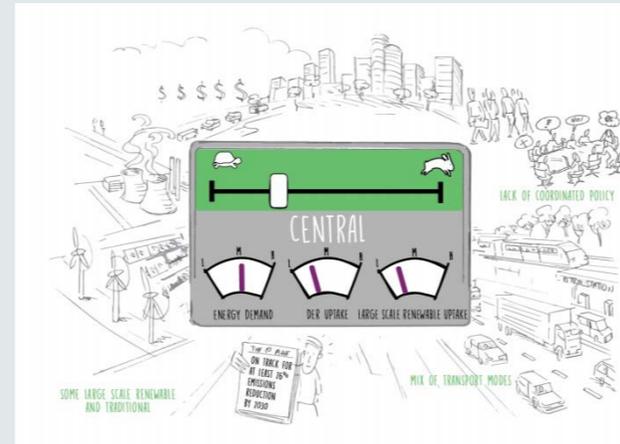
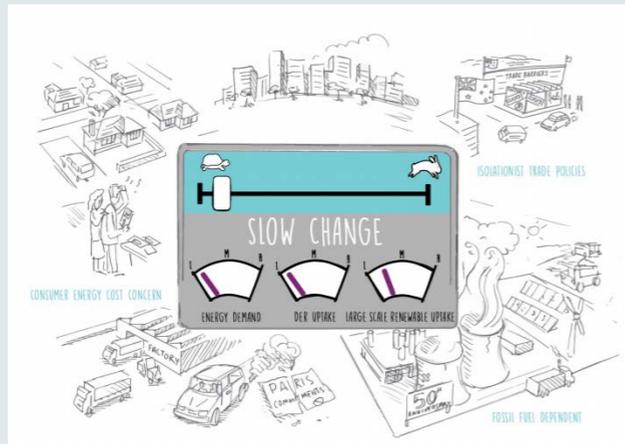
The ISP found that a portfolio approach of supply resources includes both retention of existing resources and continued growth of utility-scale renewable generation, energy storage, DER, flexible thermal capacity, including gas-powered generation, and transmission development to be the most efficient approach.

The fundamental changes occurring in the energy sector:

- Grid demand is flattening due to the growth of rooftop photovoltaic (PV) and increasing use of local storage, as well as overall increases in energy efficiency.
- Over the next 20 years, **approximately 30% of the NEM's existing coal resources** will be approaching the end of their technical lives, and will likely be retired, which highlights the importance of mitigating premature retirements as these resources currently provide essential low-cost energy and system support services required for the safe and secure operation of the power system.
- The investment profile and capabilities of various supply resources have changed and are projected to continue to change radically.
- In particular, costs of new renewable plant continue to fall, and advances and availability of **storage technologies, particularly pumped hydro, flexible gas-powered generation and distributed energy resources (DER)** are emerging as core components to a low cost and reliable energy future.

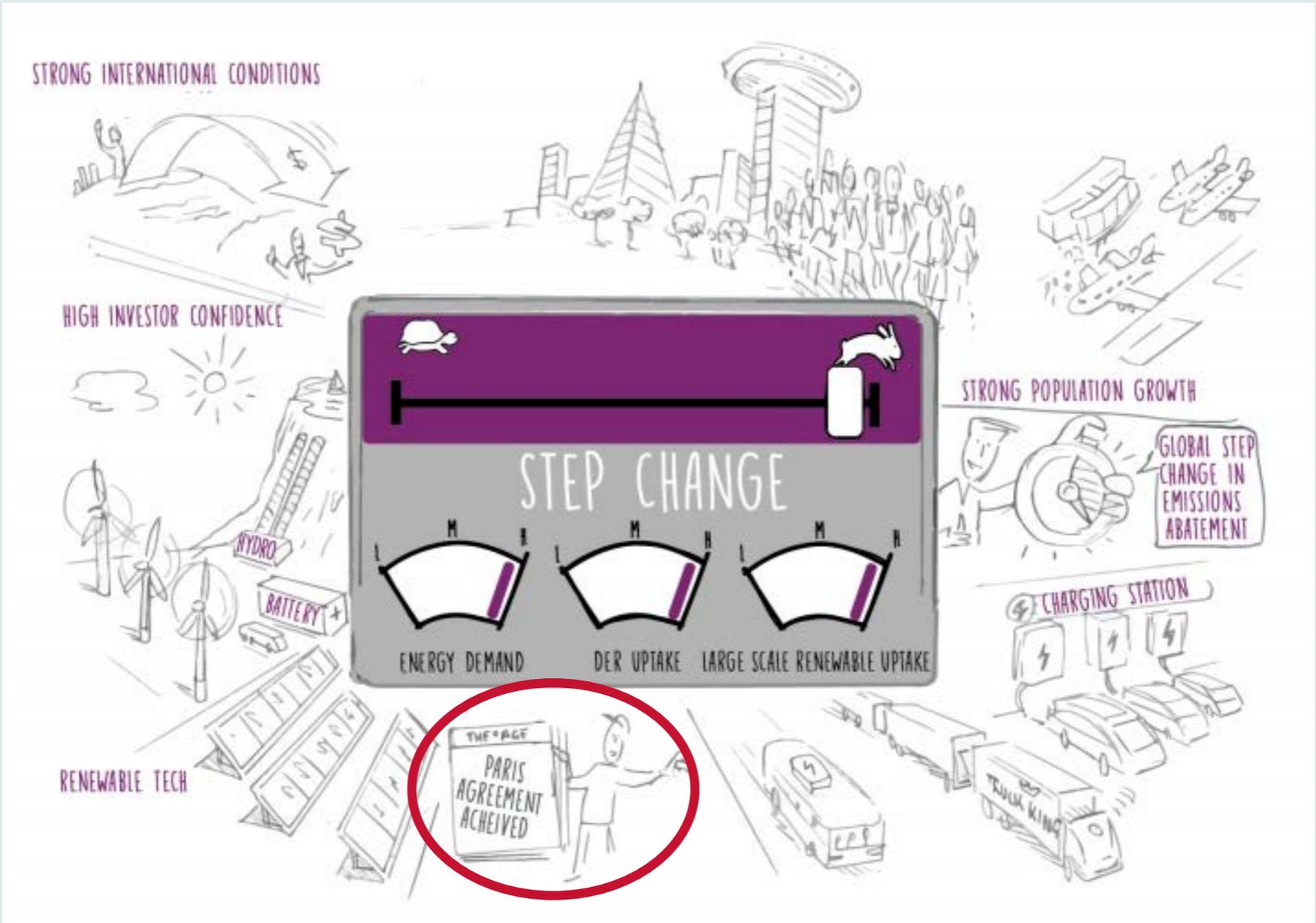
Integrated System Plan 2020 – Scenarios

Decentralisation ↑



Decarbonisation →

Integrated System Plan 2020 – Step Change



The starting point

Strong growth in renewable energy sources in recent years, but too strong?

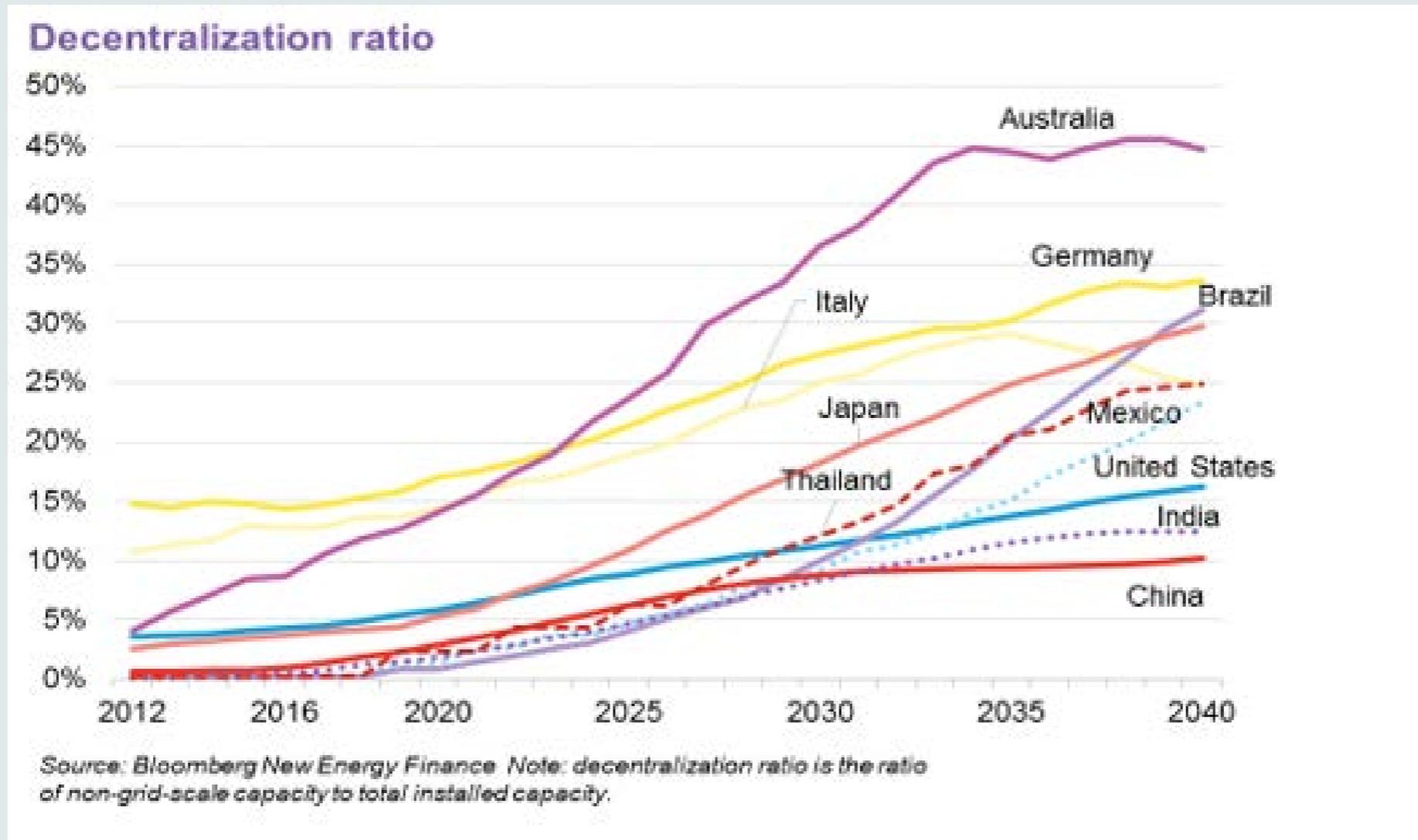
Need to ensure technology, markets and regulation is capable of managing the transition.

National Electricity Market facts

- Established in 1998
- Covering Australia's Eastern and South-Eastern states with approximately 40,000km of transmission lines and cables
- Supplies approximately 200 terawatt hours of electricity annually with a maximum demand just around 33,000 MW
- Supports approximately 9 million customers
- In 2019, current total capacity is 58,256 MW:
 - Over 5,000 MW of thermal generation has retired over the last 10 years.
 - In 2018, 3,080 MW of grid-scale renewables connected to the grid (1,993 MW solar, 997 MW wind)
 - Over 19,000 MW of connection requests currently train (About 33% of current capacity).
 - In Jan and Feb 2019 alone, 6,650 MW of new capacity was announced.
 - World's largest battery was installed in December 2017.

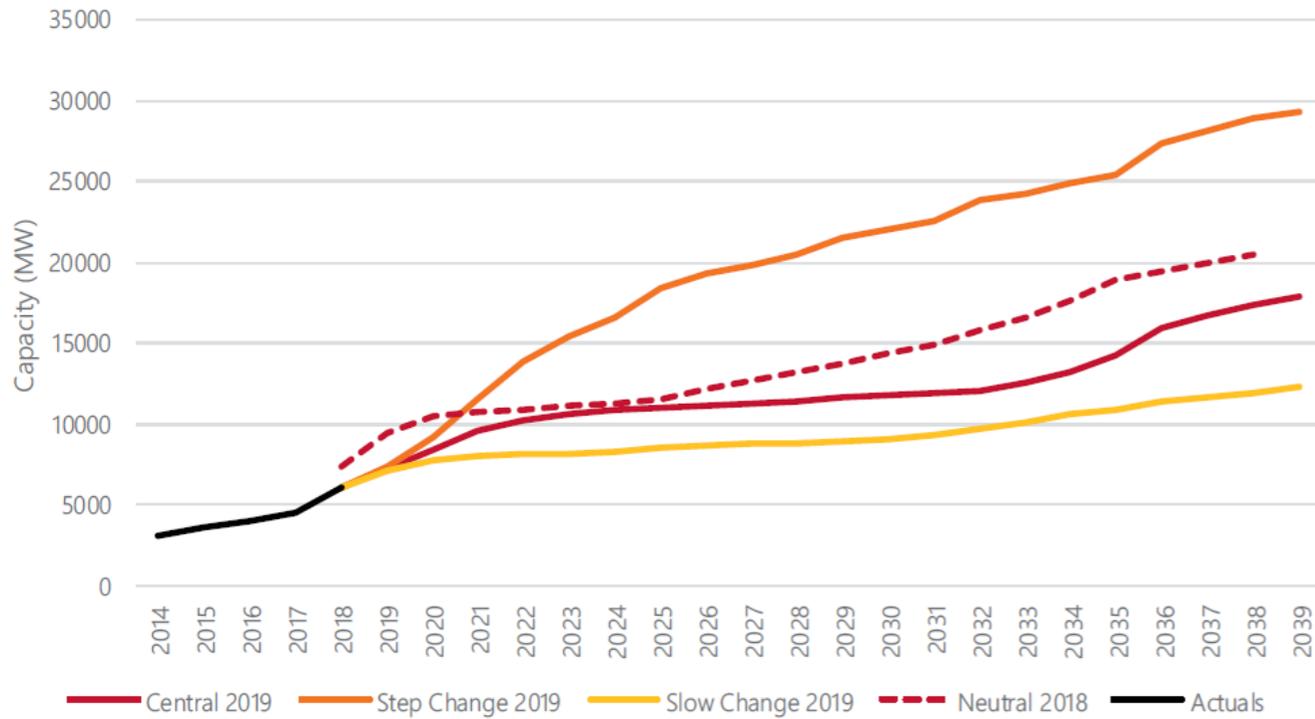
On a rapid patch to decentralisation

Managing decentralised resources adds to the challenges of ensuring secure and reliable electricity supply

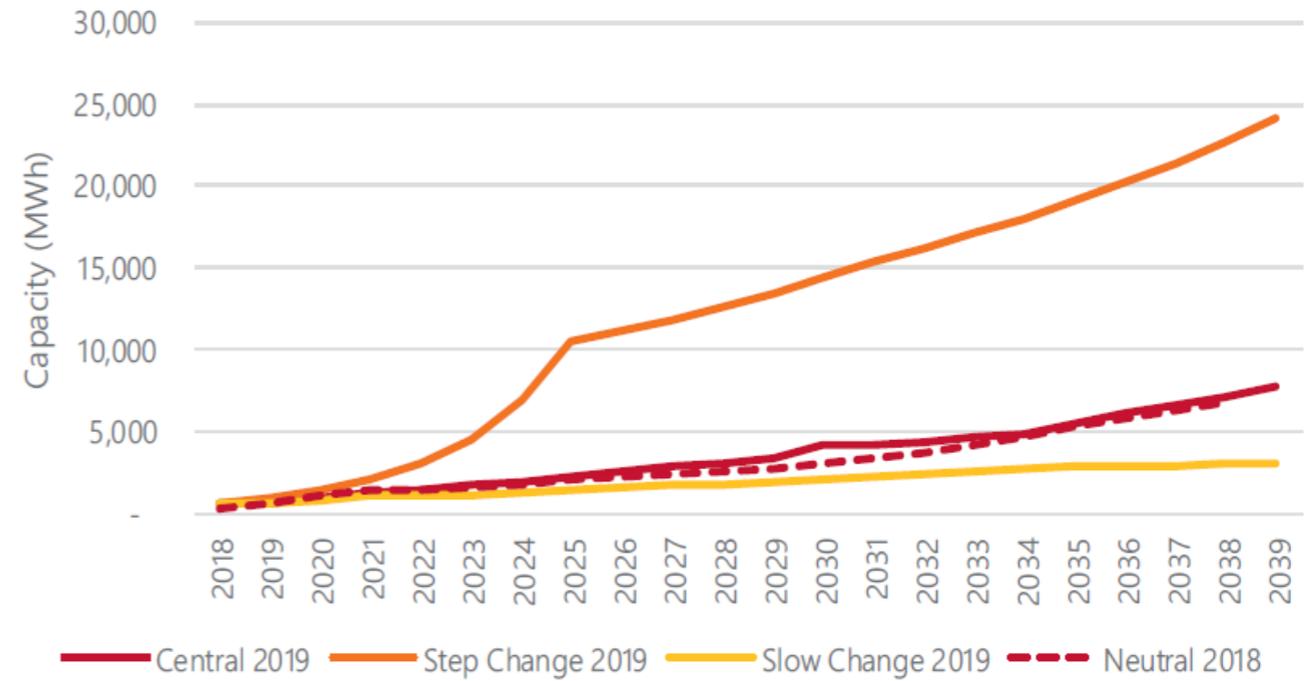


Growth in distributed energy resources (DER)

Effective Rooftop PV Capacity



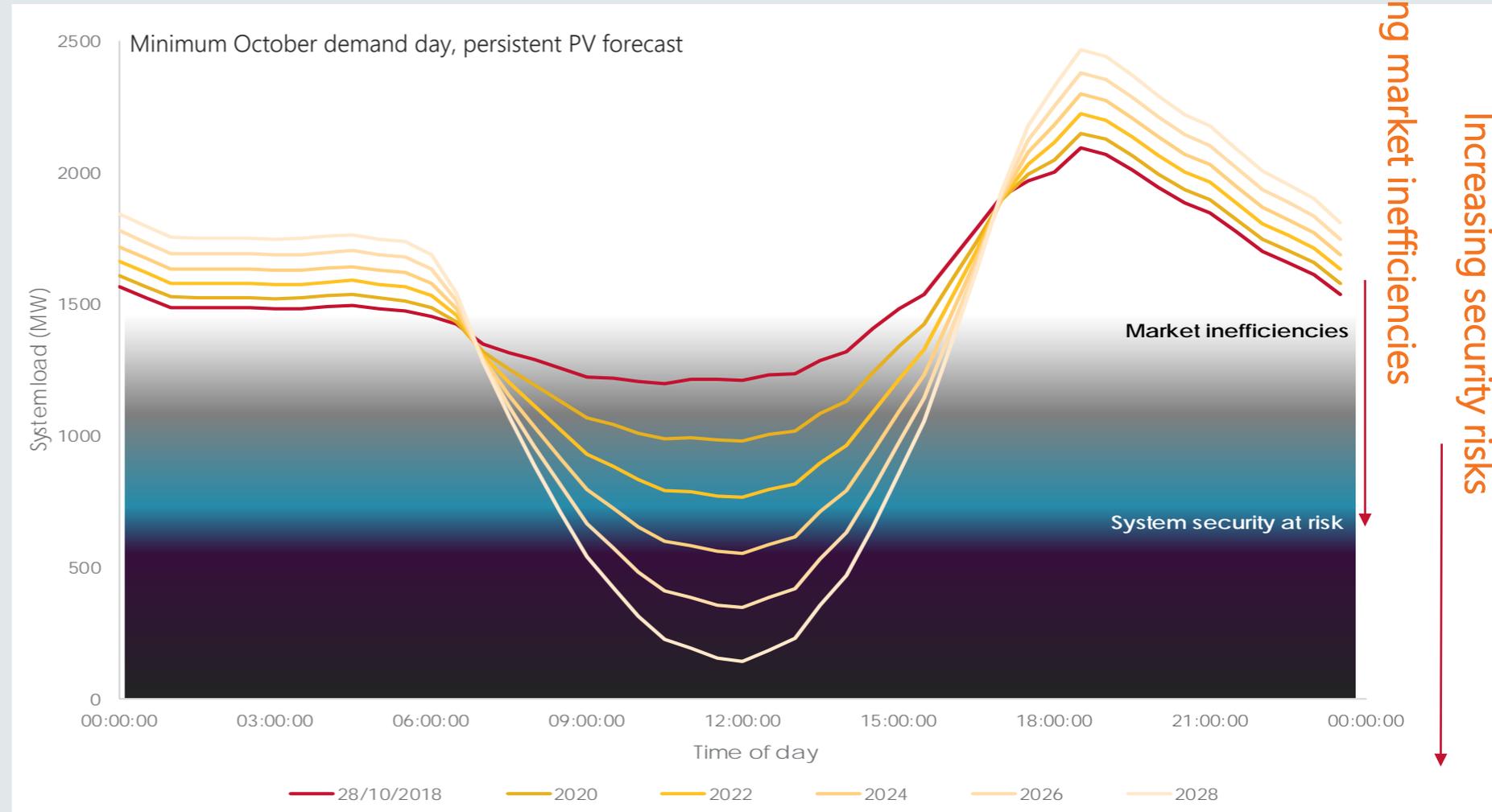
Effective Battery Capacity



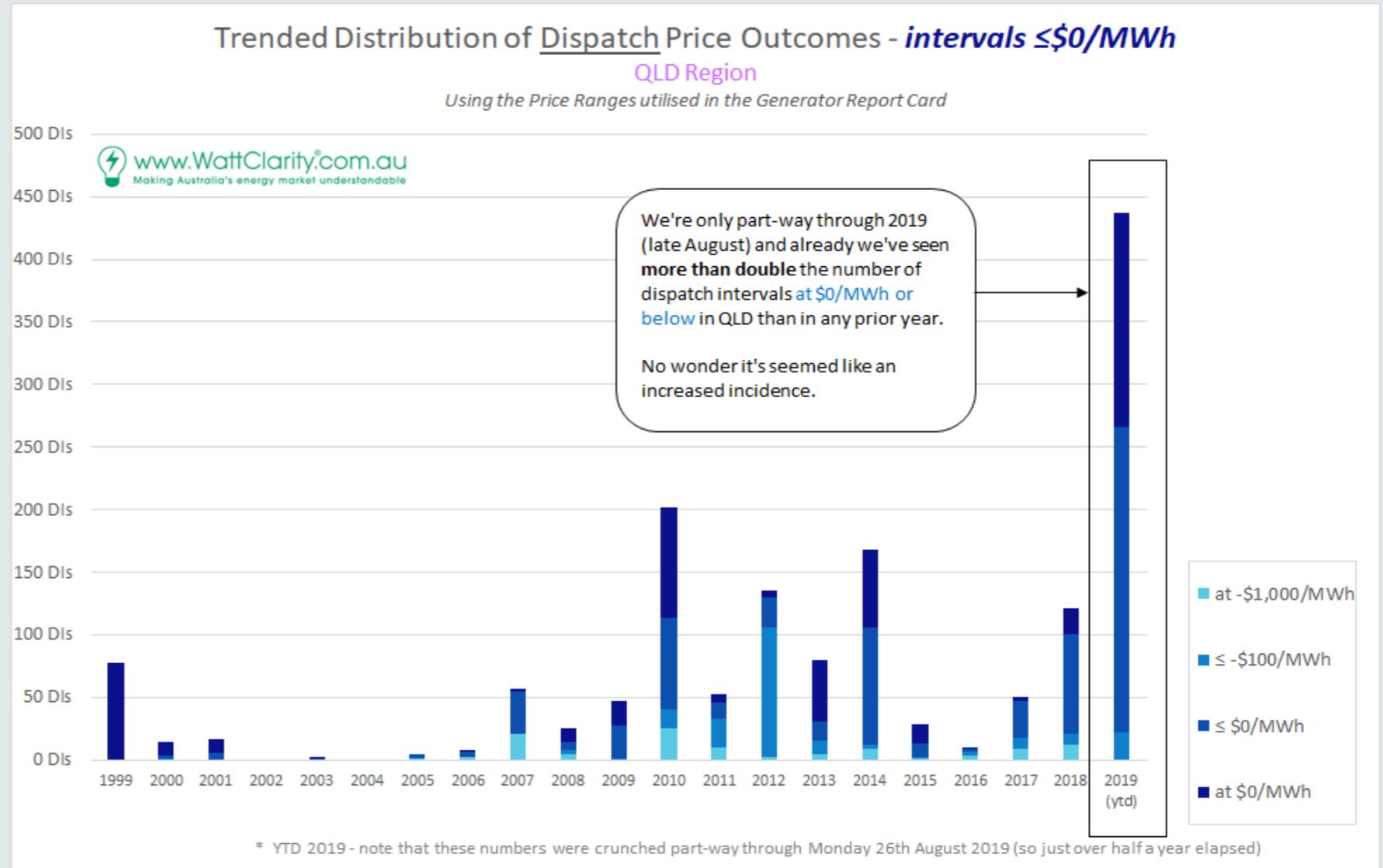
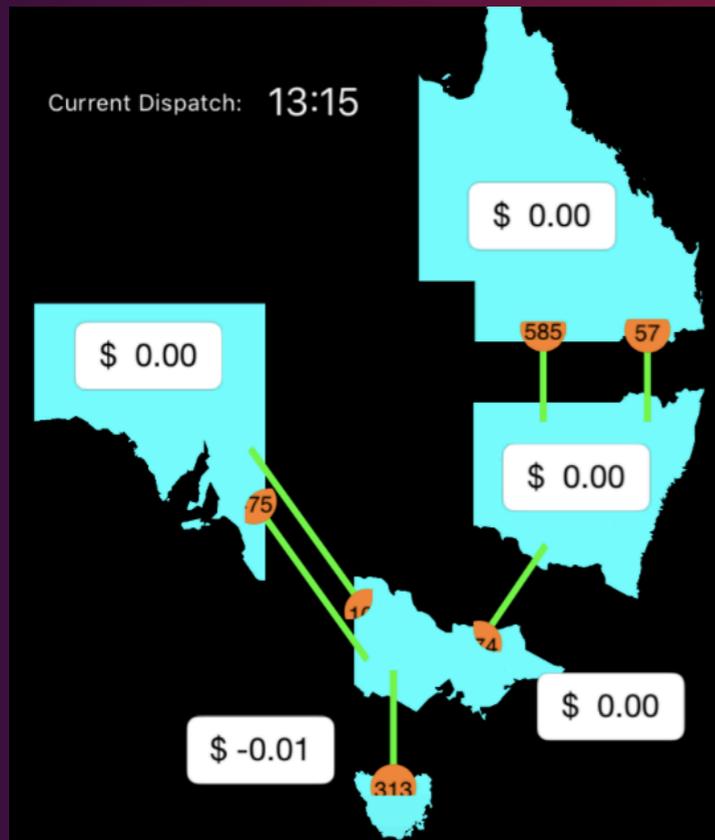
The "duck curve" challenge

Fundamental change is required as existing regulatory and market constructs are designed for a traditional power system.

The Western Australian duck belly:



Is zero (or sub-zero) prices a new normal?



HotCopper

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Qld wholesale power price goes to zero six days in a row

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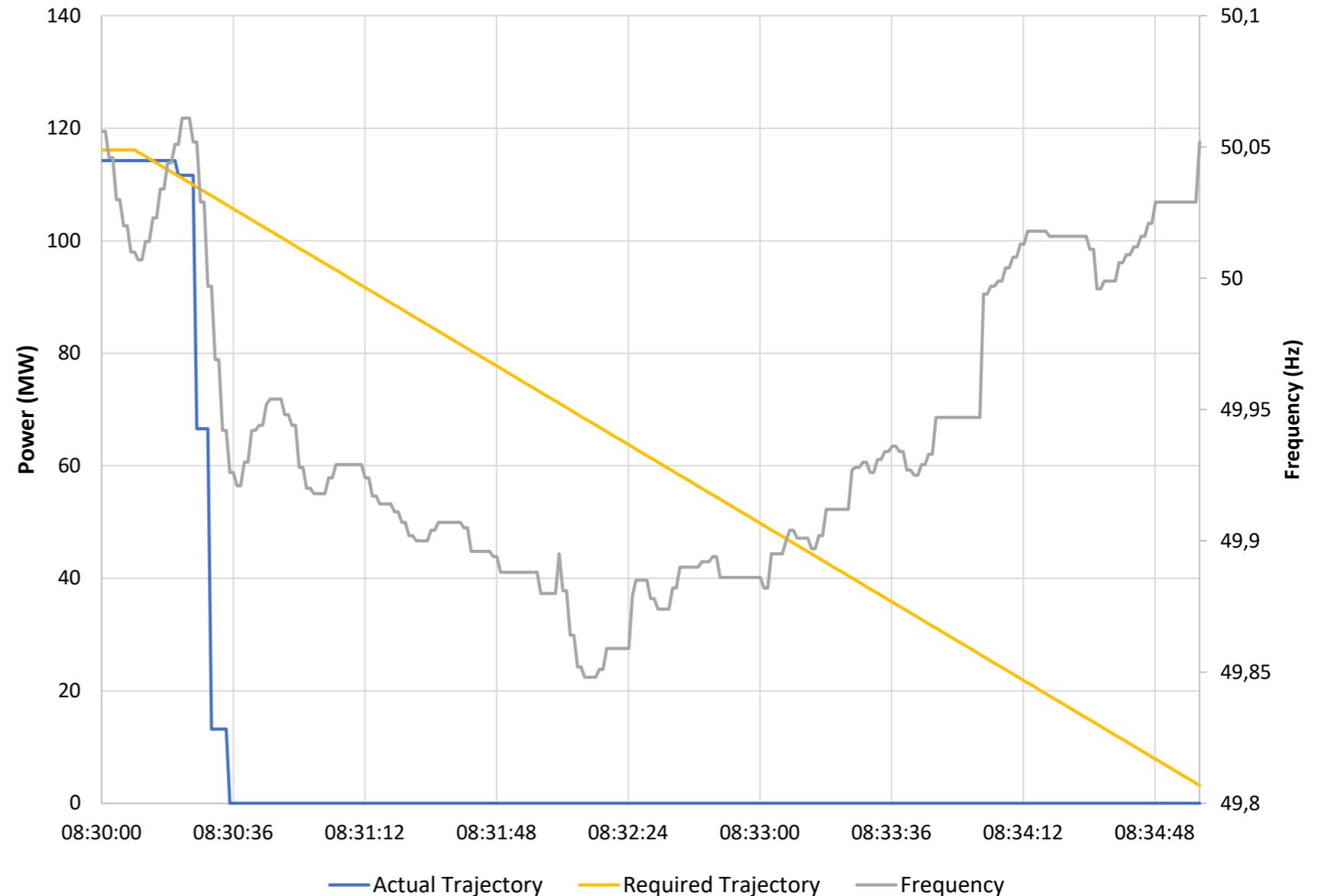
Electricity prices hit minus \$1000 in Qld

What does this mean for power system operability?

Rapid decommitment by solar can cause frequency disturbances, but also highlights the potential to use this technology for frequency support.

If not managed, could household battery storage cause similar problems in the future?

Example of Queensland Solar Farm Response to Negative Prices - 5 September 2019



Duck curve: Issues seen

44% renewable across the National Electricity Market (NEM) in July 2019.

- Issues with negative prices spreading from South Australia to all of NEM.
 - Risk of market fluctuations
- Deteriorating profitability of thermal plants:
 - How to ensure sufficiently maintained?
 - How to ensure sufficient capacity to maintain reliability?
 - 3 year closure rule
 - Reserves to address decrease in synch. generation
- Low system strength:
 - Change in requirements – difficult assessments
 - Delay in commissioning
- Network congestion as generation is build in new locations:
- Low demand becoming an issue:
 - Synchronous condensers (at system level and connections)
 - Controllable loads (hot water) and rooftop PV

Looking for solutions

1. More interconnection
 - Benefits from diversity in load and renewable generation
2. Ensure sufficient dispatchable generation
 - Government Underwriting New Generation Investments (UNGI) program:
 - Combined capacity of 3818 MW shortlisted, including:
 - 6 renewable pumped hydro projects
 - 5 gas projects
 - 1 coal upgrade project
 - ARENA support to pumped storage
 - Snowy 2.0
3. But there is more...
 - DER, DSP and VPP

A significant part of the solution could come from households

1. Energy Efficiency – the task is massive, avoiding unnecessary consumption helps!
2. Rooftop PV
 - Accurate forecast of existing capacity, its generation and future uptake
 - Understand technical characteristics and impacts on system performance. Set standards for tripping
 - Roll out controllability to scale down generation if required for system security
3. Battery storage systems
 - Track uptake – forecast future uptake
 - Understand customer behaviour – metering analysis
 - Aggregation into dispatchable power plants (VPP)
4. DSP
 - Slimming the duck – move consumption to mid day, but how?
 - Smarter operation of hot water load control
 - Enabling more appliances to be controllable (AS 4755)
5. Fuel switching
 - Electrification of transport – EV uptake reaching a tipping point
 - Transition from gas to electric heating (space and hot water)

Enabling growth in DER

Visibility:

- Introduction of DER register from December 2019
 - Information on AC and DC side of all installations
- DSP Information Portal – information about DSP must be supplied annually by all participants
- Improvement in forecasting tools of demand, wind, large scale solar, distributed solar

Technical challenges:

- Understand technical challenges of large proportions of DER
 - How to manage things like voltage in weak parts of the network during disturbances
- Requirements that ensures system security is maintained (do-no-harm)

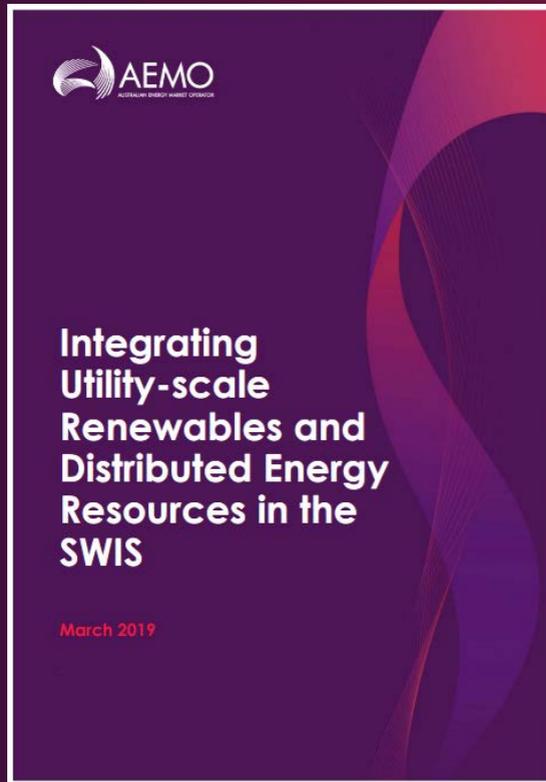
Operation:

- Ramping and firming
 - ARENA/AEMO DSP Trial
 - Flattening the duck belly – reduce solar output?
- Frequency response
 - Supplement 6s and 60s with faster response?
 - Provision from battery storage, wind and solar?

Markets and regulation:

- 5 minute settlement rules change
 - Assist integration of variable renewable generation and DSP
- Wholesale Demand Response rules change
 - Dispatchable and paid service
- Strategic reserves?

WA Energy Transformation Strategy



Deliver new Foundation Regulatory Frameworks

- The WA government's WEM Reform Program will bring critical foundational changes underpinning AEMO's ability to effectively manage the energy transition and support the efficient operation of the future power system



Distributed Energy Resources (DER) roadmap

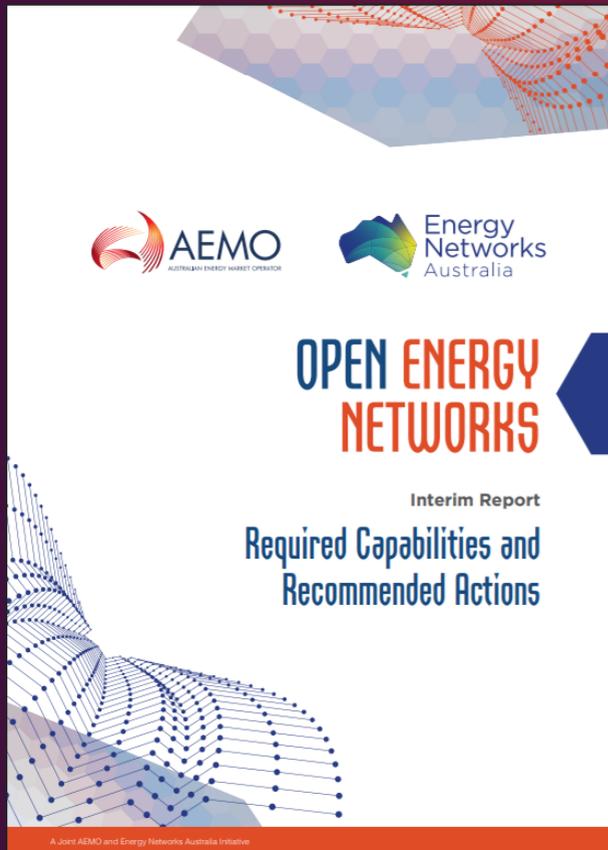
- Develop policy and regulatory settings, proof of concept trials, operational and market frameworks to enable efficient utilisation of DER.



Whole of System Plan (WoSP)

- Based on a scenario approach, the WoSP will assess a number of electricity demand trends and forecasts, and identify the required capacity mix and network infrastructure to meet those needs
- Determine the needs of the power system to facilitate the transition.

ENA and AEMO: Open Energy Network (OpEN) program



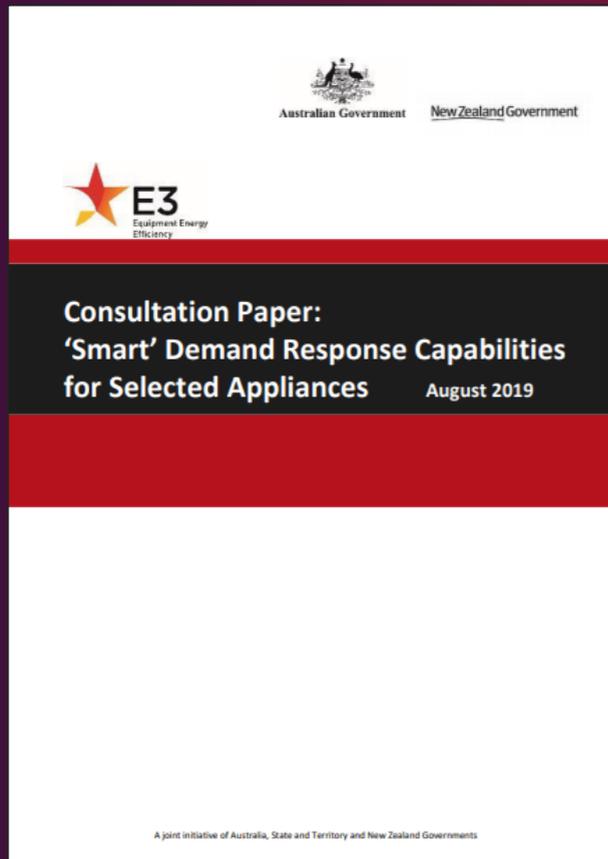
OpEN's primary objective is to ensure the system and market are fit to respond to customer needs into the future.

Interim report - recommended actions:

1. All **customers** (with and without DER) must be at the centre of decision making.
2. The role of the **aggregator** needs to be defined.
3. Industry must collaborate to improve network and demand forecasting.
4. Integration of DER into the wholesale market must be strategically managed.
5. A **market for network services** must be facilitated.
6. **Pricing signals** for DER customers must be established.

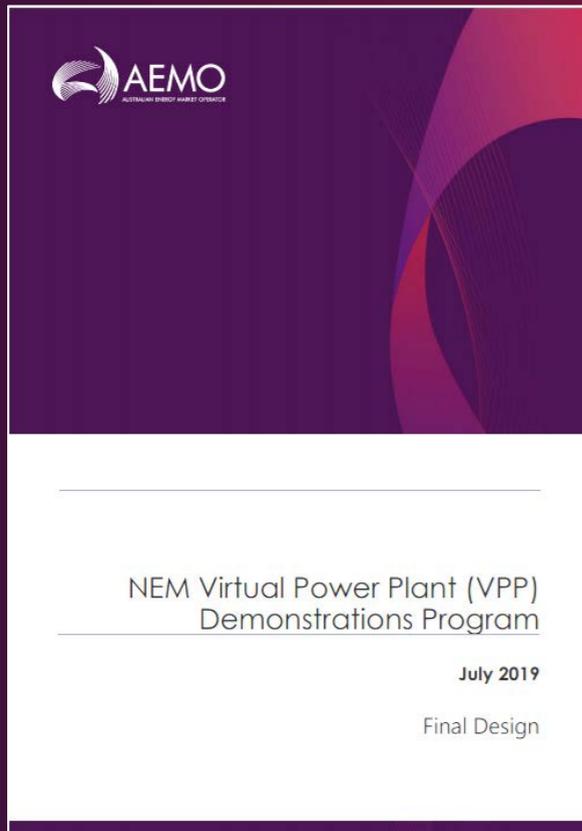
Discussion of various market models including distribution system operator and a hybrid solution.

Flexibility from residential appliances



1. World first standard for controllability of residential energy appliances.
2. Attempts in 2013 to make mandatory for a range of appliances:
 1. Air conditioners/heat pumps
 2. Electric hot water heaters (including solar boost)
 3. Pool pumps
 4. Electric vehicle chargers
3. Stalled – looking for voluntary uptake instead. There has been broad uptake by air conditioner manufacturers since.
4. Incentive program in Queensland has seen more than 60,000 air conditioners being controllable during grid emergencies.
5. Making it mandatory could enable a significant proportion of residential consumption to be flexible.
6. What about inverters for PV and battery storage systems?

Virtual Power Plant (VPP) demonstration



- AEMO has received funding from ARENA for its VPP demonstration program in April 2019.
- The VPP Demonstrations aim to:
 - Allow VPPs to **demonstrate their capability** to deliver multiple value streams across frequency response ancillary services, energy and potential network support services.
 - Provide AEMO with **operational visibility** to help AEMO consider how to integrate VPPs effectively into the NEM.
 - Assess current **regulatory arrangements** affecting participation of VPPs in energy and FCAS markets, and inform new or amended arrangements where appropriate.
 - Provide insights on how to improve **consumers' experience** of VPPs in future.
 - Understand what **cyber security** measures VPPs currently implement, and whether their cyber security capabilities should be augmented in future.
- AEMO opened for enrolment in July 2019.



AEMO

AUSTRALIAN ENERGY MARKET OPERATOR