Transition Delayed

Discussion Paper

renew.

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Cover image: Wind Technician Kristen Hough maintaining a GE wind turbine in British Columbia. Kristen previously worked in coal mines.[i]

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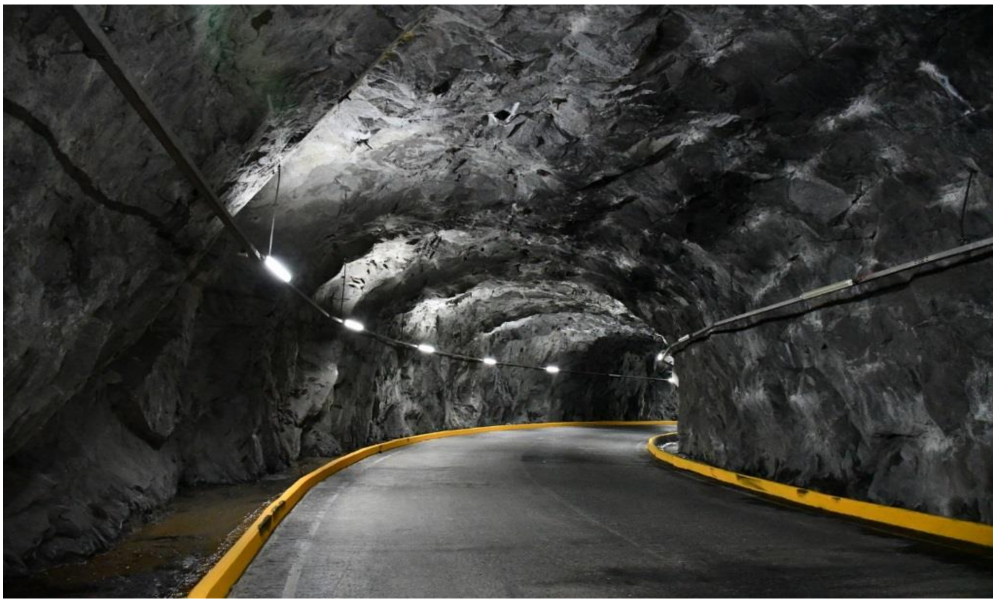

Figure 1 Snowy Hydro tunnel https://www.snowyhydro.com.au/our-scheme/snowy20/exploratory-works/

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Figure 2 Desert peas growing at Broken Hill Solar Farm.

1. Executive Summary

The electricity sector is the most critical sector in the fight against climate change, as clean electricity enables other sectors in our economy to decarbonise via electrification. However, in addition to the well-known political obstacles at the federal level, the transition to renewables is being delayed due to an outdated electricity market design that's failing to deliver the required change.

1.1. The 2020 Integrated System Plan

December 2019 saw publication of an integrated, long-term plan by one of the regulatory bodies overseeing the electricity grid's development – the Australian Energy Market Operator (AEMO).

The *Draft 2020 Integrated System Plan* (ISP)[2] considers a number of future scenarios characterised by the speed of the transition to renewables – a Central scenario based on the current rate and current policies, and a number of alternatives based on slower or faster rates of change in key areas. The fastest transition occurs in the "Step Change" scenario in which renewable energy supplies 90% of the grid's electricity by 2040, and some coal-fired power stations close before end-of-life With the addition of inter-seasonal storage based on hydrogen, this scenario provides a good platform for extension to a 100% renewable grid.

AEMO estimates that Step Change's system-wide cost is only around six per cent greater than the "Central" scenario. This is a great deal given the benefits to fuel security, jobs, direct health impacts, greenhouse gas emissions etc. In other scenarios such as Central, coal-fired power stations are still replaced with wind and solar, but more slowly since they're retained until end-of-life.

This result aligns with previous studies by universities and think-tanks that found a fully renewable grid is entirely feasible. AEMO hasn't yet released details of how a 90% renewable grid deals with tough times such as wind droughts. Renew has asked AEMO to publish such details because it will help build community confidence in the feasibility of a high-renewable grid.

1.2. Transmission

Considerable investment will be needed to replace our aging coal-fired generators as they close down. However high levels of uncertainty about policy direction means investors are hesitant to commit.

Developers of solar and wind farms have found that they are receiving lower value than expected for their electricity due to lack of information about similar developments proposed in the same area. Not knowing that transmission lines would be shared with other large generators, their output has been reduced due to inadequate network capacity. For example, in 2019-20 Ararat Wind Farm is only being paid for 90.38% of its generation which is a big drop from the previous year when it was paid for nearly 97%.

In addition, many generators' output has been curtailed due to inadequate transmission network capacity.

1.3. Energy Storage

Insufficient large-scale energy storage is being built. Whilst storage is an essential component of a reliable, low-cost future grid, it's unprofitable under current market rules which are based on the half-hourly wholesale electricity market. Private developers understandably "cherry-pick' only the most profitable and lowest-risk components of the system, so they're not building large-scale energy storage.

1.4. Reform of the Market

Current efforts to improve the transition of the electricity system focus on regulatory changes and greater intervention in the competitive market. Based on the experience to date, Renew is highly concerned that such incremental reform may take too long to achieve the rapid transition of the sector that is required under climate imperatives. In the worst case, closure or failure of coal-fired generators could lead to blackouts if firm replacements aren't built in time, and consumers will bear the unnecessary costs of a disorderly transition. Renew's view is that in a fully-renewable grid, it will be very difficult to operate the wholesale market as it's currently designed.

Stronger measures may be required in the form of a more coordinated, planned approach. For example, AEMO could be empowered to design and direct development of the grid as was done previously by state-based electricity commissions. It could raise tenders for private companies to construct and operate assets such as generation, energy storage and transmission. As with any changes in the electricity market, stakeholder consultation will be crucial to uphold the long-term interests of consumers.

Once the physical transition is complete and closures of coal-fired power plant have ceased, a more competitive market could be reinstated. With governments already intervening to directly invest in the system, this coordinated planning option would allow for these projects to work together coherently. Luckily, many recent government investments are consistent with the required transition. For example, Snowy Hydro 2.0 (adding energy storage capacity to the Snowy Hydro system) and Marinus Link (a new interconnector between Tasmania and Victoria) are both required for AEMO's Step Change scenario.

Renew will be keeping a close 'watching brief' on developments in the coming months and will be further considering the options to achieve a faster transition of our electricity system, to ensure it develops coherently in the long-term interest of consumers.

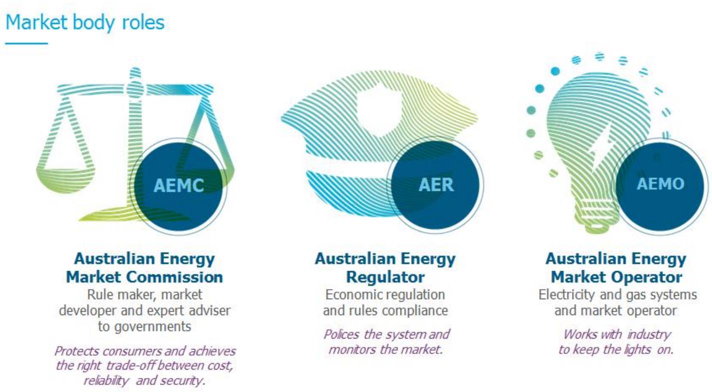

Figure 3 Market Body Roles. Source: AEMC[3]

2. Introduction

The electricity sector is the most critical sector in the fight against climate change.

It presently accounts for around 34%[4] of Australia's greenhouse gas emissions, due to its reliance on fossil coal and gas. Post a major switch to renewables, the electricity grid will allow other sectors (such as transport and heating for buildings) to clean up their energy source via electrification.

Developments in large-scale energy installations also affect households' decisions relating to appliances, rooftop solar and transport.

In 2018-19, 21%[5] of the electricity flowing into Australia's main electricity grid was generated from renewable energy resources. This is a good start toward achieving a fully renewable grid, but there's still a long way to go.

In addition to the obvious political obstacles at the federal level, the transition to renewables is being delayed due to an outdated electricity market design that's failing to deliver for Australians.

For background information, readers might find useful our two previous papers on the electricity grid's transition, "100% Renewable Grid -Feasible?"[6] and "100% Renewable grid by 2030".[7] These were published in 2015 and 2017 respectively.

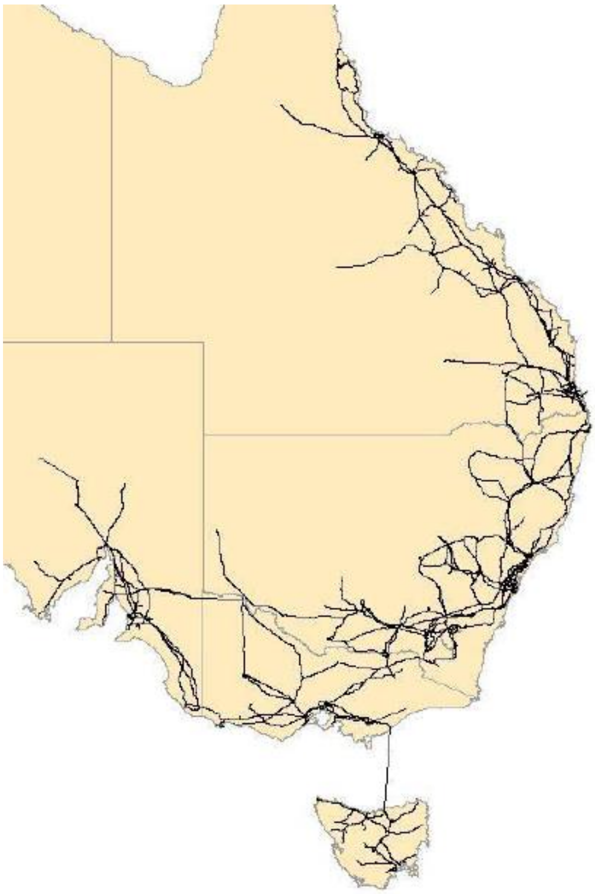

Figure 4 Transmission lines in the National Energy Market

3. Regulatory Approaches

Renew believes there are two main ways to manage an electricity system – “coordinated planning” or a “competitive market”.

The former method has a strong history in Australia before the latter was introduced nearly three decades ago. Both systems have strengths and weaknesses but in our current transition to renewables, the deficiencies of a competitive market are becoming a serious impediment to the required transition.

3.1. Coordinated Planning

In many parts of Australia electricity systems launched in the early 1900s as private concerns, initially servicing industry followed by residences. Local networks spread and connected, and state governments generally took over by mid-century via commissions such as ETSA in South Australia and the Victorian SECV. Each commission planned and managed its state’s entire system from generation to networks to billing and customer service. Assets were publicly owned. Tariffs were generally set to cover the system’s costs, but sometimes the state government would provide a taxpayer subsidy to keep electricity cheap and provide a competitive advantage to its electricity-consuming businesses. On the other hand, in some cases electricity tariffs were raised to effectively gather extra taxes for the government.

This state-based system lent itself to long-term planning, and accountability clearly sat with the organisation’s head. With a culture led by engineers, assets were operated for maximum economic lifespan. To avoid shortfalls, construction of new generators and transmission lines were coordinated to meet demand growth. Replacements overlapped their predecessors in case of teething problems. Transmission lines were built to interconnect states, enabling electricity to be shared to a limited degree.

Figure 5 Transmission line

3.2. Competitive Market

As monopolies not subject to competition[8], as time progressed the former state electricity commissions tended to over-build assets and workforces, possibly passing on higher costs than necessary to consumers. Also, as the states became more interconnected it was clear that a multi-state approach was preferable.

In the early 1990’s the state commissions in QLD, NSW, Vic, SA & Tas were broken up and abolished[9] in favour of a new National Electricity Market (NEM) and assets were mostly sold to private companies. In this new market generators, transmission and distribution networks and retailers all operate as independent private companies.[10] Generators compete to supply electricity at the lowest cost. Retailing is also competitive as consumers can choose between many retailers who can manage their bills and purchase electricity on their behalf in the wholesale market.[11]

The largest three retailers – Origin Energy, AGL and Energy Australia – command about two-thirds[12] of the retail market while a plethora of smaller companies comprise the remainder. Interestingly, Victorian consumers have been paying the highest retail profit margins[13] even though their retail market is considered the most competitive.[14]

3.3. Network Monopolies

It is impractical for a street to host multiple competing electricity cables installed by different companies. As such, transmission and distribution are not organised as competitive markets.

Instead, the NEM is broken into thirteen geographic areas, each of which has a single electricity distribution monopoly run by a private business. Similarly, each state has a single transmission company. These companies obtain revenue by charging a network tariff to all customers in their area – usually a daily supply charge, plus a variable rate based on the amount of electricity used. These are charged to the customer's retailer, who builds them into the retail tariff they charge the customer. Distribution costs are substantial - in some areas they can amount to half the total retail bill.

Network costs are regulated by the Australian Energy Regulator (AER) in five-yearly intervals. Distribution and transmission companies propose tariffs that will raise enough revenue to cover their costs including maintenance, finance costs and construction of new assets to meet growth in demand etc and secure a profit. The AER assesses the proposed tariffs and approves the tariffs they will allow. This process is always contentious (and increasingly so) – until recently each network business was able to appeal the AER's decision via legal action[15], leading to costly court cases.

3.3.1. The Wholesale Market

The market is micro-managed in 30-minute intervals.[16] For each interval, generators place bids offering to supply defined quantities of electricity for a specific price. The Australian Energy Market Operator (AEMO) processes these bids, arranging them into price order and selecting the lowest bids as necessary to meet demand for electricity on the system.[17] AEMO instructs ("dispatches") the winners to generate, while those that were too expensive are told to sit idle. For each interval the wholesale electricity price is set by the most expensive bid to which AEMO had to resort to meet demand. Electricity retailers pay this price (called the "spot price") for each unit of electricity their customers consumer during this interval. All generators receive the wholesale price for their electricity regardless of their bid.

For example, imagine that the market consisted of one coal-fired power station "C", one gas-fired generator "G" and a diesel unit "D". Per megawatt-hour (MWh) of electrical energy, C bids a cheap price of $50 because its fuel is relatively cheap and it doesn't want to incur the time and expense of frequently shutting down and restarting its troublesome boilers. Although G and D were cheap to construct, their fuel is expensive so they bid much higher at $200 and $1,000 respectively. During times of low demand, C's capacity is sufficient so the others sit idle. During evening peak times, C's capacity is exceeded so AEMO must instruct G to generate some electricity at higher expense. During a heatwave when everyone's air conditioners are running, AEMO must resort to D to cover peak demand, setting the wholesale spot price for all three generators at $1,000 per MWh during this time.

Of course, the NEM's wholesale market is much more complex than this example. There are scores of generators and they tend to adjust their bids dynamically based on market conditions.

Figure 6 Example illustrating how the wholesale market operates

3.4. Regulatory bodies

In practical terms, the NEM has no single head who is accountable for the grid's performance. In February 2019, the author of this paper asked the head of the Energy Security Board:

> *"Who should the public hold to account if the transition goes poorly leading to blackouts?"*[18]

The reply was that *"the entire industry would be accountable."* But it's difficult to see how the public can hold an entire industry to account as various executives and politicians point fingers at each other.

Australians' ultimate recourse is the ballot box. When electricity shortages arise, sometimes the jurisdictional Energy Minister is forced to ask citizens to curtail their consumption. Politicians hate this task as it attracts blame onto their political party, even if it more rightly sits elsewhere. In creating the NEM politicians gave away control of the system, but they didn't avoid being blamed for its mistakes.

3.4.1. Governing Bodies

State and federal politicians direct the grid's development via the Council of Australian Governments' Energy Council (COAG EC), which comprises state and federal energy ministers. Consensus is hard to achieve and sometimes these ministers' actions are uncoordinated. Energy is traditionally and formally the responsibility of state governments rather than federal, but as with health and education, this demarcation has become blurred in recent decades.

The Australian Energy Market Commission (AEMC) is the "Rule Maker" in the NEM and governs the process for changes to electricity market rules and the law, implementing COAG EC's overarching policy directions and decisions. As noted above, proposed rule changes can take years to come into effect, if they are approved at all.[19] The AEMC's approach is generally to facilitate competition and market where possible, and regulate only where competition is impractical (such as networks).[20]

AEMO runs the short-term electricity market (as explained above) and has a separate planning role producing documents such as the ISP. It also has a role planning the transmission network in Victoria, whereas in other states that's done by the local transmission network company. In recent years, AEMO has spoken favourably of long-term, coordinated planning to manage the ongoing transition to renewables.[21]

Electricity systems overseas usually combine the functions of the AEMC and AEMO into a single body; their separation here is unusual.

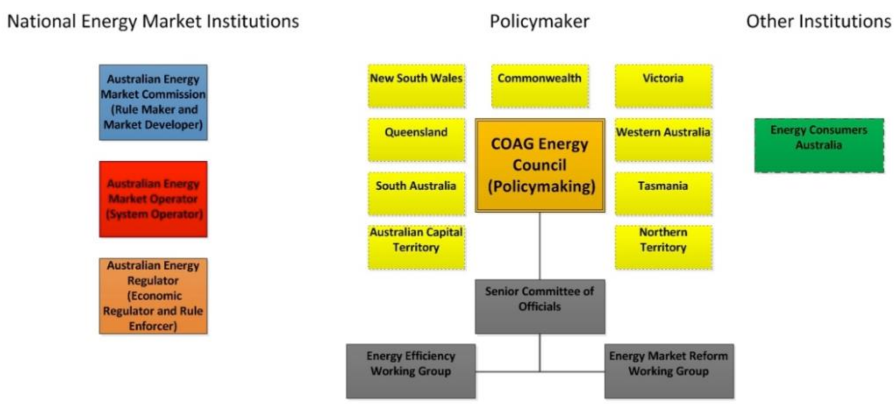

Figure 7 Bodies overseeing the electricity system. Source: Penelope Crossley, UNSW 201

A relatively new addition to the electricity landscape is the Energy Security Board (ESB). Formed in 2017 on the recommendation of Chief Scientist Dr. Alan Finkel, its role is coordinate reforms and "provide whole-of-system oversight for energy security and reliability".[22] It consists of five members at time of writing, including the CEO or Chair of each of the AEMO, AEMC and AER.

3.4.2. Private Companies

A plethora of individual companies own and manage assets (such as energy networks and generators) and buy and sell wholesale electricity (retailers), making decisions in the interests of their shareholders. Those operating in competitive markets (generators and retailers) are not permitted to cooperate, under competition law. Rather, they have a financial incentive to conceal their intentions. Networks, on the other hand, are regulated monopolies and do not compete with each other – so there is nothing stopping them from sharing ideas and plans, cooperating, and working together to meet shared challenges. Traditionally, they have not done so; but this has been changing in recent years.

In March 2020, energy company executives began meeting weekly with government via an "Energy Coordination Mechanism" to coordinate responses to the novel coronavirus COVID-19.[23]

3.4.3. Economic Considerations

The electricity market is guided by the *National Electricity Objective*, an explicitly economic concept that aims to promote economic efficiency in the energy system in order to serve the interests of consumers at lowest possible cost. Market bodies are required to focus on the efficient operation of the market and leave high level policy and broader environmental and social concerns to governments.[24] This means that to weigh climate policy objectives or affordability for specific groups of consumers against economic factors, the market bodies need specific guidance from government about how the trade-offs should be made. The lack of clear climate policy from the Commonwealth government in recent years is thus a key factor in the design of the energy market not fully supporting the transition required. On the other hand, outside of the market design the electricity system can be seen to accommodate government policies such as the federal Renewable Energy Target[25] and the former price on CO2 emissions.[26] For example, AEMO's Integrated System Plan allows for state government policies such as the Vic and QLD targets to reach 50% renewable electricity by 2030.[27]

Figure 8 GE wind turbine used in the 453 MW Coopers Gap wind farm (Qld)

The National Electricity Objective
"to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:

- price, quality, safety and reliability and security of supply of electricity
- the reliability, safety and security of the national electricity system."

Figure 9 The National Electricity Objective. https://www.aemc.gov.au/regulation/regulation

4. AEMO’s Integrated System Plan

In December 2019 AEMO published its *Draft 2020 Integrated System Plan* (ISP).[28] This document presents similar results to its earlier 2018 ISP, but it’s supported by more robust modelling and consultation. Arising from a 2017 recommendation by the Chief Scientist Alan Finkel,[29] the ISP has a considerable focus on transmission planning, an area in which AEMO has always played a role, in addition to operating the short-term wholesale market.

The ISP confirms other researchers’ earlier analysis which found that the cheapest option to replace the old coal-fired power stations is wind and solar, supported by energy storage and transmission.[30] These assets are relatively capital-intensive, but operating costs are low because their fuel is free. Over a multi-decade lifespan, those future savings become significant.

AEMO can’t force generators or retailers to build or close assets in line with the ISP. However, AEMO may soon gain the power to direct development of new electricity transmission lines which it has found necessary via this planning process.[31] This is an important step to accelerate these new connections.

4.1. Step Change – 90% renewable by 2040

AEMO modelled five scenarios varying by many factors including economics and technology uptake. The most interesting is named “Step change” and is designed to be compatible with Australian decarbonisation by 2050. Other scenarios such as “Central” are based on a slower transition in which coal-fired power stations are retained until end-of-life. Unless noted otherwise, this paper will focus on “Step Change”.

In this scenario, fossil fuels decline to 8% of total generating capacity and 10% of annual electricity generation by 2040-41. Greenhouse gas emissions fall to 15% of their value in 2018-19.

By 2040-41, wind and solar farms each total around 30,000 MW of installed capacity, while rooftop solar is around 35,000 MW.

As shown on the map to the right, north-east NSW and south-east QLD become renewable powerhouses and Tasmania exports a lot of wind power. Victoria frequently relies on renewable energy from its neighbours, transmitted via interconnectors.

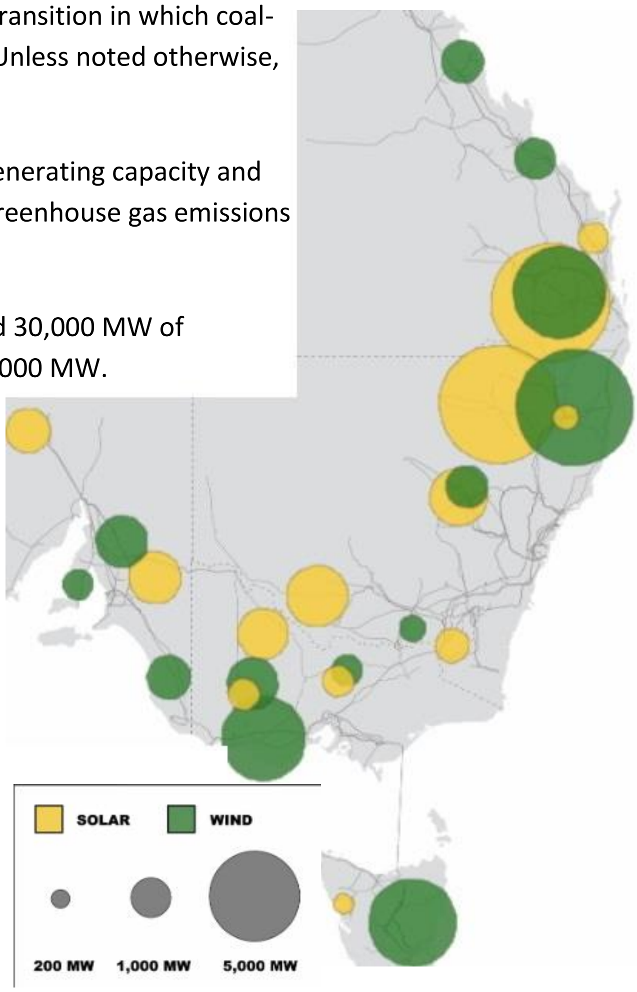

Figure 10 Dispersion of wind and solar, Step Change 2040.

The following two charts detail future growth in generator capacity and annual generation. "CCGT" is a relatively efficient gas-burning generator, while "Peaking Gas" facilities are cheaper to build but less efficient. "VPP" is a Virtual Power Plant i.e. batteries in homes and businesses, and "DSP" is Demand Side Participation, e.g. smelters contracted to occasionally turn off some operations to reduce demand.

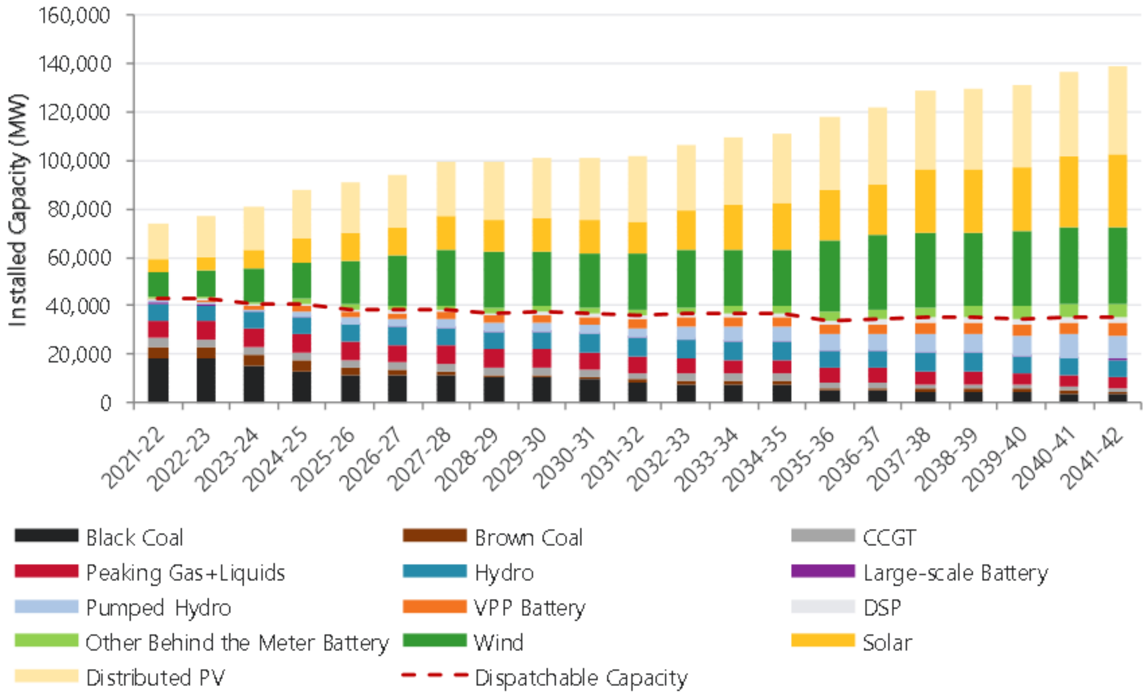

Figure 11 Generating capacity in MW, Step Change scenario. [32]

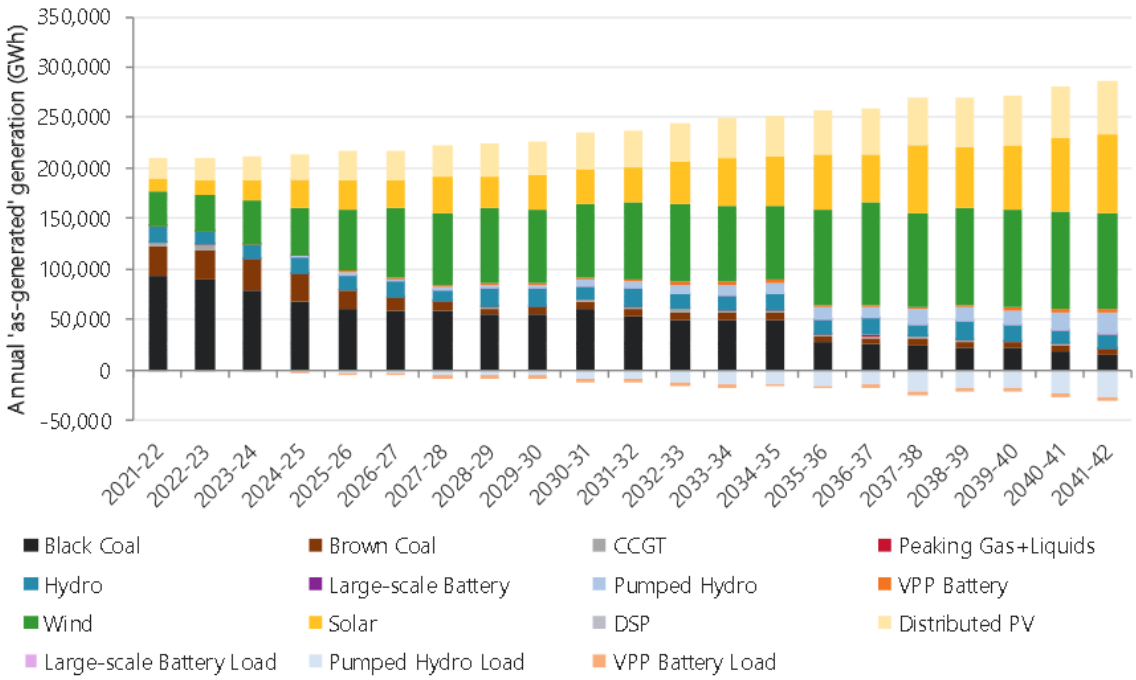

Figure 12 Annual electrical energy generation in GWh, Step Change scenario[33]

Significantly, this modelling confirms that a 90% renewable grid is achievable. On the other hand, AEMO hasn't yet described in detail how this system supplies energy through a very unfavourable week, for example when it's cloudy and calm. How deeply are energy stores depleted? Renew has requested that AEMO provides this detail because without it, it's inevitable that some commentators and policy makers won't believe that a 90% renewable grid can be reliable.

Renew advocates for the transition to renewable electricity to be completed earlier than 2040. We urge AEMO to examine the feasibility of more rapid decarbonisation in the next ISP, if not sooner.

We also urge AEMO to examine a fully-renewable grid, rather than just 90% renewable. One technique is to use excess wind and solar generation to produce hydrogen (or derivatives such as ammonia) and store it for weeks or months until it's needed to generate electricity again. Inclusion of such processes would increase the proportion of renewable electricity above 90%, potentially to 100%. This is a relatively simple extension of the "Step Change" scenario so hopefully AEMO will examine hydrogen in future. For more information, please refer to our discussion paper "Hydrogen - Help or Hype?".[34]

4.2. Energy Storage for Step Change

These high levels of wind and solar require lots of energy storage to cover nights, cloudy periods and "wind droughts". For this energy storage, the following two charts show the installed capacity in MW and storage capacity in GWh. "PHES" is pumped hydro energy storage. The numbers of hours for which the storage can discharge (at maximum capacity) before depletion is denoted by 6hr, 24hr etc.

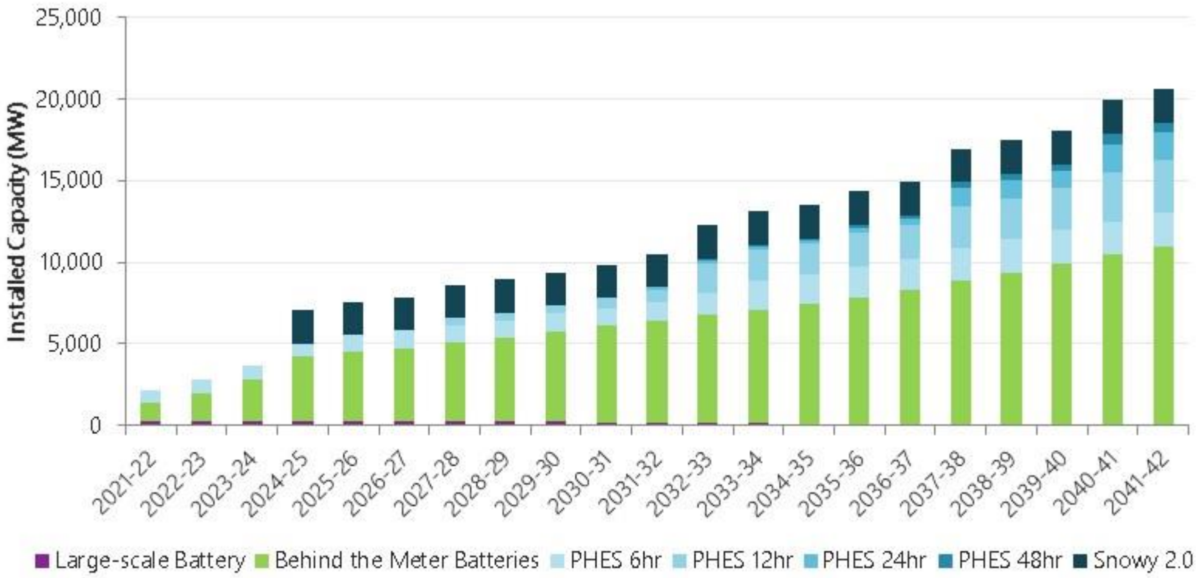

Figure 13 Energy storage capacity in MW, Step Change scenario[35]

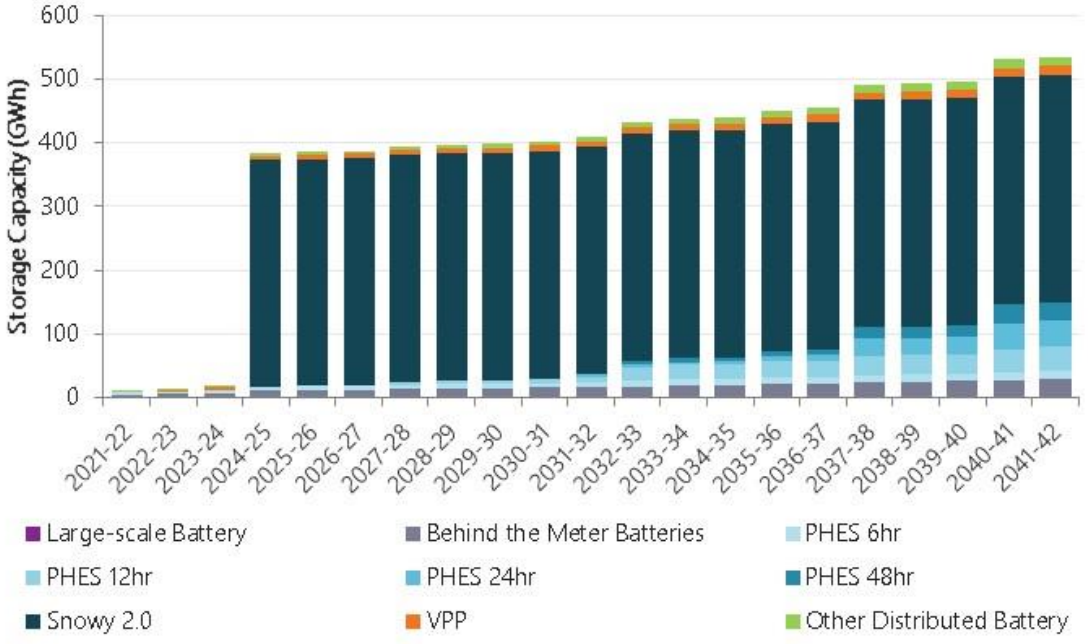

Figure 14 Energy storage capacity in GWh for Step Change[36]

In terms of energy storage capacity, Snowy Hydro 2.0 (SH2) dominates thanks to its very large, pre-existing water reservoirs. This facility will be able to dispatch as much power as a coal-fired power station (2,000 MW) for a whole week. For power capacity, smaller pumped hydro facilities and batteries in homes and businesses (behind the meter) are more significant. In the Step Change scenario, AEMO expects that these will already total more than 2,000 MW of capacity by the time SH2 is commissioned in 2024-25.

Batteries and small pumped hydro facilities are examples of "shallow" energy storage, because they deplete relatively fast, e.g. in six hours or less. This is very useful to store solar energy from daytime to use at night. Through the 2030's, AEMO sees a need for deeper energy storage to be developed, e.g. pumped hydro able to discharge for 24 or 48 hours. Deeper storages are used to handle prolonged periods of cloud or low wind.

Average demand for electrical power in the NEM is about 23,000 MW.[37] The 90% renewable Step Change scenario has a total energy storage capacity of 531 GWh.[38] This is enough to supply the average NEM demand for around 23 hours in the absence of generation. By comparison, the ANU estimated that 490 GWh of energy storage would be enough for a fully renewable grid.[39] These two figures for energy storage aren't directly comparable because they're based on different scenarios and use different transmission networks to share renewable energy around the NEM. However, it's noteworthy that they're within 10% of each other. Since multiple studies find that such amounts are required, it seems unlikely that construction of large-scale energy storage developments would lead to future regret.

4.3. Scenario Costs

The Integrated System Plan doesn't talk much about the overall costs of its scenarios, but it does outline them in an appendix.[40] For each scenario, AEMO estimated how much money would be spent on electricity generation and transmission to meet demand, – considering capital expenditure, maintenance, fuel, and so on - in each year from 2021/22 to 2041/42. Spending in distribution networks and investments by consumers in solar and other home energy technology are excluded from these calculations. As usual in the ISP, costs arising from greenhouse gas emissions or direct health impacts are also excluded. To deal with inflation, AEMO used constant real 2019 dollars. It then calculated a Net Present Value (NPV) by discounting future-year costs by applying a discount rate of 5.9% (7.9% for "Slow Change").

The following chart collates the Net Present Value of future grid costs for three different scenarios: the default Central scenario, the rapid Step Change, and the "Slow Change" scenario that sees sluggish adoption of renewable energy and life extensions for fossil fuel plants. Capex is capital expenditure for new generators, FOM and VOM relate to operations and maintenance (fixed and variable components respectively), REZ relates to Renewable Energy Zones and Rehab is rehabilitation of old assets.

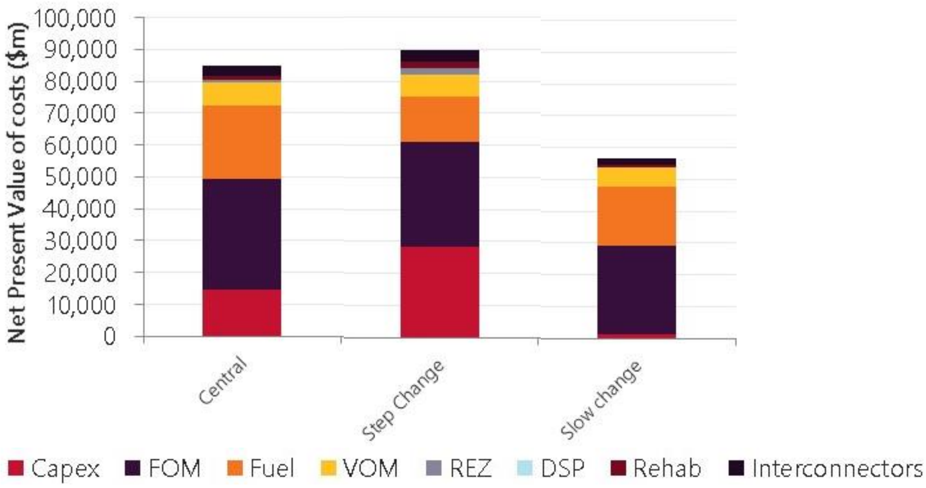

Figure 15 Discounted total system costs for selected scenarios.[41]

Due to the NPV methodology and exclusions, the magnitude of costs is not particularly meaningful and doesn't represent the cost to consumers, but the percentage difference is indicative. Significantly, Step Change only costs about six per cent more than the Central scenario. From a whole-of-society point of view, this is a small price to pay for a reliable 90% renewable electricity grid and will likely be more than offset by the broader benefits of national fuel security, increased employment[42], avoidance of health impacts from fossil fuel pollution, reduced greenhouse gas emissions, and so on. It's particularly interesting how cheap interconnectors (the black bar on top of the columns) are compared to other items.

In the chart above, the "Slow Change" scenario costs dramatically less than "Central", but this is explained by several factors. This scenario's higher discount rate is significant – for example, a cost incurred in 2040 is discounted by nearly 80% compared to a discount of only around 70% for the other scenarios. The "Slow Change" scenario is based on a stagnant economy, industrial closures and relatively cheap gas prices. Electricity consumption in 2040 is about 17% lower than Central or Step Change. All these items work to artificially suppress costs for this scenario – it's not an "apples to apples" comparison.

5. Competition and the ISP

Australia's electricity sector reform in the 1990's was part of a wave of deregulation and market-based privatisations in many sectors of the economy. The main motivation was to improve organisational performance, and governments also obtained short-term financial benefits by selling public assets. The NEM's creation was informed by the earlier, similar reform of the electricity sector in the United Kingdom.

5.1. What Sayeth Adam Smith?

For the last forty years or so mainstream economists have tended to favour competitive markets, citing economic theory that originates with the discipline's founder, Adam Smith. In his work "The Wealth of Nations" written in the 1776, Smith described how individual businesses operating in their own interests often deliver overall outcomes superior to those operating under excessive regulation. In one place he invokes the famous term "invisible hand"[43] to describe how self-interest seems to automatically guide economic development and prosperity.

On the other hand, Smith recognised that some sectors of society were unsuited to competitive free markets. One example was industries important to national security.[44] Since electricity is essential to national security, it could be argued that it's unsuited to a competitive market.

Smith also warned of the dangers of corporate greed and its influence on politics, advocating strong, effective regulation in this area.[45] This seems as true today as it was back then.

5.2. The Good Ship "Power System"

Competitive markets work better in some situations than others. For example, consider sailing ships delivering cargo from London to New York. It made sense for shipping companies to compete for customers, with profits motivating higher performance and innovation. On the other hand, a single sailing ship needs tight cooperation between crew members under a single captain's direction.

An electricity system operates as an interconnected machine like a sailing ship. The National Electricity Market (NEM) shares energy from Port Douglas in Queensland to Port Lincoln in South Australia, with electrons pulsing back and forward within cables and appliances synchronised the whole distance. A shortfall in energy supply in one location can trigger blackouts far away.

When it comes to long-term planning, the NEM operates like a ship without a captain. Each crew member is trimming the sails and steering the tiller according to their own interests. AEMO is up in the crow's nest looking for danger and shouting down possible safe courses, but some crew members aren't listening.

When sailing conditions are fine, lack of coordination may not be a problem because no-one is in doubt about what to do. Some competition between crewmates may be beneficial, e.g. to see who can furl the sails fastest. However, this changes when conditions are treacherous, and decisions must be made between different courses. When rocks lie ahead, all crew members must commit to a specific course to avoid them. Disaster beckons if different people set the sails and steer the tiller variously assuming different courses.

5.3. Generation Fleet Refresh

When the competitive market was established, it inherited from the previous state commissions a large fleet of coal-fired generators mostly built in the 1970s and ’80s. This gave the new market a few decades of “smooth sailing” because over this time relatively minor changes were needed.

Distribution networks were upgraded, and new gas-fired power stations were built to meet air conditioner-driven demand peaks. These were tasks to which the NEM’s market structure was well-suited, as even though a gas-fired generator runs only infrequently[46], it can pay for itself by bidding the wholesale electricity price up to 160 times its regular level.[47]

Now the NEM faces a challenge that it’s never seen previously – a refresh of its main fleet of generators, which are reaching the end of their lifespan and closing. Like an old car, an old coal-fired power station’s equipment (such as boilers) reach a point where further repairs become uneconomic.

AEMO has estimated (in the Central scenario) that of current coal-fired generation capacity, 19% will be gone by 2030 and 63% by 2040.[48] Various people including power station owners have warned that closures may occur sooner than estimated, due to irreparable breakdown or market conditions.[49] AEMO is developing contingency plans for the Yallourn brown coal-fired power station to close in 2026-27, instead of its assumed phase-out from 2030 to 2033.[50]

This refresh would have been tricky even under “like for like” asset replacement, without a shift to renewables. The market has no way to coordinate the closure of one company’s generator with the construction of one by another company, since cooperation between these companies constitutes illegal collusion under competition law.

According to market theory such coordination is not generally required, because a shortfall in supply of a product or service will lead to a price increase, which in turn encourages new businesses to enter the market and thus increase supply. This dynamic works well in some industries, but not in electricity. One reason is that a power station closing down reduces supply abruptly and it takes considerable time to build a new power station, of any kind. A coal-fired power station usually comprises a large portion of a state’s electricity supply so its closure will lead to a huge supply shortage that will spark a significant spike in prices, which could last for many years – a new coal-fired generator without CO2 capture would typically take around eight years[51] to complete.

Electricity is an essential service and a key input to much of the economy. As such, citizens and governments are very resistant to higher prices – especially when they could have been avoided by greater coordination. Even if they weren’t being displaced by wind and solar, it’s difficult to see how the old coal-fired power stations could be smoothly replaced in the NEM’s competitive generation market.

This was demonstrated in November 2016, when the owner of Victoria's Hazelwood coal power station announced it would close in March 2017. Five months' notice was insufficient time for any new generation to be planned and built, and this led to a significant price spike and concerns about supply shortages. Subsequently, a new market rule came into effect (in November 2018) requiring power stations to provide three years' notice before closing.[52] This was a clear acknowledgement of the inability of unfettered market forces to ensure reliable electricity supply, but is still problematic, for a number of reasons:

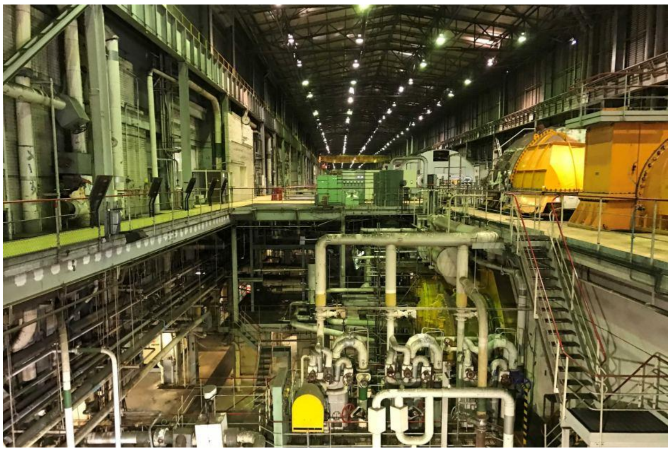

Figure 16 Hazelwood Power Station generator room. Source: ABC.

- Three years is long enough to build a wind farm or solar farm, but not to construct essential supporting facilities such as transmission and energy storage such as pumped hydro (discussed below).
- If a coal boiler breaks down irretrievably, the power station will be out of action long-term regardless of what the rule says.
- If changes in the market make a generator uneconomic, it is unreasonable to force the private owner to operate it for three years at a loss.

5.4. Grid Stability

Traditionally, generators have been required to support a stable grid by helping to maintain AC power close to 50 cycles per second. If the grid's frequency deviated from this value, each generator would respond immediately and autonomously, adjusting its power output to help restore normal frequency. More recently, generators have been allowed to relax[53] these direct responses in favour of a market solution to frequency control, FCAS[54]. Since the market solution incurs communication delays, this relaxation has reduced the grid's resilience to shocks.[55]

5.5. Other Industries

Some parts of our society and economy have never been or are no longer subject to a competitive market because a cooperative approach works better. The supply of water to our cities has many similarities to the electricity system, but it has long been managed as a public utility or monopoly. Firefighting and law enforcement are other examples.

In hindsight it's possible that some privatisation reforms were unwise. For example, private building surveyors were permitted to operate in competition to their counterparts employed by local government. In the opinion of at least one respected expert in building regulation and fire safety, Australia's current problems with flammable cladding wouldn't have occurred without this privatisation.[56]

Similarly, financial sector reforms arguably created the conditions allowing subsequent scandals in that sector.[57]

6. Renewables and the Market

Wind farms and solar farms are quite different to fossil fuel generators and their large-scale uptake wasn't anticipated when the NEM was created. They cost very little to run since their fuel is free, but their generation is variable or intermittent depending on weather conditions. Their generation is thus not "firm" – in other words they're not "dispatchable". For a reliable high-renewable grid, energy storage is required to deal with this variability, i.e. to "firm them up". New transmission lines are also required to connect them to the grid. The present market is failing to construct energy storage and transmission in pace with wind and solar generation – instead these components are lagging and delaying the transition to renewables.

6.1. The Cheapest Generation Mix

Many studies have found that to replace the old coal-fired power stations, the cheapest mix of new generators is dominated by wind and solar farms.[58] Over their lifespan, their low cost to run outweighs the extra cost of energy storage and transmission need in support.

Such long-term studies assume that generators and energy storage will be constructed and operated intelligently in the interest of consumers. Market dynamics aren't modelled because an efficient market is supposed to deliver this result.[59] If consumer outcomes are poor, this indicates that the market design is inefficient and should be reformed.

6.2. Energy Storage in the Market

The NEM's current wholesale market suits wind farms and solar farms because they earn the half-hourly spot price whenever they generate and incur no penalty for being unavailable when the weather is unsuitable. They have also benefited from payments under the Renewable Energy Target – but over the next few years those payments are expected to reduce to almost zero, so they now play little part in investment decisions for new plant.[60]

On the other hand, the current market does *not* suit large-scale energy storage. Batteries installed in the past couple of years such as Hornsdale Power Reserve (the original "Tesla big battery") in SA have earned a good financial return from acting like shock-absorbers to stabilise the grid during sudden events such as transmission lines blowing over. Their ability to instantly charge or discharge is very useful here. But there's only a small market for such services, and it's already nearly saturated. To "firm-up" wind and solar, a high-renewable grid must store a significant fraction of a state's power for hours or days, and this requires facilities hundreds of times larger than Hornsdale.[61]

Under current market rules, an energy storage facility providing regular "firming" services would be compensated only via the wholesale price for electricity.[62] For example, it might charge up around midday when excess solar generation has depressed the price to $30 per megawatt-hour and then discharge during the evening peak when the price is $120/MWh. By buying low and selling high, the owner earns $90/MWh. Such returns are insufficient to attract investors because energy storage is relatively expensive to build relative to wind and solar and some energy is lost during charge and discharge. Also, owners don't know the extent to which other energy storage facilities will be built, pushing up the midday electricity price due to competition.

The real value of large-scale energy storage is to *enable* the construction of high levels of cheap wind and solar by firming-up its generation. However, this value is not rewarded by the present market. Developers and investors have no responsibility for the grid's overall reliability, so they naturally build the profitable part of the new system (wind and solar) and ignore the unprofitable, risky part (energy storage). A similar situation exists in property development. The community would be better off if new housing developments were served by train lines. But housing developers have no responsibility here, so they focus as much as possible on building only the profitable features of the new suburbs and ignore the rest. Private developers understandably "cherry-pick' only the most profitable and lowest-risk components of the system.

Energy storage is also hampered by specific market rules that didn't anticipate a facility that could both draw from and inject electricity into the system. The NEM requires a connection to be registered either as a generator or a consumer but not both. A solar farm might include a battery to store midday energy and enable the owners to generate later into the profitable night-time peak. However, this battery must have its own grid connection installed since it's not allowed to share the solar farm's connection to the grid.[63]

Continued delays in large-scale energy storage investment will eventually discourage renewable energy, especially solar farms. Between paddocks and rooftops, solar is supplying an increasingly large portion of daytime demand for electricity, which depresses the daytime wholesale price for electricity. Lower wholesale prices will reduce future solar farm revenue, which investors will anticipate causing project delays or cancellation. Conversely if energy storage is installed in step with renewables, it will charge up during the daytime, increasing the daytime wholesale price and providing a stable market for solar.

6.3. Transmission

Most electricity transmission lines were built by the former state-based commissions to transport electricity from fossil fuel and hydroelectric power stations to consumers. Very strong connections exist to coal-mining centres such as the Hunter Valley and Latrobe Valley. In contrast, high-quality wind and solar resources exist in locations such as western Tasmania, rural South Australia and west of the Great Dividing Range. Over the last several years, these areas have gone from backwaters of the grid to regions of intense activity and interest by renewable energy investors and developers.

Areas with strong renewable resources are generally served by old, weak transmission lines insufficient to serve existing and forthcoming wind and solar farms. A clear example is north-western Victoria which is served by transmission lines running from Ballarat to near Mildura via two routes, one west via Horsham and one north-east via Bendigo. The shape of these lines combined with the experience of some renewable developers has led to this region being called the "Rhombus of Regret".[64]

Figure 17 Transmission lines in Western Vic. Source: Ausnet Services.

In this part of Victoria, some solar farms have recently been forced to halve their generation because of unforeseen technical problems in transmission lines. AEMO has warned that new wind and solar farms will have to wait until new transmission is constructed.[65] Developers have faced long delays and unexpected technical requirements. Interestingly, these issues were anticipated in an inquiry a decade ago.[66] In South Australia, around 3% of wind farms' generation is curtailed and wasted because they're generating more electricity than the grid can cope with.[67]

AEMO estimates that across the eastern states, the existing transmission network can support additional wind and solar rated to only 13,000 MW – much less than the 30,000 MW that may be required to 2040.[68]

6.3.1. Revenue Cuts

Congestion in these old transmission lines has caused revenues from many solar and wind projects to be unexpectedly slashed. At times when the line is heavily loaded, a higher proportion of energy is wasted as heat. The generator is penalised for this wasted electricity via percentage called a "Marginal Loss Factor" or MLF. For example, in a half-hour interval Ararat wind farm may deliver 100 MWh of energy into the line, but it is only paid for 90.38 MWh because its MLF for 2019-20 is 90.38%.[69] This is a big drop from the previous year, when it would have been paid for nearly 97 MWh. Sudden drops in MLF can even affect generators that were installed a decade ago, if new generation connects nearby.

Developers cannot predict such drops in revenue even in the short term, because market confidentiality rules prevent the transmission line's owner or manager from informing them about other planned projects.[70] Naturally, investors are wary of committing to projects subject to such unpredictable future revenue reductions.

6.3.2. Last-minute Extra Costs

Some solar and wind farms have been required by AEMO to install extra equipment – synchronous condensers – shortly before project completion. These large spinning machines help ensure that the transmission line's safety switches can operate properly in the event of a fault, such as towers blowing over.[71] Such equipment is only required at generators if the local transmission line is weak electrically. A more robust, well-planned system would have less need for such equipment, and would more likely place them at more strategic locations. For example, if planned and designed well, big batteries may be able provide this service in addition to their other benefits to the energy system.[72]

Figure 18 Amazon CEO Jeff Bezos opening a new 253 MW wind farm in Texas, October 2017

6.4. Generator Bids in a High-Renewable Future

Looking ahead, it is unclear whether the current market can even manage a high-renewable grid on a short-term basis. As described above, AEMO relies on generator bids and instructs the cheapest generators to operate. The most expensive bid required to meet demand sets the wholesale price for everyone.

As noted above, wind farms and solar farms are very cheap to run since their fuel is free. These generators are typically willing to accept any price down to zero, because any revenue is better than none. In a fully renewable grid, much of the time the wholesale price may be zero[73] because wind and solar alone can supply demand. At other times, other generators would be operating such as energy storage, hydroelectric or biofuels. Since these generators would only run occasionally, they might need to bid high prices to cover their annual costs.

A wholesale price that frequently jumps from low to high levels is not conducive to a stable market and may not allow the market operator to sensibly schedule generation. For example, when there's an oversupply of wind and solar, it's not clear how AEMO would pick which ones to run.

6.5. New Transmission

New transmission lines are required to serve the upcoming wind and solar farms. AEMO has identified the projects to achieve this, as illustrated on the following map.[74] Unfortunately, none of these projects have yet broken ground. The SA – NSW interconnector was approved by the AER in late January 2020, but still must pass further approval hurdles.

This transmission shortfall shouldn't have occurred because the current amount of renewable generation was anticipated in 2009 when the Renewable Energy Target was set at 45,000 MWh by 2020. If a coordinated planning process existed, generator locations could have been anticipated and serviced proactively.

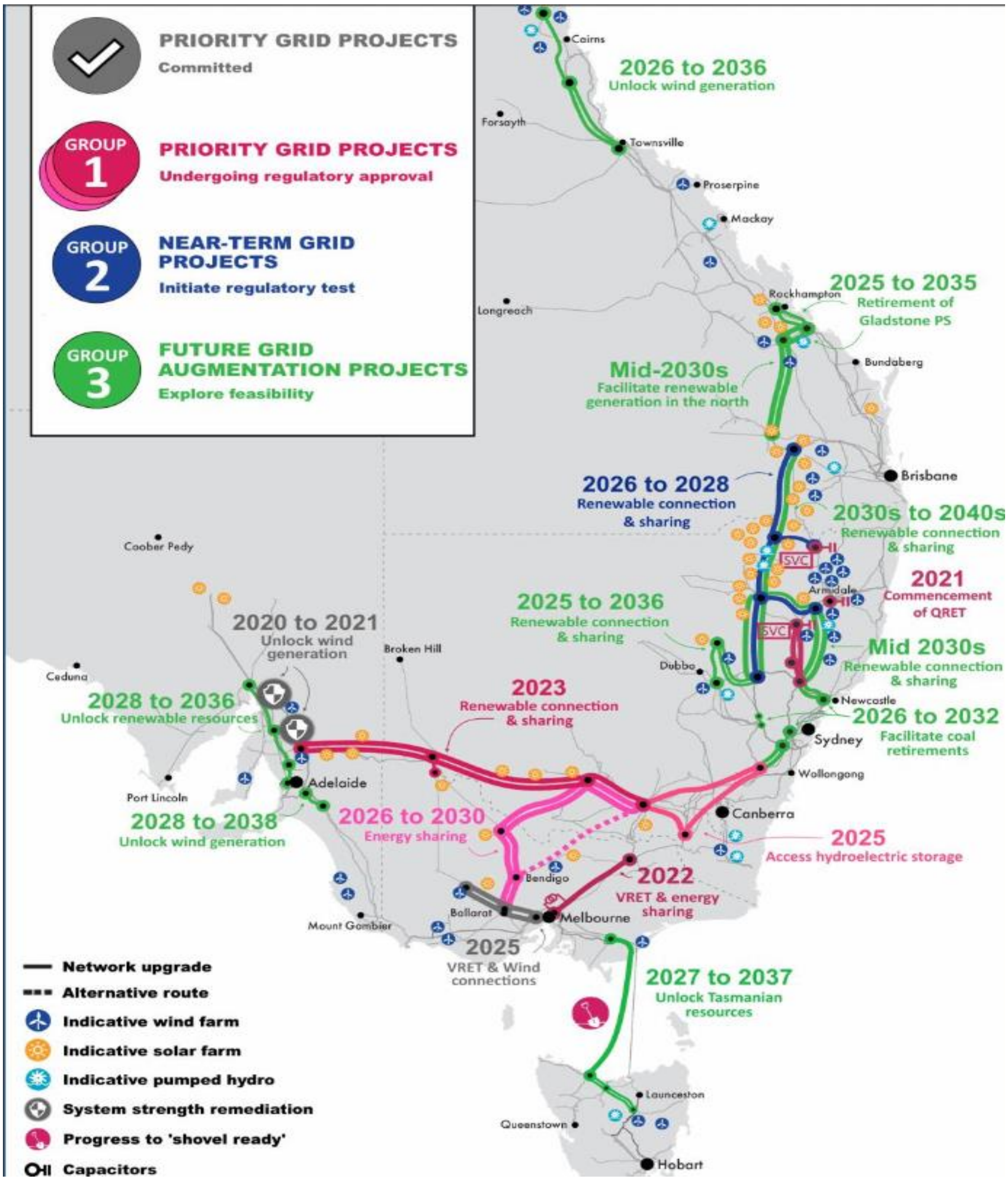

Figure 19 Figure 2 Map of transmission projects identified in the 2020 ISP

The shortfall that we now face is a result of the failure of the competitive market to holistically manage the electricity grid.

7. Pumped Hydro

Energy storage is essential to support a predominantly renewable energy system, and pumped hydro is the front-runner. In AEMO's Step Change scenario with a 90% renewable grid, pumped hydro accounts for nearly 90% of energy storage in GWh, and nearly 50% of capacity in MW.[75] Proposed projects in Australia do not dam rivers and their water is recycled. Many of them utilise existing reservoirs.

7.1. Managing a Hydro-Heavy System

Our present grid operates on a "just in time" basis, with generators' output adjusted minute by minute to balance supply with demand. The future grid will be quite different because significant energy will be stored to buffer shortfalls in demand. It will be important to carefully manage the discharge of stored energy. If stores are depleted too quickly, a shortfall may occur later in the day or week. With multiple facilities, in some cases the deeper (longer-duration) storage should be prioritised for partial discharge so that all storages have some energy remaining to discharge simultaneously during a demand peak.

Some hydro facilities face constraints on their use and discharge of water. Water discharged by most traditional hydro-electric generators flows downriver, so it's limited at some periods of the year due to implications for irrigation and environmental flows. Pumped hydro facilities recycle water between top and bottom dams, so they don't encounter these issues. An exception is those sharing an existing hydro-electric reservoir as their lower dam; those facilities may sometimes face water-related constraints.

Our present electricity market is unsuited to managing a grid that relies heavily on pumped hydro. The market treats energy storage like any other generator, with individual private companies making short-term decisions on when to run according to profitability based on the volatile spot price for electricity. Under normal market operation, companies owning pumped hydro will be tempted to discharge whenever the price spikes up, without regard for reserving energy for later in the day or week in the interest of overall system reliability (for which the company bears no responsibility).

It seems that a hydro-heavy system requires a more cooperative approach. Luckily precedents for this exist. For example, Hydro Tasmania, a Tasmanian government business enterprise, manages Tasmania's thirty hydroelectric generators cooperatively, which is especially important when the water discharged from one power station is subsequently used to power another one. Another precedent is Snowy Hydro, which similarly owns and cooperatively manages hydro assets in the Great Dividing Range in NSW. Then there's Wivenhoe Power Station, a pumped hydro facility near Brisbane owned by the QLD government, which was re-prioritised in late 2019 to complement wind and solar.[76]

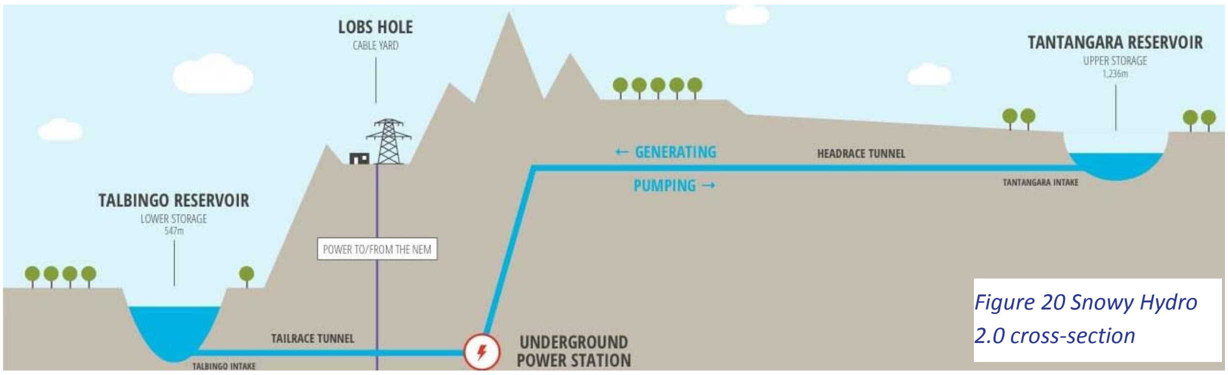

Figure 20 Snowy Hydro 2.0 cross-section

7.2. Managing the Transition

Until enough wind and solar generators are built, our grid will rely partly on fossil fuels, especially to supply late-evening peaks. As the transition progresses, remaining fossil generators will face an increasingly tough task to rapidly increase power as the sun sets or the wind dies down. The more modern coal-fired power stations can turn down their power levels to say 30% or 50%, but it's simply not feasible to completely shut them down during solar hours and then restart each evening – not only is this an arduous, complicated task, it also places additional stress on the aged equipment, increasing the chance of breakdowns.

Figure 21 Figure 2: Anglesea coal mine and power station[77]

During these transition years, frequently during the day we'll have both a surplus of solar generation and unwanted but unavoidable coal-fired power. It's logical to store this surplus energy for discharge in the evening and night. For example, in the following chart AEMO presents a simulated day of minimum demand in Victoria in 2040, for the Central scenario. During solar hours, coal generation drops to minimum stable levels, and pumped hydro is charging. It appears that wind farms have been curtailed to zero during this time, presumably because their energy has nowhere to go. AEMO hasn't presented such a chart for the Step Change scenario, but it would feature less coal-fired generation and more energy storage.

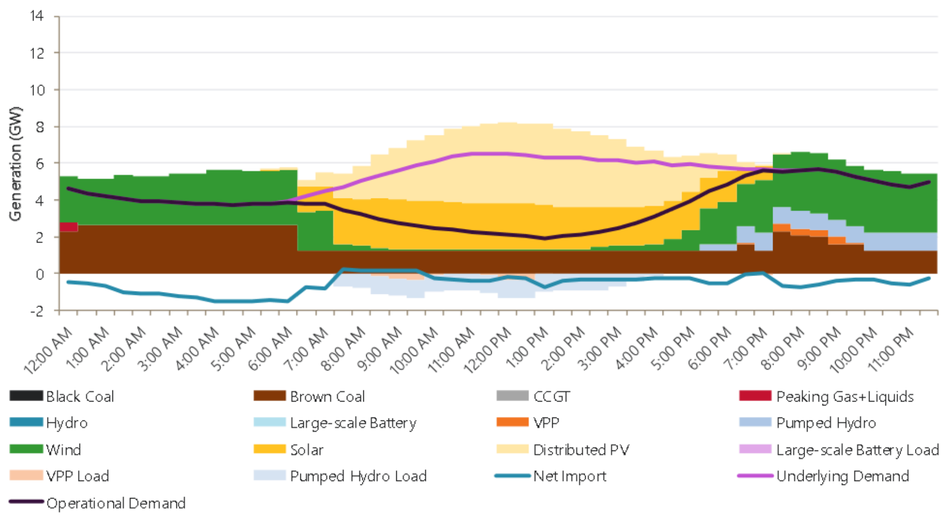

Figure 22 Day of minimum demand, Vic 2040, Central scenario[78]

7.3. Snowy Hydro 2.0

Snowy Hydro 2.0 (SH2), currently in the early stages of development, is a unique project that will provide a huge amount of energy storage using existing reservoirs in the Snowy Hydro system.[79] As noted above, it provides most of the energy storage in GWh for AEMO's 90% renewable Step Change scenario. SH2 is "deep" storage, so its 2,000 MW peak power output is relatively small for the energy stored, but still equals a large coal-fired power station. It can dispatch this power for a whole week.

An important question for SH2 has been "Is that much deep storage even useful?". AEMO's draft ISP provides an answer in the following chart, simulating its energy storage levels over the year 2039-40. A level of 350 GWh indicates that its upper dam is full, zero means empty. SH2 is fully cycled during the year and is partially-cycled several times. This demonstrates that SH2's large energy store is useful; if its dams were smaller, the grid would have required extra energy storage, or more fossil fuels would have been burned. Note that this is for the Central scenario; Step Change would tend to use SH2's deep storage even more. According to AEMO, SH2 is necessary for the grid to follow the Step Change scenario.[80] AEMO's analysis also assumes perfect foresight.[81] In the real world SH2 provides an important buffer to cover operational errors.

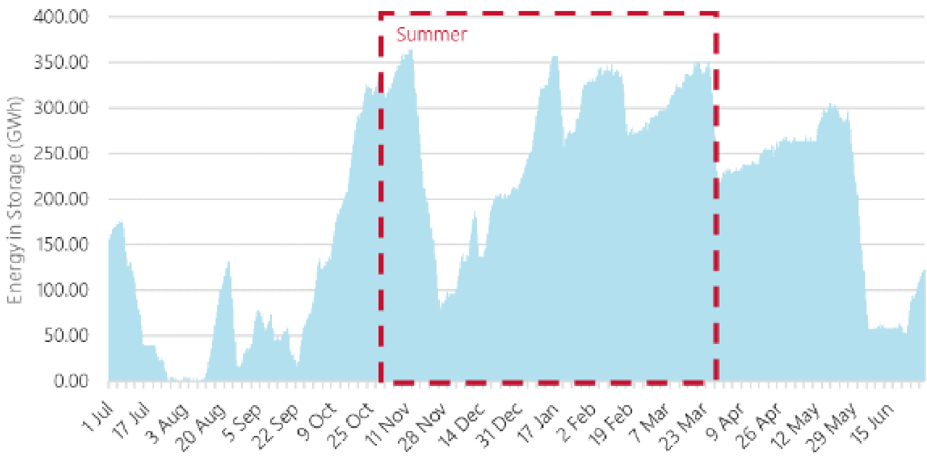

Figure 23 One year of Snowy Hydro 2.0 operation, 2039-40, Central scenario [82]

Some people have been concerned that much of SH2's pumping energy will come from coal rather than wind and solar, propping up the economics of fossil fuel businesses. In the short term this is partly true, but this is a transitional arrangement necessary for system reliability, as explained in the previous section. More important is the longer-term, in which SH2 will be a critical asset for a fully renewable grid.

SH2 has been criticised for the project's expense (approx. $4 billion[83]). There are many ways to assess this cost, but a simple method is to compare it to home solar batteries such as the Tesla Powerwall 2 (PW2). Delivering SH2's energy storage capacity in GWh would require every Aussie household (including apartments) to install 2.6 PW2 batteries at a cost of about $39,000 per household.[84] In contrast, SH2 costs about $400 per household. The PW2 option does provide much more power (10 kW per household compared to 0.2 kW per household) which is great for supplying peaks, but not essential for the seasonal storage at which SH2 will excel. Another factor is longevity – home batteries are expected to last 10 years, while SH2 should still be operating a century from now. For further debate on SH2's merits, please refer to the essay by Bruce Mountain[85] and especially Snowy Hydro's response.[86]

7.4. Battery of the Nation

Like Snowy Hydro 2.0, Hydro Tasmania's "Battery of the Nation" (BOTN) project[87] also can deliver huge amounts of hydroelectric energy, via mostly existing reservoirs. Tasmania is powered largely by traditional hydroelectricity, which has the capacity to "firm up" large amounts of wind power. The broad idea of BOTN is that when the wind's blowing, some hydro generators can switch off, conserving rainwater stored in Tasmania's high reservoirs. This extra stored water is then available to power Tassie as usual when the wind's not blowing, and to export firm power to the mainland via the proposed Marinus Link, a second Tas-Vic interconnector.[88] Specifically for BOTN, three new pumped hydro projects in Tasmania are proposed, which will enhance the Tasmanian hydro system's operational flexibility and peak power.[89]

AEMO determined that for the Step Change scenario, BOTN and Marinus Link are both necessary, and its first phase – a single submarine cable to Victoria[90] – should be progressed as soon as possible.

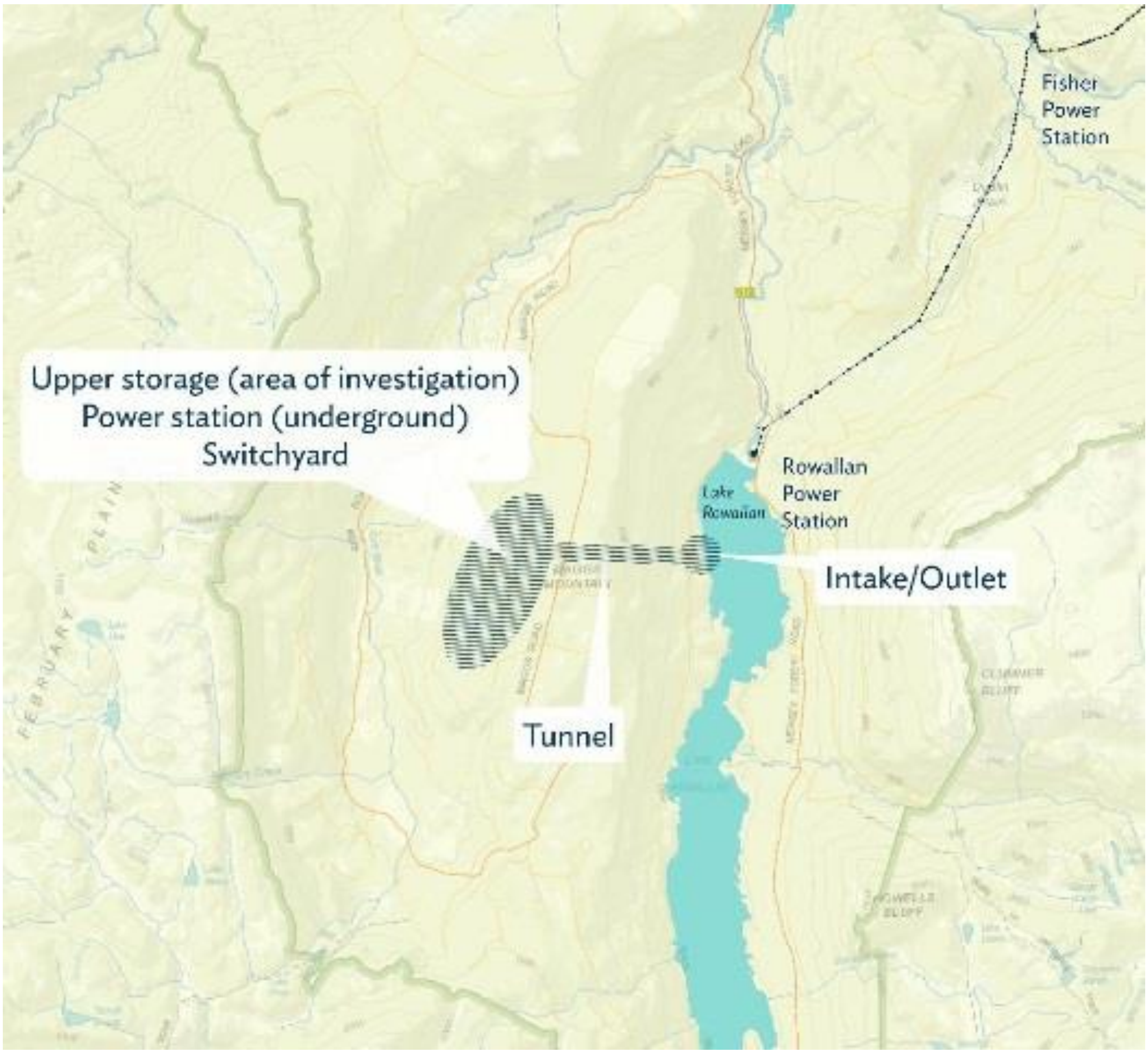

Figure 24 Rowallan pumped hydro project potential layout.[91]

8. Market Reform

All market bodies for the NEM now recognise that the electricity system is in a transition[92] and the market structure and rules need reform. However, there is some disagreement on the substance of those changes.

8.1. Comprehensive Market Reform

The main initiative to reform the market is the Energy Security Board's (ESB) "Post 2025 Market Design".[93] This is a fundamental review of the structure of the NEM, because in addition to competitive market designs it will also consider centralised planning approaches and more active roles for governments. Surprisingly though, governance of the electricity system is not within the scope of this review. The project's assessment framework includes items such as cost and reliability but not greenhouse gas emissions, with the exception that the new arrangements should be "robust to possible future government policy changes".[94]

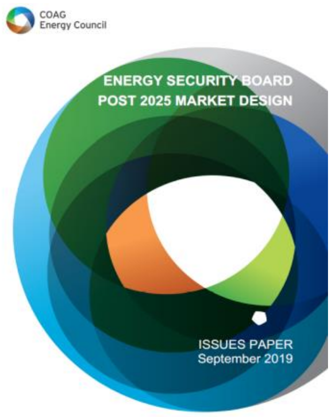

Figure 25 Cover of the ESB's 2019 issues paper

The ESB aims to identify options by early 2020 and recommend changes required to deliver a long-term, fit-for-purpose market framework by the end of 2020. Details will be finalised in 2022.

8.2. Transmission Reform: COGATI and MLFs

Electricity transmission is in the most urgent need of reform. As noted above, the present system has failed to construct lines to serve generation that's being constructed. Investors are walking away or incurring higher costs, raising the cost of electricity for consumers.

The AEMC has initiated a project[95] to reform electricity rules relating to transmission. Known as COGATI (Coordination of Generation and Transmission Investment), this proposes changing how generators and energy storage facilities are paid for the energy they produce. Instead of the current state-wide wholesale price, they'll instead receive a Local Market Price specific to their location. It also introduces a new market for Financial Transmission Rights, which generators will need to purchase if they want to receive a price closer to the state-wide wholesale price. It seems mind-bendingly complex.

The COGATI final report is due in March 2020; there is not yet any timeframe for implementation. And not all energy market bodies are on board: market operator AEMO doesn't agree that COGATI should be a priority, stating that it "considers it inappropriate to commit to this significant reform prior to addressing more pressing priorities in the NEM."[96]

Meanwhile, in February 2020 the AEMC rejected a rule change request to modify the rules on calculating Marginal Loss Factors.[97] This rejection was criticised by the Clean Energy Council, a peak body for the renewable energy industry.[98] The CEC had favoured the proposed rule change because it would have provided renewable energy owners more certainty of future revenues.

8.3. Placing Reliability Obligations on Electricity Retailers

In July 2019 a new requirement was placed on electricity retailers (such as AGL, Origin and Energy Australia) to encourage them to ensure they could provide sufficient power when needed. This “Retailer Reliability Obligation” (RRO) was originally proposed as part of the Turnbull Government’s unimplemented energy and emissions policy, the National Energy Guarantee (NEG), principally designed by the head of the AEMC.[99]

The RRO is a response to a concern that blackouts may occur due to insufficient supply if the competitive market leads to increasing numbers of non-dispatchable wind and solar farms replacing fossil fuels. To avoid blackouts during wind droughts or cloudy weather, the electricity system would need a certain level of dispatchable supply such as energy storage or fossil fuel generators. To ensure this level is maintained in the system, when retailers purchase energy, they will be obliged to purchase a certain proportion from dispatchable generators for any periods that are forecasted to be at risk of supply shortfalls. This would generally take the form of off-market contracts between retailers and generators.

The RRO is quite hard to understand; for more details see the useful introduction by Norton Rose Fulbright.[100] One question is: which generators qualify as “dispatchable”? For example, a shallow pumped hydro facility is dispatchable, but perhaps only for four hours; once the top dam is depleted it becomes useless. A contract relying on it may comply with the RRO but fail to avert blackouts in a severe event.

When individual private companies act without coordination, it’s hard to see how overall system reliability can be ensured. For example, a severe late-evening demand peak may require simultaneous discharge of all pumped hydro facilities. But some of these may have already fully-discharged, their owners having been tempted by a high wholesale price earlier in the evening. Such a case would result in an unnecessary blackout. Owners may be incentivised to retain capacity under the RRO, but how secure is the contract? Owners may calculate that paying an occasional financial penalty for non-compliance is cheaper than building enough capacity to sufficiently cover demand. Sufficient physical assets might not get built. The ESB has flagged this as a risk with the current market design, even with the addition of the RRO.[101]

8.4. Enabling Energy Storage

The present energy market doesn’t properly allow for energy storage facilities, since there’s no category for a market participant that both draws energy from the grid and delivers energy into it. AEMO submitted a rule change request in August 2019 to rectify this,[102] but so far, the AEMC has not progressed it.[103]

Another reform supportive of energy storage is the move from 30-minute to 5-minute financial settlement of the wholesale market. The smaller interval incentivises new, fast-acting technologies such as batteries and prevents market players from extracting extra profits via unscrupulous bidding practices, such as withholding supply for several periods to drive prices higher.

Figure 26 Hornsdale Power Reserve

The five-minute settlement rule change was requested in 2015 and approved by the AEMC in November 2017.[104] Allowing for market participants to implement IT system changes and re-negotiate long-term contracts, the change won’t be implemented until July 2021. This is a prime example of how the rule change process can mean urgent reforms take too long to be implemented.

8.5. State Government Interventions

As market bodies struggle to reform the electricity market, governments are starting to take matters into their own hands. In February 2020 the Victorian government announced that it will speed up new transmission by side-stepping the national approvals process involving the AER.[105] Details are scarce, but it seems that the government will select projects in consultation with AEMO, AEMO will conduct tenders, the government will pay for construction and then the asset will be paid for by a combination of electricity consumers and taxpayers.[106]

In March 2020 the Tasmanian government announced its plan to double its state's generation by 2040, leading to a 200% renewable energy supply.[107] This level of generation needs extra transmission to Victoria – perhaps Tasmania will follow Vic and bypass national processes to accelerate the planned Marinus Link.

The NSW government is developing a Renewable Energy Zone (REZ) in the state's central west around Dubbo.[108] The federal government is contributing funds for this project, together with transmission to connect Snowy Hydro 2.0 to Sydney and other initiatives.[109]

8.6. Market & Investor Implications

Government interventions such as those noted above may interfere with the competitive market. For example, through Snowy Hydro the federal government owns both generation assets and the electricity retailer Red Energy.[110] When the government devotes taxpayer money to this entity, it may be boosting its capacity to compete with private companies.

If private investors perceive that government action is likely, they may delay committing to projects until its implications for market competition are clear. For example, in late 2018 the federal government announced that it would invest in "firm" generation capacity under its "UNGI" program. As of March 2020, it had produced a shortlist of twelve projects, but no indication on which will proceed.[111] Private investors currently don't know whether their proposed assets will have to compete against a government-funded asset to be built nearby.

Figure 27 NSW indicative Central West REZ map

9. Seeking a Solution

Current efforts to improve the transition of the electricity system focus on greater intervention in the competitive market, via a number of measures small and large. Based on the experience to date, Renew is highly concerned that such incremental reform may take too long to achieve the rapid transition of the sector that is required under climate imperatives. In the worst case, closure or failure of coal-fired generators could lead to blackouts if firm replacements aren't built quickly enough, and consumers will bear the unnecessary costs of a disorderly transition.

Renew's view is that in a fully-renewable grid, it will be very difficult to operate the wholesale market as it's currently designed. Without fuel costs to naturally set generator bids, wholesale prices will tend to swing wildly between extreme highs and lows depending on weather conditions. Energy storage can potentially dampen such price movements, but its uncoordinated operation by disparate private owners raises the risk of outcomes not in consumer interests, such as unnecessary blackouts or high prices.

Stronger measures may be required in the form of a more coordinated, planned approach. For example, AEMO could be empowered to design and direct development of the grid as was done previously by state-based electricity commissions. It could raise tenders for private companies to construct and operate assets such as generation, energy storage and transmission. This option is not excluded by the Energy Security Board's post-2025 Market Design process. If such a path is taken, once the physical transition is complete and closures of coal-fired power plant have ceased, a more competitive market could be reinstated, working to new principles more suited to the new system. As with any changes in the electricity market, stakeholder consultation will be crucial to uphold the long-term interests of consumers.

With governments already intervening to directly invest in the system, such a coordinated planning option would allow for these projects to work together coherently. Luckily, many recent government investments are consistent with the required transition. For example, as noted above Snowy Hydro 2.0 and Marinus Link are both required for AEMO's Step Change scenario.

Renew will be keeping a close 'watching brief' on developments in the coming months and will be further considering the options to achieve a faster transition of our electricity system, to ensure it develops coherently in the long-term interest of consumers.

Figure 28 Tailem Bend solar farm.

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[5] State of the energy market – Data update November 2019. Australian Energy Regulator. Inc. wind, solar, rooftop solar & hydro. https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-%E2%80%93-data-update-november-2019
[6] https://renew.org.au/wp-content/uploads/2019/01/One_Hundred_Percent_Renewable_Grid.pdf
[7] https://renew.org.au/wp-content/uploads/2018/08/Renewable_Grid_by_2030.pdf

[9] Vestiges remained (e.g. Vic's SEC https://www.secv.vic.gov.au/ but their former substantial roles were effectively abolished.
[10] Some players in the market are still government-owned, e.g. the QLD govt owns transmission and distribution and much of the state's generation via Stanwell and CleanCo Corporations. Snowy Hydro is owned by the Federal government.
[11] Consumers in some areas have no choice in electricity retailer because their local utility still has a monopoly. For example, Ergon Energy in the more remote parts of Queensland.
[12] Page xiii, 2019 Retail Energy Competition Review, AEMC. https://2019.aemc.gov.au/11640/1561524254-19-11827-2019-aemc-retail-energy-competition-review-final-report.pdf
[13] Page 4, https://www.aer.gov.au/system/files/State%20of%20the%20Energy%20Market%202018%20-%20Chapter%201%20A3%20spread_1.pdf
[14] https://2019.aemc.gov.au/competition-review/jurisdiction/victoria
[15] https://www.aer.gov.au/news-release/consumers-win-from-aer-decision-on-ausgrid-revenue https://www.aer.gov.au/news-release/tribunal-confirms-aer-approach-to-setting-victorian-electricity-and-act-gas-network-prices
[16] Intervals are currently 5-minute for instructions to generators (dispatch) but only 30 minutes for financial settlement. This is planned to change to 5-minute as well. https://www.aemo.com.au/-/media/Files/Electricity/NEM/5MS/Program-Information/2018/5MS-factsheet.pdf
[17] The market is much more complex than this simplified description. For example, it has separate wholesale prices by state, and when dispatching generators, AEMO must also allow for constraints to energy flows such as in transmission lines.
[18] https://renew.org.au/events/melbourne-branch/guaranteeing-energy-supply-in-a-changing-market/
[19] For example, effective Demand Response is important to manage demand spikes on the grid without over-investing in generation. A rule change request was made in August 2018, but won't be introduced until at least mid-2021. https://www.aemc.gov.au/rule-changes/wholesale-demand-response-mechanism, https://piac.asn.au/2019/12/05/wholesale-demand-response-delayed-better-outcomes-for-consumers-necessary/
[20] For example, page 16: https://www.aemc.gov.au/sites/default/files/content/04e7c154-a9ff-47ff-a506-f42ddbd52957/First-Final-Report.pdf
[21] For example, pages 8-9: https://www.aemo.com.au/-/media/Files/About_AEMO/Our_Vision/AEMO-Corporate-Plan.pdf
[22] Page 26, https://www.energy.gov.au/sites/default/files/independent-review-future-nem-blueprint-for-the-future-2017.pdf
[23] https://www.pv-magazine-australia.com/2020/03/23/coag-energy-council-in-the-time-of-coronavirus/
[24] Page8, https://www.aemc.gov.au/sites/default/files/2019-07/Applying%20the%20energy%20market%20objectives_4.pdf https://www.aemc.gov.au/regulation/regulation
[25] http://www.cleanenergyregulator.gov.au/RET
[26] http://www.cleanenergyregulator.gov.au/About/Pages/Accountability%20and%20reporting/Annual%20Reports/Annual%20report%202014-15/Carbon-pricing-mechanism.aspx
[27] https://www.energy.vic.gov.au/renewable-energy/victorias-renewable-energy-targets https://www.dnrme.qld.gov.au/energy/initiatives/powering-queensland
[28] https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-integrated-system-plan.pdf?la=en
[29] Page 264, https://www.chiefscientist.gov.au/sites/default/files/Independent-Review-into-the-future-security-of-the-NEM.pdf
[30] Page 35, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-integrated-system-plan.pdf?la=en
[31] https://prod-energycouncil.energy.slicedtech.com.au/sites/prod.energycouncil/files/publications/documents/Actionable%20ISP%20-%20Consultation%20on%20Draft%20ISP%20Rules_0.pdf
[32] Page 38, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-appendices.pdf?la=en
Data: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-chart-data.zip?la=en
[33] Page 41, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-appendices.pdf?la=en

[35] Page 44, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-appendices.pdf?la=en
[36] Appendix 4, worksheet "HDEP_Step_Storage", chart edited, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-appendices.pdf?la=en
[37] Based on 200,000 GWh per year – page 7, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2019/2019-electricity-statement-of-opportunities.pdf?la=en&hash=7FE871D75A9C619AB66FA671477551B2

[38] Appendix 4, Sheet HDER_Step_Storage, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-chart-data.zip?la=en
[39] Page 17, http://re100.eng.anu.edu.au/resources/assets/100renewableelectricityinAustralia.pdf
[40] Page 61-62 for Central scenario and equivalent sections for other scenarios. https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-appendices.pdf?la=en
[41] Data collated from the "NPV" sheet for each scenario. https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-chart-data.zip?la=en
[42] https://www.climatecouncil.org.au/uploads/7b40d7bbefbdd94979ce4de2fad52414.pdf
[43] Page 485, Adam Smith, The Wealth of Nations, 2000, Modern Library Paperback Edition.
[44] Ibid, Page 492. *"The first is, when some particular sort of industry is necessary for the defence of the country. The defence of Great Britain, for example, depends very much upon the number of its sailors and shipping. The act of navigation, therefore, very properly endeavours to give the sailors and shipping of Great Britain the monopoly of the trade of their own country, in some cases, by absolute prohibitions, and in other by heavy burdens upon the shipping of foreign countries."*
[45] Ibid, Page 288: *"The proposal of any new law or regulation of commerce which comes from this order, ought always to be listened to with great precaution, and ought never to be adopted till after having been long and carefully examined, not only with the most scrupulous, but with the most suspicious attention. It comes from an order of men, whose interest is never exactly the same with that of the public, who have an interest to deceive and even to oppress the public, and who accordingly have, upon many occasions, both deceived and oppressed it."*
[46] Page 33,
https://www.aer.gov.au/system/files/Wholesale%20electricity%20market%20performance%20report%202018%E2%80%94LCOE%20modelling%20approach%2C%20limitations%20and%20results.pdf
[47] Per MWh, the market price cap is $14,700 and the average wholesale market price in NSW for 18/19 was $92.38.
https://www.aemc.gov.au/sites/default/files/2019-02/Schedule%20of%20reliability%20settings%20%28MPC%20and%20CPT%20for%202019-20%29.pdf
Figure 2.25, https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-%E2%80%93-data-update-november-2019
[48] Draft 2020 Integrated System Plan, Central scenario, Figure 9. https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2020-integrated-system-plan-isp
[49] https://www.energymagazine.com.au/energyaustralia-responds-to-speculation-over-yallourn/
https://www.abc.net.au/news/2019-11-19/alinta-energy-considers-early-coal-exit/11715566
Page 78, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-appendices.pdf?la=en
[50] https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-integrated-system-plan.pdf?la=en
[51] 4 years for develop plus 4 to construct. Page 47, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/9110715-REP-A-Cost-and-Technical-Parameter-Review---Rev-4-Final.pdf
[52] https://www.aemc.gov.au/rule-changes/generator-three-year-notice-closure
[53] https://assets.cleanenergycouncil.org.au/documents/advocacy-initiatives/finkel-review/freqeuncy-control-in-the-nem-workshop-outcomes.pdf
[54] http://www.wattclarity.com.au/articles/2017/03/lets-talk-about-fcas/
[55] http://climatecollege.unimelb.edu.au/power-system-stability-kate-summers
https://www.aemc.gov.au/sites/default/files/2019-11/Rule%20Change%20Submission_ERC0263_ERC0274_%20ERC0277%20-%20Kate%20Summers%20%28Private%29%20-%2020191031.pdf
[56] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=2ahUKEwjYm9GQxM3nAhXEIbcAHdduAf4QFjABegQIBRAB&url=https%3A%2F%2Fwww.aph.gov.au%2FDocumentStore.ashx%3Fid%3Ddae1642e-b1f7-4a4d-ab76-c1dcbf50cb76%26subId%3D512345&usg=AOvVaw0en6Xm7rVtlWJ_LucosmN_
[57] https://theconversation.com/do-the-crime-do-the-time-not-if-youre-a-banker-in-australia-33548
[58] For example AEMO's Integrated System Plan https://www.aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2020-integrated-system-plan-isp, ANU's research http://re100.eng.anu.edu.au/ and studies listed in https://renew.org.au/research/100-per-cent-renewable-grid-possible/
[59] Stated by AEMO Chief System Design and Engineering Officer Alex Wonhas in an interview with RenewEconomy. See the 15:30 minute mark. https://reneweconomy.com.au/podcast/energy-insiders-podcast-australias-energy-future-is-renewable-and-digital/
[60] https://www.cleanenergycouncil.org.au/advocacy-initiatives/renewable-energy-target
[61] For example, a large coal-fired power station such as Liddell or Yallourn can generate 2,000 MW of power. To supply this power for a whole day, an energy storage facility needs to store 48,000 MWh of energy. This is about 370 times the energy storage capacity of Hornsdale Power Reserve.
[62] Energy storage facilities operating on a less frequent basis may earn revenue from off-market contracts acting like insurance policies for large consumers, retailers etc. They would reserve energy for times of wholesale price spikes.
[63] Page 95,
http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Coordination%20of%20generation%20and%20transmission%20investment.pdf
[64] https://assets.cleanenergycouncil.org.au/documents/events/aces-2019/Presentations/Andrew-Stiel.pdf
[65] Pages 4 & 9, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Power-System-Limitations-December.pdf
[66] See pages 219 and 226 onwards in chapter 9: https://www.parliament.vic.gov.au/57th-parliament/enrc/inquiries/article/870
[67] Page 6, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/SA_Advisory/2019/2019-South-Australian-Electricity-Report.pdf
[68] AEMO 2020 ISP, page 50.
[69] Page 29, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Loss_Factors_and_Regional_Boundaries/2019/Marginal-Loss-Factors-for-the-2019-20-Financial-year.pdf

[70] Rob Grant, chairperson at Clean Energy Group, interviewed in Nov 2019: https://reneweconomy.com.au/podcast/energy-insiders-podcast-is-this-the-end-of-the-wind-and-solar-boom/
Simon Taylor, Group General Manager Customers, Powerlink speaking at the CEC's Large-Scale Energy Forum on 8th May 2019. https://reneweconomy.com.au/its-not-easy-to-build-a-solar-farm-in-australia-any-more-59308/
[71] https://www.pv-magazine-australia.com/2019/04/06/long-read-behind-the-limited-return-of-the-syncon/
[72] https://aemo.com.au/en/news/synchronous-condensers
[73] Or even negative – the spot price can go as low as -$1,000/MWh, which means generators have to pay to keep operating
[74] Page 14, AEMO 2020 ISP.
[75] Summed storage quantities in appendices 3 and 4, HDER_Step_storage and Step_Storage: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-chart-data.zip?la=en
[76] https://utilitymagazine.com.au/renewable-generator-pumping-power-prices-down/
[77] https://www.climatecouncil.org.au/uploads/7b40d7bbefbdd94979ce4de2fad52414.pdf
[78] Page 82, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-appendices.pdf?la=en
[79] https://www.snowyhydro.com.au/our-scheme/snowy20/
[80] Page 37, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-appendices.pdf?la=en
[81] Page 46, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-integrated-system-plan.pdf?la=en
[82] Page 68, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-isp-appendices.pdf?la=en
[83] https://infrastructurepipeline.org/project/snowy-2.0/
[84] PW2 costs $15k including installation. 10 million households.
[85] https://theconversation.com/snowy-2-0-will-not-produce-nearly-as-much-electricity-as-claimed-we-must-hit-the-pause-button-125017
[86] https://www.snowyhydro.com.au/our-scheme/snowy20/faqs20-2/
[87] https://www.hydro.com.au/clean-energy/battery-of-the-nation
[88] https://www.marinuslink.com.au/
[89] https://www.hydro.com.au/docs/default-source/clean-energy/battery-of-the-nation/botn-phes---prefeasibility-studies-summary-report-aug19.pdf?sfvrsn=2b089a28_2
[90] Page 52, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-integrated-system-plan.pdf?la=en
[91] Page 19, https://www.hydro.com.au/docs/default-source/clean-energy/battery-of-the-nation/botn-phes---prefeasibility-studies-summary-report-aug19.pdf?sfvrsn=2b089a28_2
[92] https://www.aemc.gov.au/news-centre/media-releases/powering-grid-future
https://arena.gov.au/assets/2019/12/aemo-renewable-integration-study-update.pdf
http://coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/ESB%20-%20Post%202025%20Market%20Design%20-%20Scope%20and%20Forward%20Work%20Plan%20-%2020190322.docx.pdf
Page 16: https://www.aer.gov.au/system/files/State%20of%20the%20Energy%20Market%202018%20-%20Full%20report%20A4_2.pdf
[93] http://coagenergycouncil.gov.au/publications/post-2025-market-design-national-electricity-market-nem
[94] http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/EC%20-%20Post%202025%20Market%20Design%20Issues%20Paper%20-%2020190902_0.pdf
[95] https://www.aemc.gov.au/market-reviews-advice/coordination-generation-and-transmission-investment-implementation-access-and
[96] https://www.aemc.gov.au/sites/default/files/2019-11/AEMO%20-%20Proposed%20access%20model.pdf
[97] https://www.aemc.gov.au/rule-changes/transmission-loss-factors
[98] https://www.cleanenergycouncil.org.au/news/aemc-sticks-with-outdated-loss-factors-undermining-investment-confidence
[99] https://www.aer.gov.au/retail-markets/retailer-reliability-obligation
[100] https://www.nortonrosefulbright.com/en/knowledge/publications/d8efe51e/retailer-reliability-obligation
[101] "the growing use of purely financial insurance products and customers increasing their spot exposure will mitigate the risk of high prices for the retailer but will reduce investment in resources that maintain reliability of supply. These arrangements may have the potential to break the link between prices and investment, which is assumed by the current market framework". Page 18: http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/EC%20-%20Post%202025%20Market%20Design%20Issues%20Paper%20-%2020190902_0.pdf
[102] https://aemo.com.au/-/media/Files/Electricity/NEM/Initiatives/Emerging-Generation/23-August-2019--Integrating-ESS-rule-change-proposal-final.pdf
[103] https://www.aemc.gov.au/rule-changes/integrating-energy-storage-systems-nem
[104] https://www.aemc.gov.au/rule-changes/five-minute-settlement
[105] https://www.premier.vic.gov.au/wp-content/uploads/2020/02/200218-Victoria-Acts-To-Secure-A-More-Reliable-Energy-System.pdf
[106] Based on interview with Lily D'Ambrosio: https://reneweconomy.com.au/podcast/energy-insiders-podcast-victoria-goes-it-alone-to-save-renewable-transition/
[107] http://www.premier.tas.gov.au/releases/acting_on_climate_change
[108] https://energy.nsw.gov.au/renewables/renewable-energy-zones
[109] https://energy.nsw.gov.au/government-and-regulation/electricity-strategy/memorandum-understanding
[110] https://www.redenergy.com.au/about-us/
[111] https://www.energy.gov.au/government-priorities/energy-programs/underwriting-new-generation-investments-program