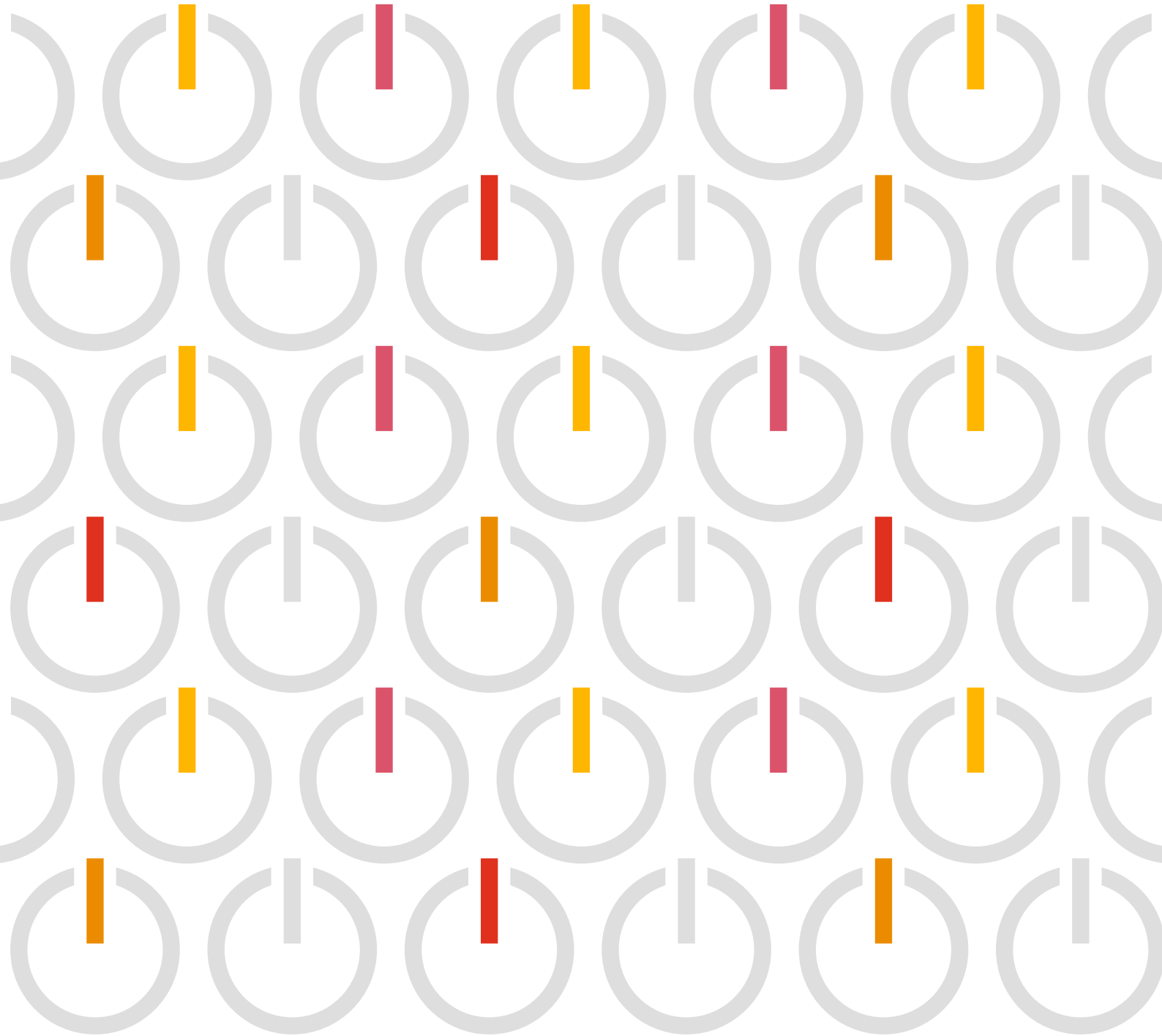


The Future of Energy

Australia's Energy Choice



In collaboration with

Jacobs





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Why this paper?

Energy, and what Australia's future energy ecosystem might look like, is a polarising topic for many.

Affordability and reliability are paramount when considering what this future might be, but this future also needs to consider the environment and economy if it is to carry weight and have impact with policy makers, customers, community and industry.

Unfortunately there is a roadblock hindering agreement on this energy future and the policy choices needed to get us there: our public discourse.

The debate is often partisan and mired in claims that green (renewable) is good and black (coal) is bad, or *vice versa*. Numerous analyses show all types of power generation are the cheapest sources of generation, and many could be considered correct - in isolation. However, such conclusions are irrelevant to the debate about the best sources of generation if they don't also consider their impact on the entire energy system and the economy.

As a result, there is confusion about the real impact of different policy decisions on our energy system and on our economy.

Under this cloud of confusion, successive Governments have been challenged to implement a cohesive national energy policy that survives beyond their short tenures. Meanwhile, operators of coal-fired generation are caught between Government pressure to keep ageing thermal generation plant online and a competing need to evolve their businesses in line with an energy sector transitioning to cleaner energy sources. At the same time consumer preferences are changing and their priorities are shifting dramatically.

To provide impartial, fact-based input to the debate, we have conducted detailed analyses considering the financial, economic and environmental impacts of four different energy scenarios for Australia through to 2040.

1. **Reference case** - replaces retiring thermal generators with mix of new gas and renewables on a least cost basis
2. **Renewables case** - as per reference case but replacing most retiring thermal plants with renewables
3. **Coal case** - replacing retiring thermal plants with a mix of coal, renewables and gas
4. **Accelerated renewables case¹** - where we've assumed accelerated thermal plant closures with largely renewable replacement.

Our analysis looks at outcomes to 2040. We've gathered insights from opposing 'sides' of the energy and climate debate to develop an objective view on the different elements of the energy trilemma – affordability, reliability and sustainability.

Our motive is to equip policymakers and the investment community with facts and perspectives that help them move beyond the polarised debate towards a policy approach that supports optimal investment decisions and secures the best energy future for Australia.

¹ For this case we have made assumptions on possible early voluntary closure dates. We have not assumed any kind of government intervention to force closures.

Our findings



It is possible to solve Australia's energy trilemma within a generation.

Our findings will surprise many. A power generation mix dominated by renewables by 2040 can deliver reliable and affordable electricity, as well as drive an increase in Australia's economic welfare. Conversely, replacing retired coal-fuelled thermal plant with new High-Efficiency Low-Emissions (HELE) coal plants would result in a comparatively poorer economic outcome.

This modelling runs counter to earlier modelling which showed investment in renewables leads to lower economic benefits. The story has changed as:

- the cost of renewables has continued to come down as technologies have matured and scale has been achieved
- most coal-fired generators are nearing the end of their economic and technical lives and must be replaced - with the dominant replacement technologies being renewable
- the changing power generation mix and the need for different enabling power grid infrastructure is changing the footprint of Australia's power grid and requires investment

We suggest pursuing an energy mix dominated by intermittent renewables with reliability provided by a mix of dispatchable power stations is a **no regrets** policy direction for Australia. This would result in the country being supplied by 80% renewable energy within 20 years and with lower emissions from power generation (68% lower than 2005). It would also add more than \$13b to GDP and enable an additional \$6b in consumption by Australians.



If we accelerate this transition, Australia could see even stronger economic and emissions benefits; moving to a 90% renewable power system in 2040, adding \$15b to GDP and enabling increased spending by Australians of \$11b.

Our national 'moon shot' is how do we transition our energy system so it is the most positive enabler of economic prosperity for our nation? From our analysis and forecasts this will see us rapidly move towards a renewable energy dominated future - whether that's 80% or more remains to be seen.

This transition is not to be feared, but it must be managed. Adopting a truly proactive mindset would result in an energy system that is supplied by 90%+ renewable power domestically, and potentially developing a renewable export market, enabling Australia to become an international player in the export of power.

Our analysis highlights the importance of energy network infrastructure - the connective tissue. Globally we are seeing a networks investment renaissance which must happen in Australia within the next decade as our energy market transition continues. This will be needed under all of Australia's energy choice scenarios.

Our work has assumed existing technologies and published learning rates for these technologies, so by its very nature is somewhat conservative. We have seen many examples where forecasts of technology take-up rates and cost curve improvements are 'under-cooked.'² This suggests the speed of change and the estimated systems costs within each of our scenarios is likely to be improved upon in time, and provides exciting electricity system innovation and customer cost reduction opportunities if we tackle the energy system transition as a 'project' of national importance and unleash the best minds and innovators across the economy.

² For example Australian Energy Market Operator (AEMO) and the International Energy Agency have regularly underestimated the take up rates of new technologies in their annual power sector forecast reports





Continued inaction or misguided choices will propel us towards a disruptive energy future with increased grid failures, less-reliable supply, volatile prices and significant environmental consequences.

There is a direct link between Australia's energy system and our economy. Historically low power and gas prices have underpinned our economy. We have had, and continue to have, a very strong resources export sector which has grown significantly in recent years (thermal coal exports increased by 50% between 2010 and 2018, while LNG exports multiplied 3.5 times over the same period).³ In June 2018 the ACCC reported that Australian domestic residential electricity retail prices had increased by 35% in real terms over the 10 years to 2017/18.⁴ Our domestic gas prices are now strongly influenced by international LNG prices, and as a result, the retail price for gas doubled between 2013 and 2018.⁵

All of these factors, combined with the global supply chains we rely on for renewable generation plant components, demonstrate our energy markets are genuinely subject to global forces. These pressures are not going anywhere, especially when you consider the expected increase in global demand for electricity of 56% by 2040.⁶

Add to this the reality that our energy market - and the way people consume and produce energy - is changing. It is obvious we need to take action nationally to ensure our energy market and the economy are collectively strong. Unfortunately we are not seizing the opportunities this transition is creating. We are not taking sufficient steps to minimise the disruption it's bringing.

Without a structural, long-term plan or vision, future infrastructure investments are directly impacted. We have seen a 'boom' in renewable energy construction over the last four years (i.e. 7,400 MW new capacity added and a further 6,100 MW committed or highly probably,⁷ but over the same period only 700 MW of dispatchable capacity⁸ and 190 MW of transmission interconnection capacity⁹ have been added. Many of these investments were underpinned by subsidies of one form or another.

Agreeing and implementing the right policy and regulatory mechanisms within the next two years will support the vital energy infrastructure investment decisions needed, putting Australia on a path towards an affordable, reliable, economically beneficial and sustainable energy future that ensures consumers, community, industry and taxpayers are positioned positively for decades to come.

As we put this paper together, we consulted with many across the energy industry and all agree, there is little time to continue on as we are. Most agree that we have up to two years to:

- put an end to direct government interventions in energy markets
- obtain regulatory approvals and start work on extending transmission networks
- put in place changes in market settings to incentivise dispatchable generation investments
- determine an environmental policy that creates the right ambition for Australia

3 Australian Government, Department of Industry, Innovation and Science - Resources and Energy Quarterly, June 2019

4 ACCC, Retail Electricity Pricing Inquiry—Final Report June 2018

5 Energy Security Board, The Health of the National Electricity Market, 2018

6 IEA, World Energy Outlook 2019 (Stated Policies Scenario)

7 Clean Energy Regulator - website, as of 31 October 2019

8 AGL Barker Inlet GT, SA Government GT capacity, plus battery capacity in SA and VIC

9 Heywood interconnector upgrade

Time is short

Policymakers and regulators have very little time to build consensus on the energy future we should be aiming for and implementing a robust framework that will lead us there.

If we can not achieve consensus, then at minimum we need the right market settings to give investors confidence to start construction of the necessary near-term energy infrastructure investments required. The Energy Security Board's Post 2025 process is a great initiative, this is due to report in 2020 on all required market reforms to be in place by 2025. All market design work is due for completion by 2022. Furthermore, there are promising moves from regulatory agencies on the ISP¹⁰ holding more weight and being actionable in future. Numerous other reforms are in the making but complex energy market governance structures must be navigated. As COAG Energy Council looks to the future, and as these major reforms take shape, political point-scoring must be avoided.

Over the next five years, 2.4 GW¹¹ of thermal generation capacity in Australia needs to be replaced. Beyond that, the retirement rate of thermal generation ramps up significantly. However, investment decisions will need to be made on replacing that generation capacity years before these plants are retired. In the immediate term we are already seeing issues from grid congestion and challenges around reliability and power quality. These all require investment capital quickly.

AEMO comment in the 2019 Electricity Statement of Opportunities report "The forecast reaffirms that targeted actions must be taken now to provide additional dispatchable capacity to reduce the risks of supply interruptions during peak summer periods."¹²

Failure to create market certainty and clear investment signals within the next two years risks delaying new energy infrastructure coming online

in time, pushing Australia into a reactive situation, making dramatic interventions more likely. Being reactive increases the risk of building assets that aren't the best for the nation long term.

An example could be a new coal-fired plant being built, which our analysis shows, would increase emissions, marginally increase system operating costs and have a muted impact on economic activity relative to alternative options.

Globally, the energy transition is well underway, resulting in major investments in both transmission and distribution grids. The AEMO ISP has done good work in developing a plan for the future transmission 'mesh' we will need across the NEM, but we still need a consensus view on what investment is required at the distribution level. This must be an urgent next step for Australia as it is a crucial missing piece in our energy-choices puzzle.

Many but not all of the power quality and grid management issues we are expecting in future are predictable. A single and comprehensive national plan isn't only possible, it is imperative.

We must quickly provide the market and investors with certainty and direction.

10 ISP - AEMO Integrated System Plan

11 2.4 GW thermal generation capacity is equivalent of 2x Hazelwood coal plant closures

12 AEMO, Electricity Statement of Opportunities 2019, August 2019, p3



Australian context

– a policymaker’s view

We analysed AEMO’s forecast data and other published data from the last 18 months to develop our Reference Case.¹³

This outlook shows that by 2040, Australia will have replaced nearly 50% of its current large-scale, fossil-fuelled generators resulting in 60% lower carbon emissions from power generation than in 2005.

Australia’s energy system is undoubtedly on a highly transformative path. This path can only be successfully navigated through timely investment in energy infrastructure – both generation and grid. The current uncertain investment climate and direct government interventions in Australia’s energy market creates the risk of a disorderly transition towards this future scenario. This is particularly true of investments in dispatchable generation and major grid investments. As a result the energy market transition will likely be characterised by late reaction to market signals by energy infrastructure developers, leading to ongoing government interventions and periods of insufficient capacity and volatile prices. Apart from the negative impact this will have on consumer reliability and affordability, this may have an adverse impact on our climate, as ad-hoc interventions may not take a long term view.

A key challenge for policymakers is confusion around who should lead on specific issues. In Australia, energy policy is a state-level responsibility, with the Council of Australian Governments (COAG) ensuring broader coordination across the various governments and market bodies.

We are increasingly seeing States and Territories developing aspirational policy positions. In addition market bodies (eg ESB and AEMC) are conducting important policy development and market design work.

As a result, Australia has a mix of renewable energy targets and aspirations with different rates of change in generation mix expected over the next 20+ years. Some of these are legislated while others are not which adds to uncertainty. South Australia is already considered by some to be a global renewable ‘superpower’ with >50% of its generation coming from renewable sources in 2018.¹⁴

The following table shows the different targets/ aspirations in place across the country. As we can see there are multiple different timeframes being targeted. In time we expect these to come together. It would be helpful to have a consensus in the short term on targets to 2040 for both renewables and emissions.

The challenge will be that pursuing these targets will need to be underpinned by an ongoing sizeable investment in dispatchable (on-demand) generation, such as pumped hydro, battery storage, gas and possibly other thermal sources. We foresee challenges in the current market design to incentivise such new investment.

¹³ Our forecasts have largely relied on data from AEMO Integrated System Plan 2019 Assumptions, January 2019 to June 2019

¹⁴ Clean Energy Council - Clean Energy Australia report 2019



State by state + federal energy policy & target/ aspiration analysis

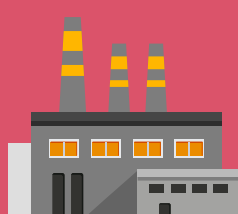
Government	Renewables target / aspiration	Emissions target / aspiration
Federal	33 TWh large scale generation by 2020 (approx 23.5% renewable)	26-28% emissions reduction by 2030 (compared to 2005)
ACT	100% renewable energy by 2020	Net zero emissions by 2045
NSW	—	Net zero emissions by 2050
NT	50% renewable energy by 2030	Net zero emissions by 2050
QLD	50% renewable energy by 2030	Net zero emissions by 2050
SA	100% net renewables by 2030's	Net zero emissions by 2050
TAS	100% by 2022	Net zero emissions by 2050
VIC	50% renewable energy by 2030	Net zero emissions by 2050
WA	—	Net zero emissions by 2050

Australia is expected to generate enough renewable energy to meet the 2020 Large-scale Renewable Energy Target (33 TWh)¹⁵. Additionally, the electricity sector is expected to contribute at least its proportional share of Australia's commitment to the Paris Agreement.

Still, given Australia's total domestic emissions are only expected to decrease 11% by 2030,¹⁶ there's a role for the electricity sector (which represents 34% of Australia's carbon emissions) to explore further options to reduce emissions and simultaneously reduce the cost of electricity generation.

We have the highest uptake per capita of small-scale solar PV anywhere in the world.¹⁷ A similarly fast-paced uptake is now starting to occur with battery storage installations. These trends will continue, with forecasts suggesting Australia will have the highest proportion of distributed energy resources globally.¹⁸

Several factors amplify the challenges of integrating these developments into Australia's energy systems highlighted below:



Several major fossil-fuel-burning generators will retire over the next decade



The large variability in our weather and demand



Emerging energy market design challenges



Australia's east coast has one of the world's longest transmission systems, comprising some very long 'stringy' sections with very low customer densities

As a result of these challenges, our market is often cited by global players as being ideal for innovative technologies to first come to market at scale.

¹⁵ Clean Energy Regulator, September, 2019

¹⁶ CSIRO, National Outlook Technical Report, 2019. CSIRO also quote ClimateWorks Australia 2018 in this assessment

¹⁷ Bloomberg New Energy Finance, New Energy Outlook 2018

¹⁸ 40% estimated by 2030 - BNEF, New Energy Outlook 2018

Global context

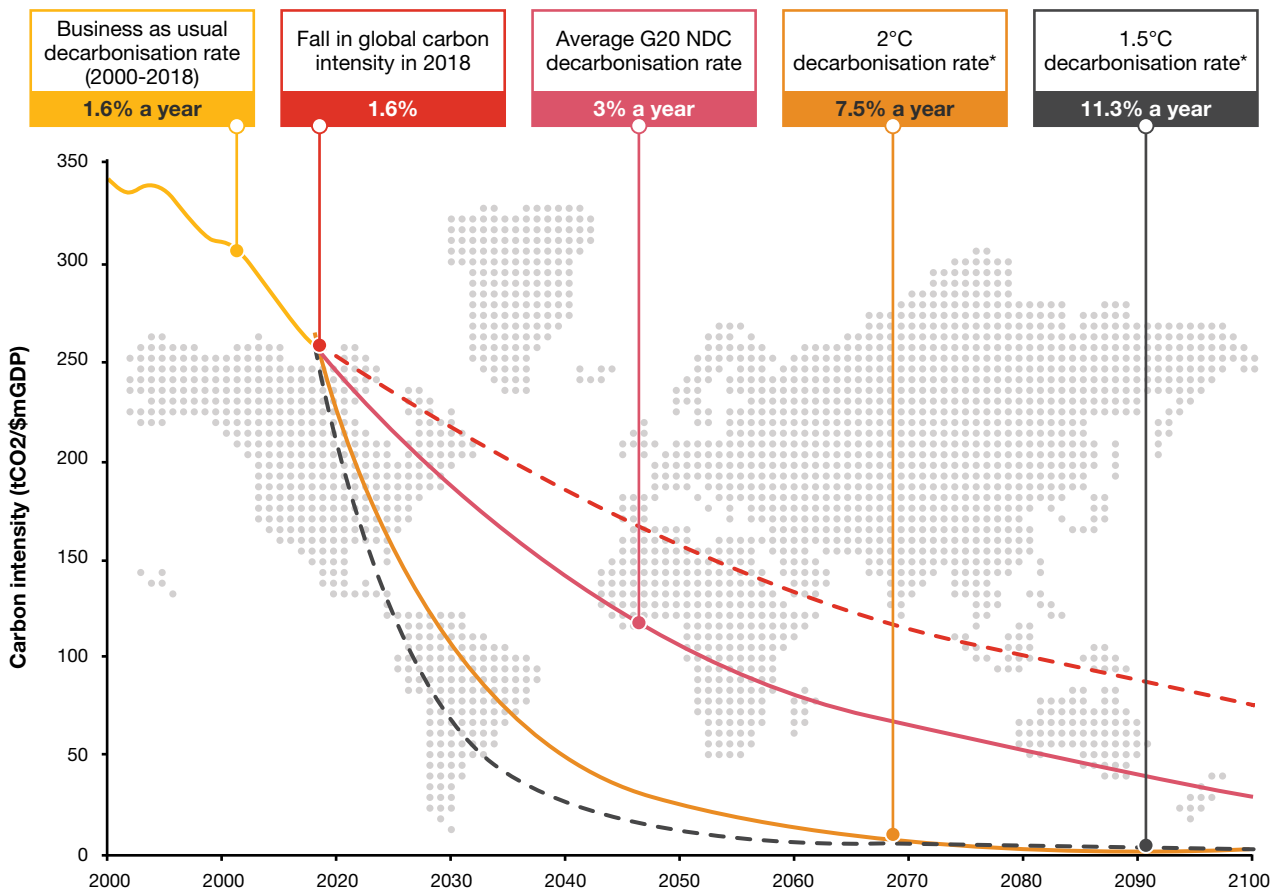
Power markets globally are already seeing change and the trends are clear.

In most parts of the world, the quest for decarbonisation is a given. For most, it's a question of speed and the best policies and mechanisms to drive the transition from fossil fuels.

The UN Paris Climate Change Agreement shows the decarbonisation commitments of the globe.

In many countries, emission reduction targets of net zero emissions by 2050 and renewable energy targets of 50% by 2030 and 100% by 2050 are becoming increasingly common. The 2020 revisit of the Paris Agreement will likely see increases in decarbonisation commitments made by many nations.

The following chart¹⁹ highlights the current trajectory of the G20 nations in decarbonisation and what's estimated to be required to reach the temperature scenarios underpinning the Paris Agreement. It is an understatement to say that there is a way to go to reach these targets.



19 PwC, The Low Carbon Economy Index 2019, October 2019

Increasingly, power generation investment globally is focused on renewables

In 2018, the world invested approximately US\$300b in renewable power generation, more than 2.4 times the amount spent on fossil-fuelled generation.²⁰ Around 12% of global power generation was spent on nuclear. There will be ongoing minor growth in the nuclear fleet around the world based on projections (see following chart), with no signs of major take-up any time soon.

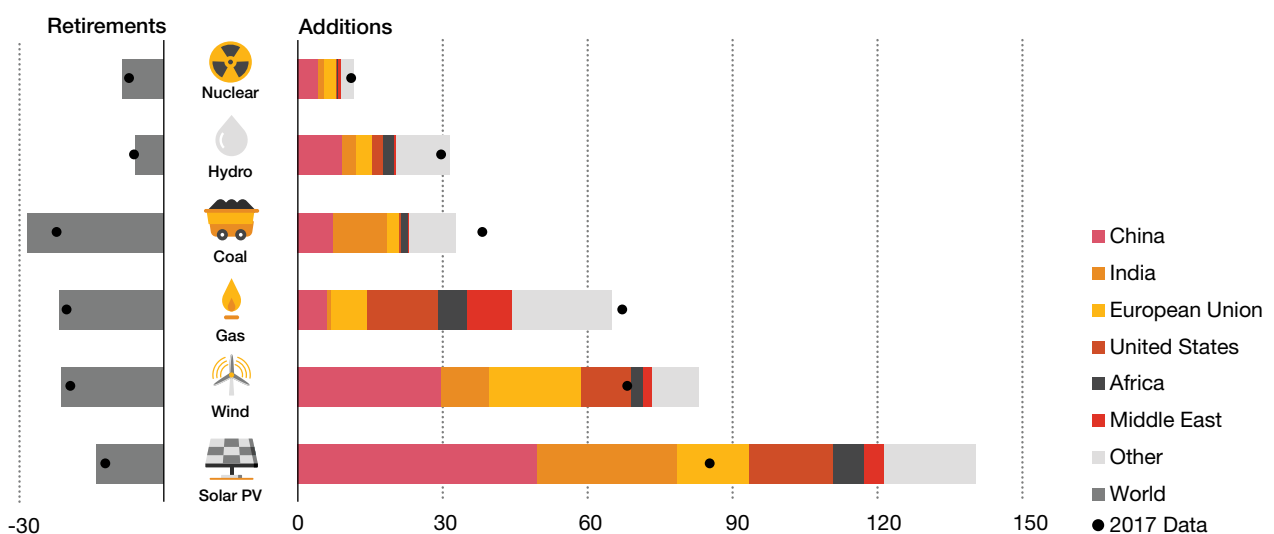
While often not discussed with the same passion as generation, close to US\$300b was spent on network assets across the globe in 2017 and again in 2018. Increasingly, this investment is focused on enabling power systems, as well as expanding and replacing networks around the world. Enabling power systems refers to investments on digitising and securing our power grids, and on managing the increasing amount of distributed and renewable energy sources.

Two charts summarise the energy markets of the world and their direction of travel. Both are from the International Energy Agency (IEA) reports/data. The first looks at the forecasted annual global generation capacity additions and retirements from 2019-2040. It shows that the vast majority of additions will be from non-fossil fuel sources over the next two decades.

It also shows that the highest proportion of retirements will be from coal and gas assets. The chart highlights the lessening relevance of coal-fired generation globally with coal plant additions just exceeding retirements on average. It also shows that gas is still viewed positively as a generation source, with gas plant additions double the rate of retirements. Australia's major trading partners are predominantly investing in renewable generation and gas, including the US, China and India. These figures have changed dramatically over the last two years with lower global coal plant additions and higher coal plant retirements predicted than previously forecast (-15% and +30%, respectively) and with a major increase in the forecast annual solar PV investments across the globe (increasing by around 65%).

This data gives a view that Australia's two core existing energy exports - coal and gas - have an ongoing place in the global economy, and anticipate for the next 20 years there will be continuing solid demand for Australia's traditional high quality energy resources. However, there is a major shift underway towards renewables and further distancing from fossil fuels by many governments globally, putting pressure on our current energy exports longer term.

Global annual average capacity additions and retirements by technology 2019-2040



Source: PwC analysis based on IEA, World Energy Outlook 2019 (Stated Policies Scenario)

20 International Energy Agency (IEA) 'World Energy Investment 2019' report

The second IEA chart of note below, gives an overview of a sample of major economies' energy policies.²¹ Most are challenging for coal. Nuclear has its most significant support from major developing economies, though the proposed investments in nuclear energy are still relatively minor compared to renewables and gas.

Global trends indicate strong momentum for an energy transition to occur and potentially at a faster pace than previously thought.

Major global economies' energy policy summary

Region	Policy	Authority	Release date	Impact on outlook by source			
				Renewables	Nuclear	Gas	Coal
China	13th Electricity Development Five-Year Plan (to 2020)	NEA	December 2016	↑	↑	↑	↓
India	Draft National Electricity Plan (to 2022)	CEA	December 2016	↑	↑	↑	↓
Korea	Proposed energy pillars (to 2025)	New admin.	2017	↑	↓	↑	↓
France	Announced energy policy (to 2025)	New admin.	2017	↑	↓	—	↓
European Union	No new coal power plants post-2020	26 of 28 countries	2017	—	—	↑	↓
Indonesia	PLN electricity supply business plan (2017-2026)	PLN	March 2017	↑	↑	↑	↓
Canada	Phase out traditional coal-fired power plants by 2030	New admin.	November 2016	↑	—	↑	↓
United States ²²	Removal of Clean Power Plan (to 2030)	New admin.	2017	↓	—	↓	↑

Note: NEA = National Energy Administration in China; CEA = Central Electricity Authority in India; admin. = administration; PLN = Perusahaan Listrik Negara, the state electricity company in Indonesia.

Some nations have found a way to embrace an energy and climate future (e.g. the United Kingdom, France, Germany and New Zealand), creating long-term confidence for investors, and enabling energy companies and other market players to focus on how to get on with the job rather than second guess what the job might be.

²¹ The International Energy Agency (IEA), World Energy Outlook 2017

²² We observe that the USA Clean Power Plan has in fact improved the outlook for gas and renewables and worsened the outlook for coal

Australia's energy choices from now to 2040

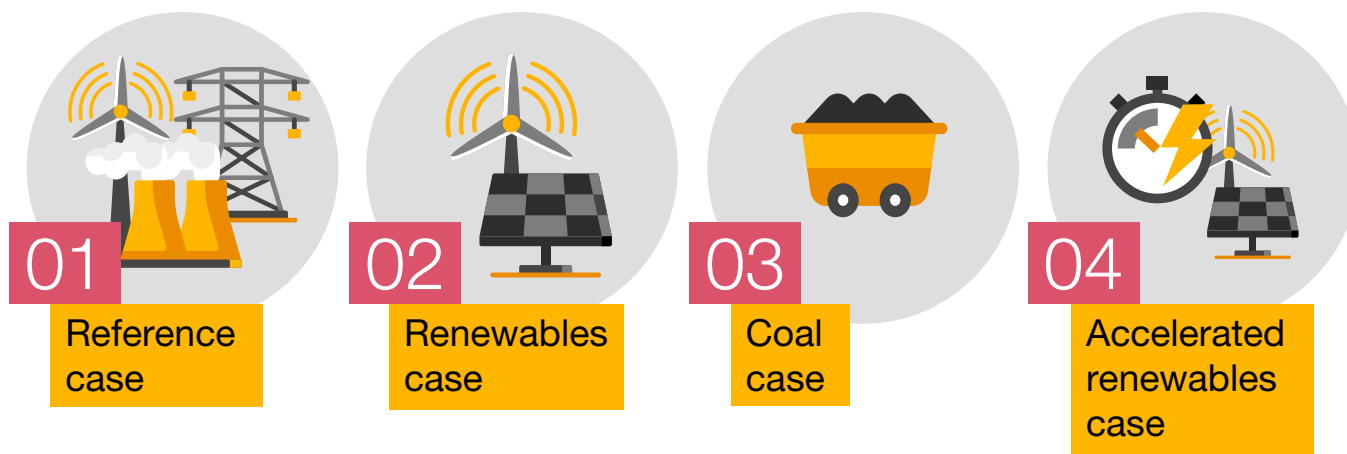
Modelling of energy market scenarios serves an important role in understanding the impact of potential futures on a range of key criteria. In order to provide the energy debate with a better foundation for discussion, we have focused on four energy choices for Australia, modelling their financial, economic and emissions impact.



Three of these scenarios share the same assumptions regarding the timing of thermal capacity retirement and vary only in the mix of new capacity added. They provide a good baseline comparison of the impact of different technologies. The fourth option serves to understand the impact of accelerated thermal capacity closure and increased renewables penetration. Because the amount of capacity replaced is higher compared to the other three scenarios, the results are not strictly comparable, but provide directional insight.

The models only take into account emissions from stationary energy generation and are not intended to model emissions from other sources (e.g. transport and LNG production).

Energy scenarios for Australia



Based on analysis of various AEMO forecasts and supporting data and assumes major thermal power plant closures in line with company announcements - sees 47% of Australia's thermal generation capacity retiring by 2040 replaced by a mix of new gas and renewable generation on a least cost basis

In line with the reference case on most assumptions, including the retirement rate of thermal generation – replaces most retiring thermal capacity with renewables

Aligned with the reference case and its thermal plant retirements – assumes that for all coal-fired generation closed 50% of its capacity will be replaced by High-Efficiency Low-Emissions (HELE) coal technology

Deviates from the reference case by accelerating the thermal plant closure schedule, particularly for plants currently scheduled to close in the 2040's and 2050's – sees 60% of thermal capacity closed by 2040 and replaces it mostly with renewables

In the absence of a long-term energy policy, the 'reference case' is an estimate of Australia's current pathway based on existing energy infrastructure plans, investment requirements and current policy settings (both Federal and State/Territory). However, it assumes that any plant retirements are replaced in a timely way with the lowest cost generation technology, or combination of technologies.

This scenario sees Australia in 2040 having 65% renewable generation, and emissions from the power sector being 57% lower than they were in 2005. Our power system would be reliable and energy costs will have declined compared to current levels. It is a case that some would argue as being 'good enough' for our future. But Australia can prosper much more by following the renewables case or the accelerated renewables case. As seen in our modelling, there is economic opportunity from an increased investment in renewables over the next two decades.

Key modelling principles

To ensure the modelling can support an objective debate, the analysis adhered to the following key principles:

01 Scenarios must be comparable

Scenarios use the same set of assumptions where possible, for example, on demand growth,²³ costs and learning rates.²⁴ The weighted average cost of capital (WACC) is 7% for all technologies to ensure consistency between scenarios. No carbon taxes or emissions trading schemes have been used in our modelling.

02 Scenarios only include existing technologies

Scenarios focus on known technologies such as solar PV and wind to make them realistic, rather than on prospective technologies like High-Temperature Solar Thermal (HTST) and fuel cells. Current nation-building energy infrastructure projects have been included in all scenarios (e.g. the Snowy 2.0 pumped hydro project, Marinus Link interconnector to Tasmania, and the various transmission interconnection projects included in AEMO ISP reports).

03 Focus on economic impact vs. emissions

The economic impact tends to be where opinions vary wildly. There is (generally) less confusion about which scenarios are better for the environment.

04 Focus on energy system cost rather than on energy prices

Our analysis has focused on system costs included capex, opex and fuel costs rather than attempting to predict wholesale prices.

05 Remuneration for energy asset owners

We observe that as time progresses there is almost certainly going to be new models to remunerate asset owners. We have focused on ensuring asset owners are provided with sufficient revenues to meet their return of capital and return on capital needs, rather than the specific mechanisms to do so.

06 Focus on creating a reliable energy system in all cases

One of the key concerns of increasing renewables generation is the reduction in dispatchable capacity in the system and a resulting reduction in reliability. One of the key principles in developing our model has therefore been that the energy system in all cases must satisfy reliability standards to make them comparable. We have done this by ensuring timely investments occur in dispatchable generation and network assets.

²³ AEMO, Electricity Statement of Opportunities 2018, August 2018 - we have used this forecast to identify economically optimal energy choices in a rapidly changing and growing energy market.

²⁴ Generation costs and learning rates have been taken from AEMO Draft ISP 2020 Assumptions.

Our approach to modelling has been relatively conservative. Our hypothesis is that this is the best way to compare scenarios and brings a strong sense of reality to the ensuing debate of our work.

All scenarios modelled see Australia with a more reliable energy system than we have currently. In the renewables scenarios this resulted in increasing amounts of pumped hydro and battery capacity, as well as gas turbines to provide dispatchable generation during extended periods of low output from wind or solar.

Additionally, synchronous condensers were added to the energy system to ensure system security when high levels of non-synchronous generation capacity (i.e. most renewables) enter the market. The required interconnection transmission capacity have been included in each of the scenarios. However, new investments in distribution networks have been excluded from the analysis.

One of the main drivers for investments in the distribution system, including system management tools, is the amount of bi-directional flow and price-responsiveness that occurs from distribution level resources (both generation and demand management).

Substantial work is progressing through the market bodies, ARENA, and multiple state-based programs, to determine the ability of the distribution networks to accommodate increasing amounts of active distribution level resources.

For our analysis, the amount of active distribution resources has been kept the same in each of the scenarios. This being the case, excluding the distribution network investments was an acceptable simplification that eliminated a significant amount of complexity when assessing investments required, as well as the benefits offered by these distributed resources. Definitive work is required to outline the networks resilience and investment plan for Australia's energy transition.



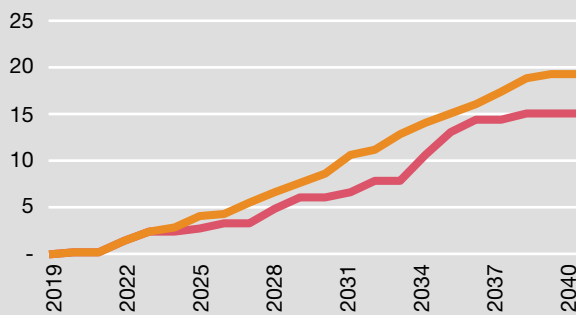


Analysis: changes in generation mix and emissions

The charts below highlight the changes in generation mix and resulting emissions that occur under the different scenarios. The results show that Australia is likely to see between 61% and 90% of its electricity sourced from renewable generation by 2040, depending on which path it decides to pursue.

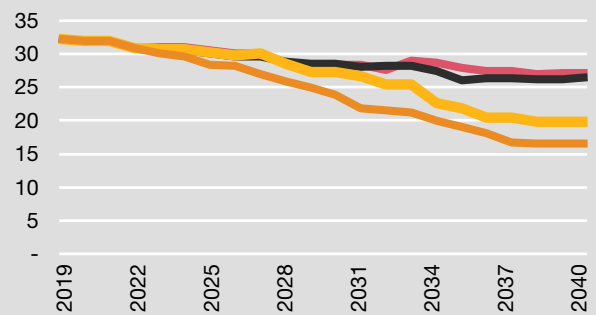
Figure 1: Comparison of changes in thermal capacity

Thermal capacity retirement (GW)



Reference, Renewables, Coal case
Accelerated renewables case

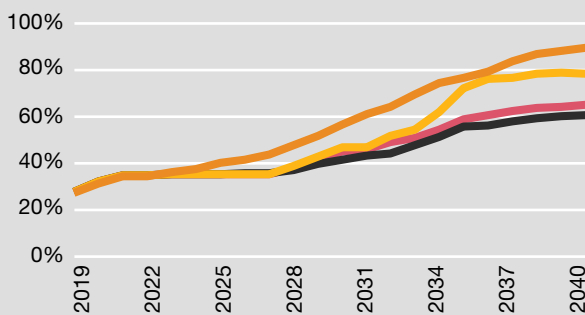
Thermal capacity in supply mix (GW)



Reference case
Coal case
Renewables case
Accelerated renewables case

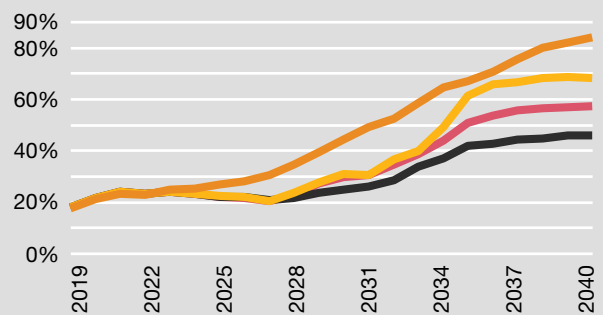
Figure 2: Comparison of changes in renewable generation and emissions reduction

Renewable generation (%)



Reference case
Coal case
Renewables case
Accelerated renewables case

Emissions reduction from power generation (% v 2005)



Reference case
Coal case
Renewables case
Accelerated renewables case



Analysis: financial costs and economic impact

Table 1 summarises the financial costs and economic impact for each modelled scenario.

Table 1: Comparison of scenarios

	Comparable scenarios			Stretch
	Reference case	Renewables case	Coal case	Accelerated renewables case
Cost 2019-2040 (NPV, \$b, Dec-2018\$)				
Capital	40.3	44.8	42.7	53.3
Ops & maintenance	37.9	39.0	38.6	38.8
Fuel	42.5	38.0	41.6	33.1
Total system cost	120.7	121.8	122.9	125.2
<i>Delta v. reference case</i>	-	1.1	2.2	4.5
Key ratios 2040				
Thermal capacity replaced	47% (15 GW)	47% (15 GW)	47% (15 GW)	60% (19.3 GW)
Renewable generation	65%	79%	61%	90%
Emissions reduction from power generation (vs 2005)	57%	68%	46%	84%
Unserved Energy (USE ²⁵)	<0.002%	<0.002%	<0.002%	<0.002%
Cost of the energy system (\$/MWh). <i>NB this not the wholesale price²⁶</i>	65.1	66.4	67.2	71.6
Economic impact, delta to reference case (NPV, \$b, Dec-2018\$)				
GDP	-	+13.2	+6.2	+14.8
Consumption	-	+5.6	+0.5	+10.7

All costs are the discounted total spent over the 2019-2040 period for each scenario. Capital cost represents the annualised cost of capital for investments in generation, storage and networks, and applies a weighted average cost of capital of 7% for all technologies to ensure consistency between scenarios. This assumption arguably favours coal over other technologies as independent research indicates that new coal fired generation faces higher project risk and market risk.²⁷

25 USE below 0.002% is the reliability standard in the NEM

26 This figure illustrates the cost of the energy system in each of the four Cases. It is not a wholesale electricity price which arises through market forces. The cost of the energy system figure is calculated by dividing the total system cost by the total volume of electricity produced.

27 Jacobs for Finkel Review (Emissions mitigation policies and security of electricity supply, June 2017) reports a WACC of 9.9-14.9% for coal technology, 6.1-8.1% for gas CCGT and 6.1-7.1% for renewables; GHD for AEMO (AEMO costs and technical parameter review, September 2018) reports a WACC of 10% for HELE technology, 6% for CCGTs and 6.2% for renewables

The compared scenarios demonstrate:

01

All scenarios show positive economic returns compared to the reference case when focusing on GDP (from \$14.8b for accelerated renewables, down to \$6.2b for the coal scenario).

02

Rather than focusing on changes to GDP, a more appropriate focus is on changes to 'consumption'. This measures household economic well-being through the acquisition of goods and services. To the extent that consumption can be considered as a proxy for living standards, an increase in consumption implies the Australian population is better off. This lens suggests that both renewable scenarios are meaningfully positive (from \$5.6 to \$10.7b) while the coal scenario is only marginally positive (\$0.5b).

03

All of the cases vary in their total system cost (NPV) over the next 20 years by less than 4%.

04

The renewables case is only marginally more expensive (<1%) than the reference case and enables Australia to reach almost 80% renewable generation by 2040 and sees emissions reductions of 68% from power generation compared to 2005 levels.

05

The accelerated renewables case, while more costly, replaces a higher amount of thermal generation before 2040, which in the other cases still needs to be replaced between 2040-2050. It also should be considered within the broader context of its positive effect on GDP, consumption and emissions.

06

Economically, there is a clear and obvious offset between fuel and capital costs as we move from thermal to renewable generation.

The total financial costs and the associated impacts on wholesale prices are key aspects to consider, but are not looked at in isolation. Arguably more important is the likely economic effects of the various scenarios, especially given that all cases deliver a power system that should provide lower prices for consumers than we currently see.

Our analysis highlights employment in fossil fuel power generation and related industries are reducing. Importantly this is being more than offset by a larger gain in employment in the renewable generation and related sectors.

The renewables scenario shows that States with sizeable coal generation industries, that require a higher degree of transition away from coal, will see an increase in the construction and renewable power generation sectors that offsets the decline in employment in other sectors. As a result, depending on the timing of the transition and the subsequent investments, employment in New South Wales, Queensland and Victoria will increase from the transition.

Predictably, the investment in new generation stimulates construction activity and also expands activity in downstream supplying sectors like cement manufacturing, civil engineering construction, and non-residential building. This short term gain to employment from construction applies to all forms of investment.

The impact on the cost of energy is also an important consideration in relation to employment, as it is an essential input into all sectors of the economy. Relative to the renewable scenarios, investing in new coal HELE plants as we have modelled in the coal case has the smallest gain to employment of the scenarios - a result of the higher increase in energy system costs offsetting the increase in construction related jobs.

Social cost of carbon

Although the focus of our analysis has been on the economic impacts from changes in the energy system’s costs, we have also considered the flow-on impacts for the economy via an assessment of the social cost of carbon.

This is not a new concept. It has been part of carbon policy analysis for almost 20 years. The following helps articulate and clarify its logic:

“ The ‘social cost of carbon’ (SCC) is a commonly estimated measure of the economic benefits of greenhouse gas (GHG) emission reductions (e.g., Tol 2005, 2008; Nordhaus 2008; Hope 2006, 2008; Anthoff et al. 2009a,b). The SCC represents the present value of the marginal social damages of increased GHG emissions in a particular year—including the impacts of global warming on agricultural productivity and human health, loss of property and infrastructure to sea level rise and extreme weather events, diminished biodiversity and ecosystem services, etc.—and therefore it also represents the marginal social benefits of emissions reductions. Properly defined, the SCC is the correct “shadow price” to place on GHG emissions in a benefit-cost or social welfare analysis of climate change policies.²⁸

We include the economic impacts of the social cost of carbon in the analysis by calculating the opportunity cost savings (or cost increases) from abating (or increasing) CO2 emissions. The opportunity cost reflects the difference between the cost of emissions to society (the ‘social cost of carbon’) and the cost per tonne of CO2 abated (a function of the change in emissions and the change in the energy system’s total costs, relative to the reference case).

At a practical level, the consideration of this opportunity cost can be thought of as affecting the amount of taxpayer funding required to meet Australia’s commitments to reduce CO2 emissions (e.g. through the Emissions Reductions Fund); if more emissions can be reduced through the transition of the energy system towards renewables then fewer emissions need to be reduced elsewhere in the economy to meet current commitments (and vice versa where there is an increase in emissions from the energy sector, more needs to be done by other sectors).

When including the social cost of carbon in the comparison of the cases, the economic impact of the accelerated renewables case improves while the coal case will negatively impact GDP and consumption (i.e. when compared to the results in Table 1).

Table 2: Comparison of scenarios - Economic impacts including social cost of carbon

	Comparable scenarios			Stretch
	Reference case	Renewables case	Coal case	Accelerated renewables case
Economic impact, delta to reference case (NPV, \$billion, Dec-2018\$)				
GDP	-	+13.1	+4.7	+16.5
Consumption	-	+5.6	-0.4	+11.8

²⁸ “The Social Cost of Carbon Made Simple Made Simple”, Stephen Newbold, Charles Griffiths, Chris Moore, Ann Wolverton, and Elizabeth Kopits, 2010

The rise of energy services

In line with this seismic shift in power generation sources underway, there's an unprecedented change in the way energy is being provided to customers by utilities and other players.

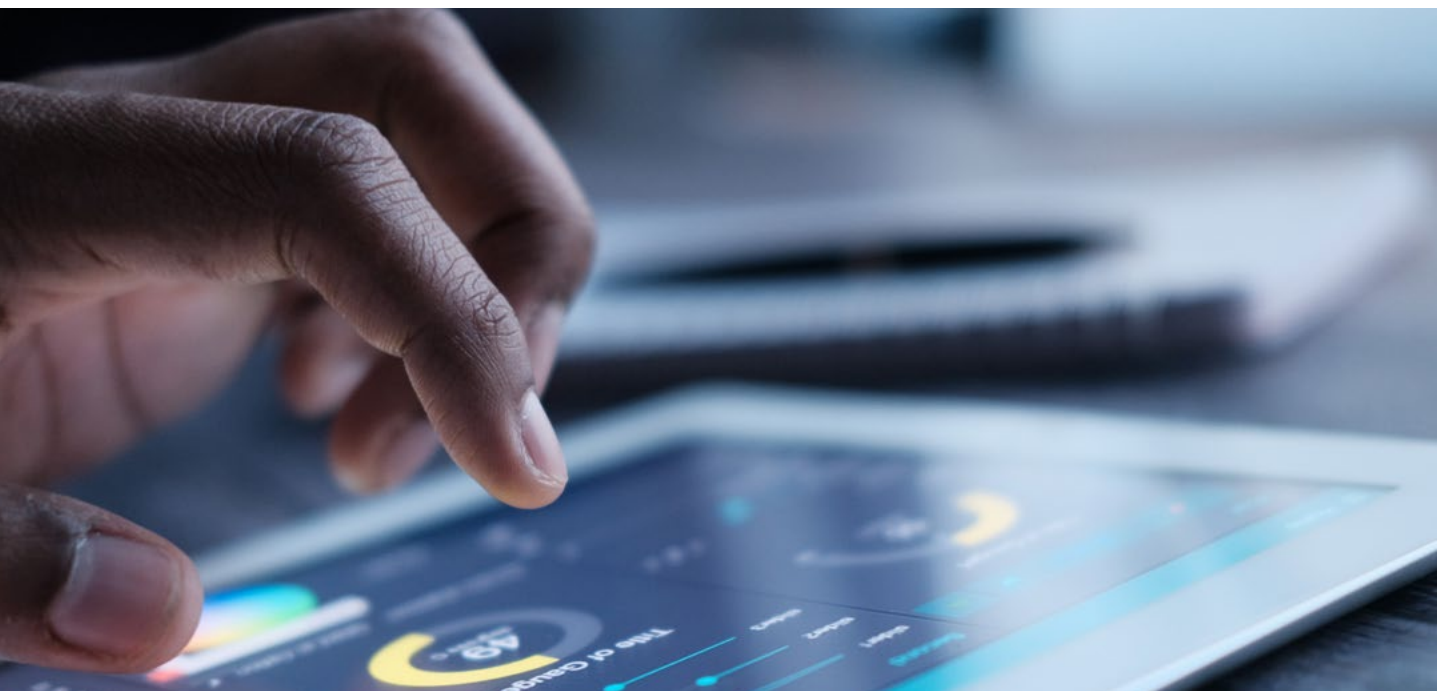
There are two primary drivers behind this shift:

- the shift in generation technologies - the move away from centralised, large generation to much more distributed generation and the associated volatility in security, reliability and quality of power supply brings opportunities to monetise different types of energy provision. The Hornsdale Power Station, for example, with its combined renewable generation and utility-scale battery (the so-called Tesla 'Big battery') has created a 'value stack' of traditional dispatchable power and energy services.
- a more demanding customer - the energy sector and utilities are increasingly under pressure to innovate and provide customers with more control while reducing costs, finally catching up with other industries, such as telcos and airlines.

The 'local-power' phenomenon adds to this. The ability of customers to generate, and increasingly store energy from their own assets is relatively new. This is driving the development of new services and new platform business models. Our energy market design must evolve to incorporate them as they develop. At present, the bulk of the service innovation underway is at the retail end of the value chain and to some extent at the generation end. This is within the unregulated parts of the value chain. While service innovation is beginning to happen within the networks segment, rigid investment regulations are restricting this development.

This again points to the need for a definitive analysis of the future network (transmission and distribution) investment needs for Australia.

At an energy system level, we expect to see energy services feature more prominently in the future. We are aware that much work is underway in Australia by the ESB and others on the future of the NEM and within this, there is analysis being undertaken on differing services models and how they might be applied within an Australian context.





Australia's energy transition

For Australia to harness the potential economic benefits of moving to a more reliable and a more renewable future, Australia's supply mix, networks and wholesale market need to undergo a significant and well-planned transition.

Failure to reform our energy market to ensure key energy infrastructure investment decisions are made in the short term could push Australia into a disruptive energy future. Poor or unbalanced energy policy choices undermine stability and create a poor investment climate. Taking a forward view on energy system needs with a blend of dispatchable and non-dispatchable generation is not only possible but essential for our economy and our wellbeing.

Our analysis shows that moving to a more renewable energy generation model is positive for Australia's economic growth and standard of living. Replacing existing coal fired power stations with new HELE coal stations is less likely to have positive economic outcomes.²⁹ In its own right, this is an important input to Australia's energy debate. As a reminder, this assumption does not include any carbon tax or emissions trading system.

²⁹ We observe this has been a topic of debate during our work, with polarised views on the cost of capital required to fund new coal generation and even whether or not financing, insurances, etc could be sourced for new coal generation assets



Where to from here

At the risk of being simplistic we see there are four key actions we must take as a nation:

1. Ensure that the current energy policy and market reform work being undertaken by our various regulatory bodies and governments comes together in a single coherent and comprehensive plan quickly and have the necessary legislation and regulation agreed within the next 1-2 years. Governments of all persuasions must not continue with political brinkmanship on the matter of energy policy.
2. A definitive body of work be undertaken within the next 1-2 years to develop a view of the critical role of the energy networks (both transmission and distribution) sector and its investment needs over the next 10+ years as it continues its transformation to becoming the physical energy platform we need for our energy future.
3. Developing transition plans for those industries, States and regions undergoing radical change - given our analysis points to major regional shifts in employment and economic prosperity as the transition under all scenarios (including the reference case) unfold. Building coherent and action oriented industry and regional economic transition plans are fundamental to how Australia's energy communities continue to flourish as our energy markets transition.
4. Ongoing innovation is key to solving Australia's energy puzzle and creating world leading expertise. Much of what we will reshape over the next 20 years will occur across the globe which provides an opportunity to develop world-leading Australian expertise on how to build new energy systems and the underpinning technologies, both physical and digital.





This report injects much needed economic perspective into the energy debate. Further to the four proposed actions, we don't have all the answers for what should happen next.

However, over the course of the coming months, we will be holding a number of energy leadership discussions to identify opportunities and action-critical items that need to be addressed immediately in order to shift the dial, with a focus on the next two years.

If you believe you have ideas or thoughts that will positively impact this dialogue and future planning, we would love to hear from you.



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