Australian Power: Can renewable technologies change the dominant industry view?[1]

Lynette Molyneaux[2], Craig Froome, Liam Wagner, John Foster

Energy Economics and Management Group,
School of Economics,
and
Global Change Institute,
The University of Queensland,
St Lucia, Qld 4067,
Australia

Abstract

With carbon dioxide the major contributor to anthropogenic climate change, being required to reduce the carbon emissions from burning coal for electricity presents a systemic shock to Australian power. The Australian government is committed to the development of its coal seam gas resources for export to lucrative world markets and to transition domestic power generation to greater resilience by moving away from a reliance on coal to lower-emissions intensive gas. Using a commercially available modelling package, PLEXOS, we model what a transition to gas fired generation in the year 2035 would deliver and compare that to a transition to power from renewable technologies. The results indicate that a transition to gas fired generation reduces emissions only marginally and that wholesale prices will be higher than the renewable energy option.

Keywords: Resilience, Electricity, Renewable Energy, Distributed Generation
JEL Classification: Q40, Q42, Q47

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1. Introduction: consequences of a dependence on fossil fuels

In the late 1980s, Japanese alumina and aluminium consortia led the charge in a global search for investment opportunities in countries with affordable, reliable power after the Middle East energy crises showed how vulnerable the oil-reliant Japanese power system was to fuel source shocks. Australia responded by developing large centralized coal-fired power stations to attract this energy intensive industry in search of a new home [6].

[1]This paper represents a subset of modelling and research conducted by The University of Queensland's Global Change Institute in the series of papers entitled Delivering a Competitive Australian Power System, the first of which was published in 2011 [1]. An earlier version of this work was presented at the Australian Solar Energy Society Conference, Melbourne December 2012 [2]

[2]Tel.: +61 7 33467059; fax: +61 7 33657299; email:l.molyneaux@uq.edu.au

Heavy investment in large centralized power stations precluded Australia from pursuing a diversified portfolio approach. This meant that as evidence increased of consequences of greenhouse gas concentrations in the atmosphere from burning fossil fuels, the Australian power industry failed to embrace alternatives. Today the power sector finds itself with a generation fleet that is less efficient and more CO_2 emissions intensive than any of the OECD and many of the BRICS countries' fleets with only South Africa and India showing worse statistics.

If energy-intensive industry in the 1980s sought out affordable and reliable supplies of power, the trend is unlikely to change in the 2020s as firms consider the uncertainties and increasing costs associated with power systems subject to carbon constraints and increasing energy price volatility. A useful method of evaluating the vulnerabilities facing national electricity systems is the Resilience Index as detailed in [7]. This index provides a systematic top-down analysis of national power systems by comparing their efficiency, diversity and security. Figures 1.1 and 1.2 provide a graphical representation of the comparative countries' power system resilience mapped to the cost to industry for power in 1990 and 2010.

Countries with affordable, resilient power are represented in the bottom right hand corner, by comparison to countries with cheap but vulnerable power systems which are represented in the bottom left hand corner. Notably India's power system has become less resilient since 1990 whilst South Africa, France, Australia and Canada's power systems have retained the same level of resilience that they had in 1990. However, the remaining countries' power system resilience has increased since 1990, generally due to increased diversity of fuel source. Australian power is shown to be neither reasonably priced nor resilient. As evidence of this, some energy-intensive companies have recently announced an intention to move to countries with more affordable, resilient power systems [8].

With the introduction of Carbon Price legislation in Australia, generators will be faced with increasing costs which will be passed through to consumers. With a sizable proportion of the generation fleet due for replacement in the next decade, power generators find themselves considering whether to invest in less emissions-intensive gas-fired generation or embark on a path toward generating energy from renewable sources. The Draft Energy White Paper has forecast that investment in gas-fired generation will deliver affordable power whilst still meeting carbon dioxide (CO_2) emission reductions [11].

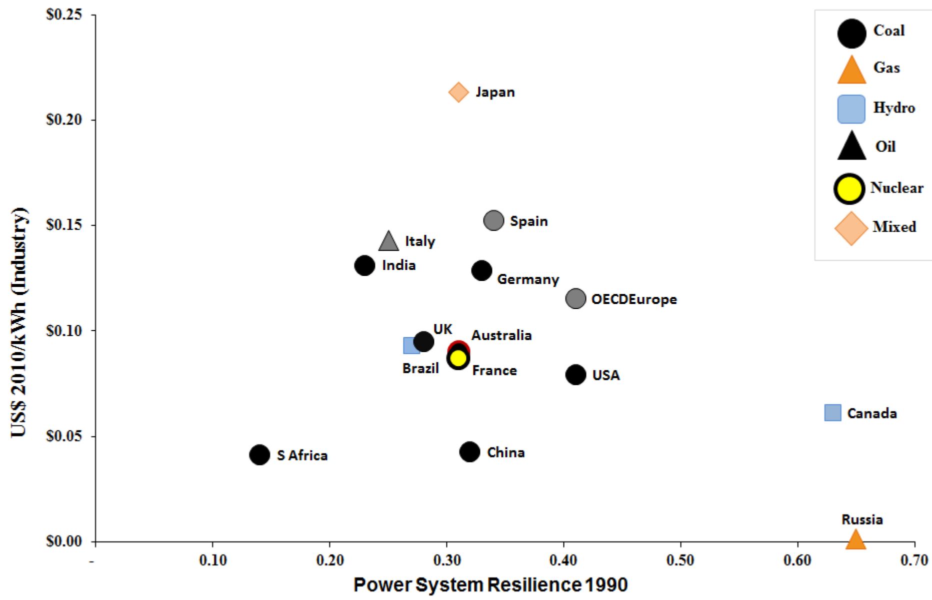

Figure 1.1: Power system resilience in 1990 [9, 10]

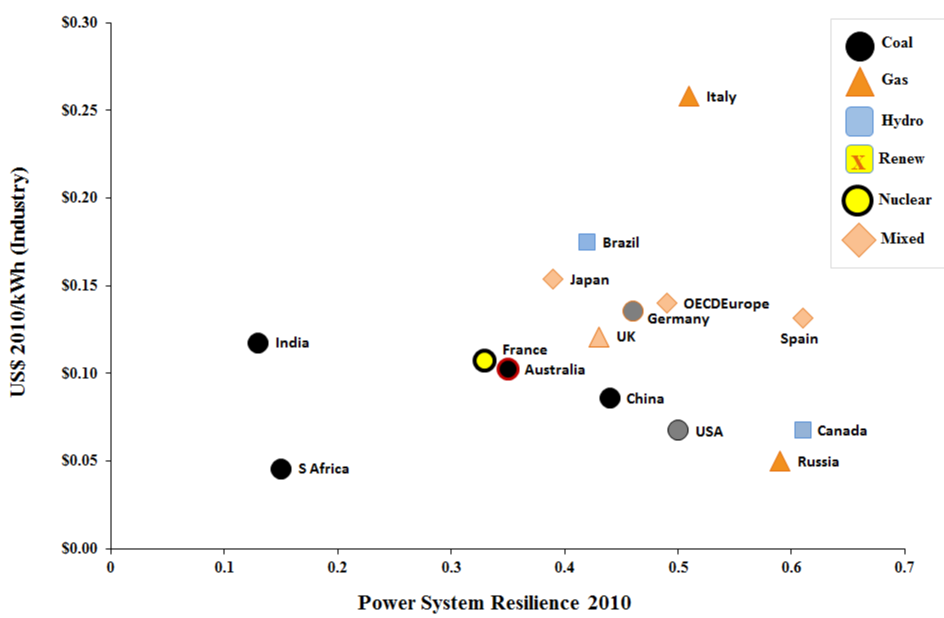

Figure 1.2: Power system resilience in 2010 [9, 10]

However, there are considerations other than emissions cost. We suggest that the industry will have to respond to:

- Rising electricity prices driven by increasing global fuel prices and distribution investment
- Emissions constraints
- Infrastructure renewal
- Public support for renewable energy and
- A technology shift to renewable and distributed generation

over the next two decades. To understand the implications of the multiple driving forces, we conducted scenario analysis to outline the consequences of a major shift to gas as opposed to a major shift to renewable power generation by the industry.

In section 2 we detail the scenario analysis conducted, in section 3 we analyse how the results from the modelling for each scenario addresses the forces facing the industry, with section 4 predicting how resilient Australian power might be in 2035 compared to its competitors. Section 5 provides some concluding comments.

2. Australian Power: Scenarios for 2035

The dominant industry view is that gas is a transition fuel which allows Australia to reduce its emissions from power generation at an affordable price. In general, many groups share the view that renewable energy is too expensive and unreliable to be a major component of the energy generated to meet demand. These views have been predicated on different drivers; for instance the low power densities of renewable sources of energy are considered to be insufficient for current consumption habits [12, 13]; and the technical limitations of the current electric power system make it prohibitively expensive if not impossible to overcome the issues of intermittency, variability and flexibility associated with specifically wind and photovoltaic power [14]. At the other end of the spectrum, groups are promoting very aggressive renewable energy deployment to meet carbon emission targets to allow Australia to meet its commitment of an 80% reduction in emissions by 2050 [15]. Modelling associated with 100% renewable energy deployment points to the feasibility of renewable energy meeting a large proportion of Australia's current electricity requirements [16, 17]. Thus far, the Australian government policy response has been to introduce Carbon Price legislation and a Renewable Energy Target (RET) which expires in 2020, which are considered sufficient to provide incentives to shift Australian power to sustainability and lower emissions. (Although Government projections don't seek an 80% emissions reduction from the energy sector, relying instead on the purchase of offshore emissions reductions to help meet the targets.) For now the Carbon Price legislation is under threat in the highly possible event of a change in Government [18] and the RET is under attack from prominent power companies actively promoting a reduction in the Renewable Energy Target [19, 20, 21, 22] and the associated contractual requirements [23].

We consider 2 scenarios, Business as Usual which reflects the dominant industry view as detailed in the draft Energy White Paper, and a Consumer Action scenario which predicts that renewable energy will be deployed as a result of public support and the industry will be influenced by a global roll out of new technologies that are emerging as a result of developments in Europe, Japan and China. In light of the significant lack of bipartisan support for the Carbon Price legislation and the aggressive infrastructure switch required to serve energy from only renewable energy sources, our Consumer Action scenario recognizes the significant resistance within Parliament, Government and the industry to substantial upheaval in the generator fleet and the delivery of power. The scenario accepts the need for continued dispatch from the existing fleet whilst it is efficient and cost effective to do so, replacing retired generators and meeting new demand with renewable and distributed generation as a transition rather than a revolution. Bearing in mind the quantum of sunk costs in existing infrastructure and what Smil refers to as the inertial reliance on existing technology [12], a scenario that is predicated on a complete replacement of the existing fleet by 2035 would require such an upheaval that, in our opinion, it is unlikely to be realistic. For this reason, to make a pragmatic comparison, we assume that the fleet will either be augmented by gas-fired generation as in the Business as Usual scenario, or by renewable and distributed generation, as in the Consumer Action scenario.

To facilitate the scenario analysis we model the deployment required to meet demand in 2035 in the National Electricity Market (NEM). Modelling of the NEM is conducted using PLEXOS, an electricity market simulation package, which uses deterministic linear programming techniques, and transmission and generating plant data, to optimise the power system and determine the least cost dispatch of generating resources to meet a given demand [24]. PLEXOS simulates generator behavior, such that generators participate in the market if they can cover costs and make a profit. Wholesale cost projections represent generator behavior and cost recovery, rather than just the latter.

2.1. The Business as Usual Scenario

2.1.1. Business as Usual (BAU) scenario assumptions

The International Energy Agency (IEA) has, for a while, been advocating a switch to gas-fired generation as a transition to lower carbon intensive power [25]. With the development of coal seam gas resources in the Eastern states of Australia, the Department of Resources, Energy and Tourism (DRET) has been in general support of the IEA view. This scenario reflects the view that gas will be the fuel behind new generation investment and the assumption that consumers will continue to react as they have over the last two decades, with consumption rising by around 2% per annum, a perception that consumption is not responsive to price rises, and that consumers are more concerned with cheap, reliable power than facilitating a shift to renewable forms of energy and reduced carbon emissions.

Thus, Australia will develop its unconventional gas resources to fuel lucrative global demand, investment will be made in gas-fired power stations to meet electricity demand, and the retirement of aged coal-fired generators will result from the introduction of the Carbon Price legislation. As currently set out in legislation, the RET is scheduled to deliver 41,000 GWh of renewable generation (mainly wind because of its lower cost) by 2020. After 2020 no further renewable generation will be deployed because of perceptions of its high levelised cost and concerns over intermittency. As feed-in-tariffs are perceived as expensive and contributing to electricity price rises [26], growth in energy from photovoltaic (PV) power is not considered likely in this scenario. The assumptions are laid out in Table 2.1.

Table 2.1: Assumptions for BAU Scenario

Source of assumptions	Australian Energy Market Operator [28]		
Capital costs	CCGT \$1100/kW	OCGT \$1100/kW	Wind \$2558/kW
Network topology	Existing		
Generation locations	Located close to transmission infrastructure		
Fuel price (Moomba) Gas	Mid \$8.32/GJ	Low \$4.89/GJ	High \$12/GJ
Modelling assumptions	To facilitate deployment of only gas-fired technologies, investment in SCPf coal is discouraged.		

2.1.2. The results from modelling BAU

Using Treasury projections for carbon price, the model predicts that generators in the National Electricity Market (NEM) will invest \$61 billion to deploy 26GW of combined cycle gas turbines (CCGT), 2 GW of open cycle gas turbines (OCGT) and 12 GW of wind power to meet demand in 2035.

The investment in gas-fired and wind generation will result in a reduction in CO_2 emissions from 183 million tones of CO_2 emissions per annum (mtpaCO_2) in 2010 to 167 mtpaCO_2 in 2035. This is sobering since a target to reduce emissions to 80% below 2000 levels by 2050 would require emissions from power generation in the NEM to decrease to 32 mtpaCO_2. A further reduction of 135 mtpaCO_2 to reach the 80% target in only 15 years would be extremely unlikely.

The wholesale cost of generation increases from approximately \$47/MWh currently to \$154/MWh in 2035. This increase is not only as a result of the cost associated with CO_2 emissions but also the increased cost of gas as a fuel and the projected increase in global gas prices which will flow through to domestic gas prices as a result of the investment in liquefied natural gas (LNG) export facilities.

Table 2.2: KPIs for Business as Usual scenario

	2000	2010	2035 (BAU)
mtpa CO_2 from electricity	161	183	167
Emission intensity	0.87	0.85	0.52
Generation (TWh)	185	215	324
Annual growth		1.50%	1.70%
Wholesale cost ($/MWh)	$60	$47	$154
Coal generation	87%	80%	42%
Gas generation	4%	11%	41%
Renew generation	9%	9%	17%
Fuel used (PJ)	1789^e	2059^e	2372
Fuel cost ($mill)	n/a	n/a	$9,421
Generation investment (bn)			$61
Gas price ($2011)	$3.51	$5.19	$8.32
Carbon price ($2011)	$0	$0	$ 74

e denotes that these values are estimated from AEMO data [28]

In this scenario, coal-fired generation decreases from 80% currently to 42% with a corresponding rise in gas-fired generation increasing from 11% currently to 41% in 2035.With the benefits of the RET, renewable energy increases from 9% currently to 17% in 2035. The Key Performance Indicators (KPI) are outlined in Table 2.2.

2.1.3. Sensitivity analysis for BAU

A number of uncertainties are inherent in the BAU scenario. The sensitivity of the system to significant shifts in gas price, the RET, and carbon price were tested and revealed that:

- a high carbon price of $159/t$CO_2$ shifted more generation from coal to gas, decreasing emissions by 22% but increasing wholesale costs by 22% and an increase in fuel cost bill of $4 billion;
- extending the RET to 20% of generation in 2035, increases investment by $4 billion but decreases average wholesale cost by 5%;
- low gas prices of $4.89 (at the Moomba hub) reduces emissions by 21%, lowers wholesale costs 41% with a corresponding reduction in the fuel bill of $2.2 billion. However, it should not be forgotten that the majority of the fleet would be relatively new making abatement post 2035 very difficult to achieve;
- high gas prices of $12 (at the Moomba hub) increase the fuel cost by $2.7 billion but with no evidence of a corresponding rise in average wholesale cost.

2.2. Consumer Action scenario

2.2.1. The Consumer Action (CA) scenario assumptions

We predict that this scenario may be likely if widespread support for renewable energy and a strong perceived need for action on climate change, translates into the roll-out of Concentrated Solar Thermal (CST) with storage and Geothermal power to replace coal-fired generation as it was retired. To transmit power from remote locations to load centres, investment in transmission infrastructure will be made. In addition, high power prices would encourage community action to insure against rising electricity bills and political inertia would drive consumer-led action toward more sustainable sources of energy by investing in distributed generation (DG) technologies, including solar panels on rooftops (for domestic and commercial use) to help reduce the impact of meeting daily and summer peak demand and the deployment of micro-gas turbines, landfill gas, co-and tri-generation using renewable sources for gas like the city of Sydney is considering [27]. The assumptions are laid out in Table 2.3.

Table 2.3: Assumptions for CA Scenario

Source of assumptions	Australian Energy Market Operator [28] and CSIRO for distributed generation assumptions [29, 30]			
Capital costs	Wind $2558/kW	Concentrated Solar Thermal with 6 hours storage $6200/kW	Geothermal $6200/kW	PV with storage $2100/kW
Distributed generation Capital Costs	CCGT with CHP $1543/kW	Biomass with CHP $2527/kW	Biogas /Landfill gas $2068/kW	Reciprocating engine with CCHP $2218/kW
Network topology	Existing plus AEMOs Innamincka options 4 and 6 to reach significant nodes in the network			
Generation locations	Distributed across the states, Geothermal located in Innamincka			
Gas price (Moomba)	$8.32/GJ			
Modelling assumptions	To facilitate deployment of renewable and distributed generation, investment in the following technologies are discouraged: Nuclear, CCS, SCPf coal, CCGT			

2.2.2. The results of modelling CA

Solar power, both thermal and photovoltaic (PV), as well as wind and geothermal power, are always dispatched because of their low marginal costs. However, PV is not schedulable nor does it operate through the market, making it difficult to include in modelling generator behavior. In the past, PV has been accounted for by reducing demand to reflect PV generation, but we have simulated PV generation through the market, by aggregating PV generators in load centres and then assuming that they can dispatch as a group, perhaps indicating a potential change in application necessary for distributed generation.

Using Treasury projections for carbon price, the model predicts that generators in the National Electricity Market (NEM) will invest in 12GW of wind, 11GW of PV, 10 GW of CST with storage, 7GW of biogas, 5GW of distributed gas, 3 GW of geothermal, 2 GW of CCGT and OCGT at a total cost of $160 billion to meet demand. The investment in renewable forms of generation will result in a decrease in CO_2 emissions from 183 mtpaCO_2 in 2010, and 167 mtpaCO_2 in 2035 in the BAU scenario, to 101 mtpaCO_2 in 2035. Generation from coal-fired power stations will decrease to 31%, generation from gas-fired power stations will increase to 15%, and generation from renewable forms of energy will increase to 54% of total energy generated.

Contrary to expectations, the average wholesale cost is projected to be lower than the BAU scenario, at $126/MWh. However, some coal and gas generators have to operate at very low capacity, close to their minimum requirement to balance the intermittent load. This reduces their margins and is a consequence of failing to retire inefficient power stations and in effect using them to balance intermittent load. With such low margins, generators are unlikely to operate less efficient plants simply to balance intermittent generation. So, in the absence of storage or other load balancing options, it may be necessary to make capacity payments to key generators to ensure load stability. The KPIs are outlined in Table 2.4.

This scenario introduces network risk. Firstly investment will have to be made in developing transmission to transport energy from remote, renewable hubs to load centres. Secondly, network stability will have to be addressed to ensure voltage stability in the face of rapid power changes or excess load from large scale deployment of wind and PV generation. Germany, with its substantial deployment of wind and solar generation, is already engaged in integrating large scale intermittent generation into the European power grid so there are valuable insights to be gained from the European experience.

Other studies into the deployment of very high levels of renewable energy have modeled the feasibility of current renewable energy resources being able to meet expected 100% of current demand [15, 17]. Our modelling sought to establish the market response to high levels of renewable energy rather than the suitability of the network for such a task. Notwithstanding that, the network was accurately represented in the modelling by: ensuring that the transmission and interconnection infrastructure and associated constraints and loss factors as documented by the Australian Electricity Market Operator [28] were measured as part of the Optimal Power Flow; generation of wind energy was based on a log normal distribution of the occurrence of wind, and solar energy was based on historical solar incidence traces for each capital city on data from the Bureau of Meteorology;

and that demand was met with no unserved energy. So, from a high level perspective, there is no inherent limitation in the ability to serve high levels of energy from renewable, intermittent sources although at a more granular level, grid managers may experience management issues. Without minimizing the management challenges associated with integrating intermittent and variable renewable energy generation into the grid, this quote from the chairman of the Western Danish system operator ELTRA in 2003, is illustrative of the learning curve facing distributors:

"...we said that the electricity system could not function if wind power increased above 500 MW. Now we are handling almost 5 times as much. And I would like to tell the government that we are ready to handle even more, but it requires that we are allowed to use the right tools to manage the system"[31].

A requirement for substantial investment in the network to meet transmission and grid stability issues could be offset against reduced requirements for peak demand if PV generation is used to address summer peaks and if consumers can be encouraged to shift demand from peak demand times. Our modelling however addresses generation only, providing no insights into grid stability, so we suggest further research to establish the capacity of the grid to absorb intermittency.

Table 2.4: KPIs for Consumer Action scenario

	2000	2010	2035 (BAU)	2035 (CA)
mtpaCO_2 from electricity	161	183	167	101
Emission intensity	0.87	0.85	0.52	0.31
Generation (TWh)	185	215	324	327
Annual growth	–	1.5%	1.7%	1.7%
Wholesale cost ($/MWh)	$60	$47	$154	$126
Coal generation	87%	80%	42%	31%
Gas generation	4%	11%	41%	15%
Renew generation	9%	9%	17%	54%
Fuel used (PJ)	1789^e	2059^e	2372	1734
Fuel cost ($mill)	n/a	n/a	$9421	$7329
Generation investment (bn)	–	–	$61	$160
Gas price ($2011)	$3.51	$5.19	$8.32	$8.32
Carbon price ($2011)	$0	$0	$74	$74

e denotes that these values are estimated from AEMO data [28]

3. How the Scenarios Address the Forces Facing the Power Industry

3.1. BAU scenario

The World Energy Council conducts an annual survey of its members to establish their energy concerns. The 2012 report lists energy prices as the most critical uncertainty facing energy business leaders today [32]. With Australia's development of its LNG facilities both in West Australia and in the eastern states, domestic prices will be subjected to the vagaries of international energy price volatility. When added to the costs associated with shifting from low cost coal to higher cost gas-fired generation, pursuing this scenario could result in an increased cost of power generation and therefore will fail to deal with the pressure on power prices.

A continued focus on increasing grid infrastructure investment to prepare for continually rising demand, especially residential peak demand, fails to address consumer concerns about rising retail electricity prices, and also fails to deal with pressure on power prices. A substantial shift to gas-fired generation may reduce the carbon-intensity of the NEM but with increased consumption of power, greater generation to meet increased demand will result in little abatement, failing to deal with a requirement to mitigate against climate change.

Whilst gas-fired generation may involve increased fuel costs, its lower capital cost makes the BAU scenario effective at meeting the requirement for affordable infrastructure renewal.

The extraction of coal seam gas (CSG) in highly productive agricultural areas has resulted in community resistance to its extraction over concerns about the impact on productive farming land and ground water resources. Whilst the government has tried hard to market unconventional gas as a low-emission source of energy, it is far from renewable and its emissions intensity is the subject of some debate [33]. For these reasons, shifting generation to CSG-fired generation does not reflect public support for renewable forms of energy.

Europe and Asia are committed to substantial investment in production capacity and deployment of renewable and distributed generation. This indicates that there is a global trend towards new forms of technology. The BAU scenario fails to embrace this global trend.

3.2. CA scenario

Generation from renewable sources of energy reduces the power system's exposure to global fuel price volatility and therefore provides certainty with respect to energy and power prices. With a focus on diversifying fuel sources toward renewable energy, this scenario effectively mitigates against the global energy forces that will predominate in the future. As Australian peak demand has increased dramatically to address the hottest days of the year, generating power from rooftop solar for use when summer demand peaks, will directly reduce the need to bolster network capacity for just a few hours' of peak demand a year. A reduction in investment in the distribution network will reduce the potential for sharply increasing retail electricity prices because of network infrastructure requirements. When it comes to reducing emissions, renewable forms of generation offer the most significant reduction in emissions. This will better enable Australia to act effectively on climate change and ensure that a public requirement for action on climate change is respected. Power from renewable energy comes at a high capital cost, but this has to be balanced against the reduced cost of fuel many decades after installation. Whilst the capital cost of this scenario is a barrier to renewing the generator fleet, it should not be forgotten that the generator behaviour predicated in the model indicates that wholesale prices will be lower than prices for the BAU scenario.

A substantial shift to renewable forms of generation shows that this scenario actively addresses a public expectation to transition to more sustainable forms of power. With European deployment of renewable and distributed generation and Asian development of affordable production of renewable and distributed technologies, the CA scenario recognizes that there are technology changes underway globally that need to be addressed rather than deflected. Australia made a commitment to open participation in a global economy in the 1990s, the transformation of its power system should reflect that openness and willingness to embrace technological advancement and a transition to greater levels of sustainable development.

3.3. Comparing the scenarios

3.3.1. Increasing Fuel Prices

Relying on fuels that are vulnerable to volatile global markets increases the risk of rising wholesale costs. The BAU scenario has a higher fuel cost component than the CA scenario, and a higher non-renewable fuel cost component which could be more volatile than domestically available renewable fuels (biomass and biogas) as can be seen in Figure 3.1.

3.3.2. Emissions Constraints

Emissions reductions under BAU are very limited, whereas emissions reductions under CA are much higher. Whilst the emissions under CA are much better than BAU, emissions reductions to 32 mtpaCO_2 by 2050 would still pose a substantial challenge for the power industry to achieve. Figure 3.2 shows the difference between the 2 scenarios.

3.3.3. Infrastructure Renewal

The scenarios offer very different capital investment and fuel cost profiles. BAU offers relatively low cost capital renewal, versus CA which requires a high upfront capital spend coupled with lower annual fuel costs. Whilst the upfront capital cost for CA appears daunting, it should be noted that it offers the opportunity to spread the costs of generation investment across a wider base thereby reducing the risks associated with having to pick winners from amongst a complicated array of expensive technology options.

Figure 3.3 provides a comparison between the upfront capital cost of the 2 scenarios but also it does a simplistic comparison of the total fuel cost over 30 years. It is interesting to note, that the difference between the 2 scenarios narrows considerably when the fuel cost is capitalized (without discounting).

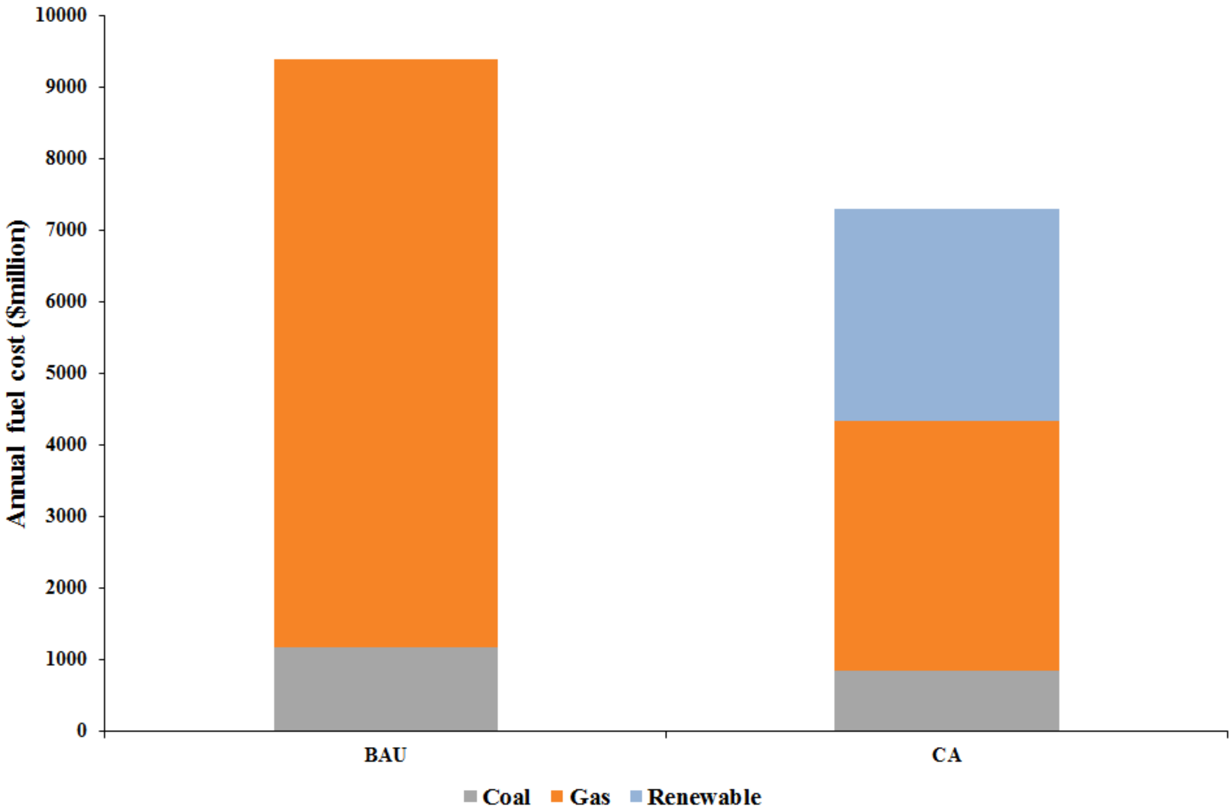

Figure 3.1: Annual fuel cost

3.3.4. Public Support for Renewable generation

The BAU scenario essentially shifts generation from coal to gas whilst the CA scenario deploys generation with a considerably higher diversity of fuel source. Having a higher diversity of generation, adds considerably to resilience, reducing vulnerability to fuel, technology and carbon lock-in. Figure 3.4 provides a breakdown of the proportion of generation from different renewable energy sources.

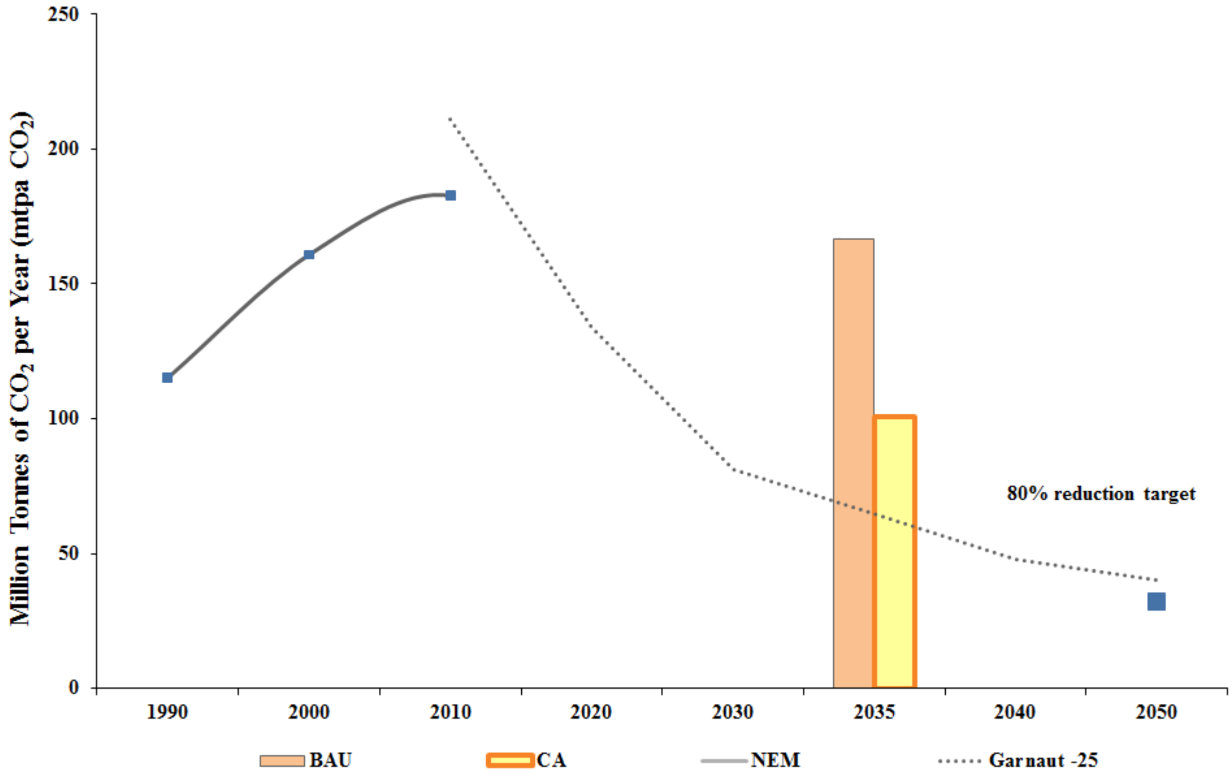

Figure 3.2: Scenarios proximity to 80% reduction

4. Summarising the difference between the scenarios

Despite the fact that low capital costs make gas-fired generation attractive to generators, our modelling of the BAU scenario provides little evidence that a shift to gas will adequately address the forces driving the power system (see Table 4.1).

Table 4.1: Responses to forces driving the power system

Forces driving the power system	BAU	CA
Rising fuel prices	×	✓
Rising distribution costs	×	×
Carbon constraints	×	✓
Infrastructure renewal	✓	×
Public support for renewables	×	✓
Technology shift to renewables and DG	×	✓

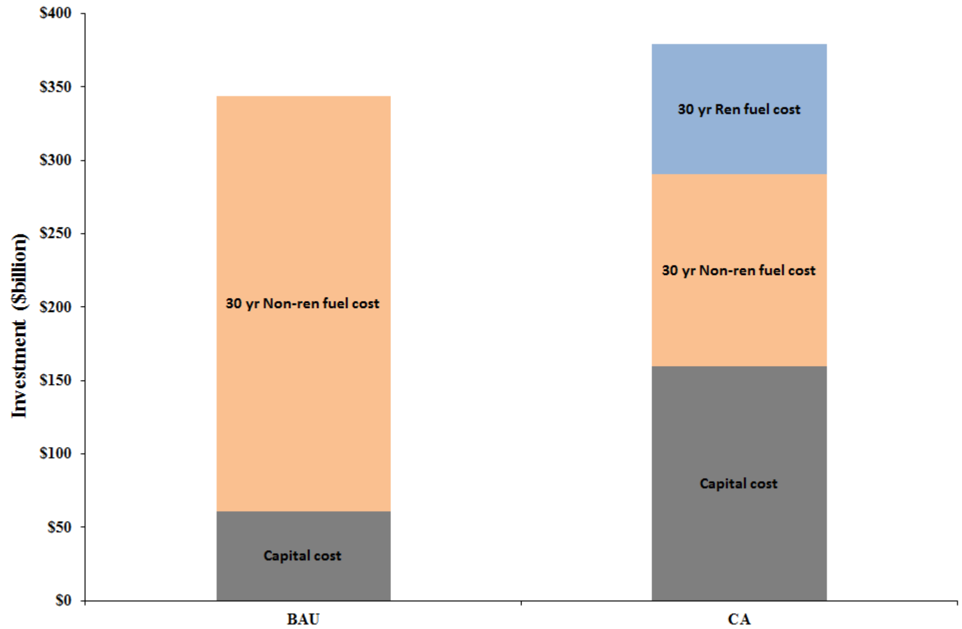

Figure 3.3: Investment required

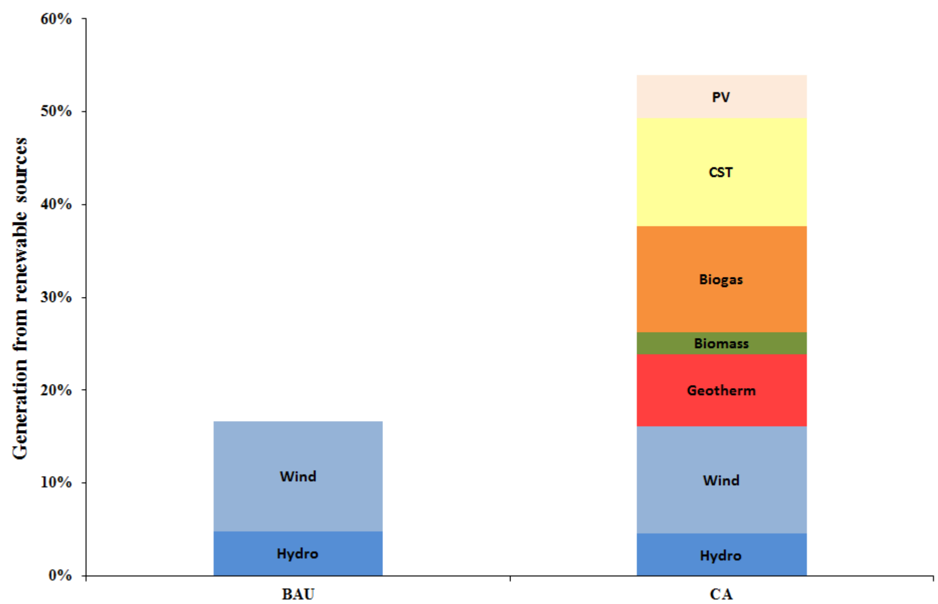

Figure 3.4: % of Generation from Renewable sources

By contrast, the CA scenario provides considerably more evidence that it is preparing the power system to be able to respond to future uncertainties making it more attractive to energy intensive industries.

These findings would support the analyses done by: Krozer [34] which indicated that growing renewable energy use in the European Union has not led to high electricity prices and may have reduced the impact of price increases due to oil price surges; Sensfuss et al [35] which found that renewable energy generation reduced wholesale prices; and Moreno et al [36] also indicated that electricity prices in Europe increase with increased energy dependency.

5. Projecting Power Resilience in 2035

Figure 5.1 provides a preview of the NEM's resilience in comparison to the IEA's projection for comparable countries as forecast in the World Energy Outlook [3]. As can be seen, the resilience of the NEM will improve dramatically if the Australian power industry were to embrace the CA scenario. The BAU scenario shows a little improvement on current levels of resilience, but it still shows low resilience compared to Australia's competitors.

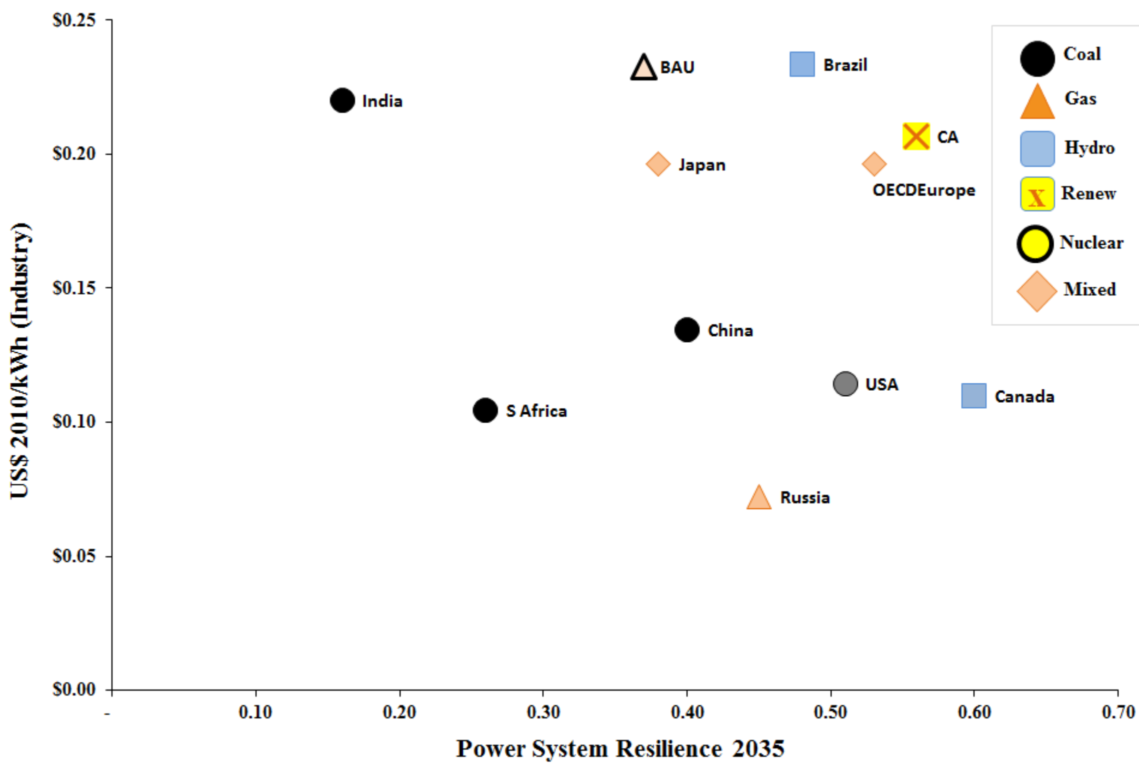

Figure 5.1: Power system resilience 2035 [3]

6. Conclusion

The modelling undertaken shows no evidence that a shift from coal-fired generation to gas-fired generation will enable Australia to improve its emissions of CO_2. In addition, there is no apparent justification for the claim that a high proportion of energy sourced from renewables will drive up wholesale costs in comparison to a power system heavily dependent on coal seam gas. The dispatch of power was optimized based on the current grid topology but modelling did not focus on the impact of high levels of distributed, intermittent generation on distribution networks. It is however suggested that if current levels of investment are refocused to provide a more robust distribution network able to accommodate DG rather than meeting peaky demand, then the money would have been well spent.

Whilst our findings might indicate that pursuing a gas-centric scenario will lead to increased prices and reduced carbon emissions, they may not be sufficient to change the dominant industry view which is intent on replacing coal with gas.

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