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Electricity market issues in South Australia

Analysis of an interconnector between New South Wales and South Australia

pwc

Mr Greg Garvin
Executive General Manager – People, Strategy and Stakeholders
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Haymarket NSW 2000

Dear Greg,

In accordance with our engagement letter dated 13 August 2016, we provide this report. The commentary included in this report outlines analyses relevant for the consideration of a potential high voltage electricity interconnector between New South Wales and South Australia. We understand that TransGrid is assessing the viability of such an interconnector at the present time. This report does not advocate for such an interconnector but merely looks to provide some data to assist in the debate on its viability

Our work did not constitute an audit or review in accordance with Australian Auditing Standards and consequently no assurance or audit opinion is expressed. Except where otherwise stated, we have not subjected the financial or other information contained in this report to checking or verification procedures. Accordingly, we assume no responsibility and make no representations with respect to the accuracy or completeness of the information in this report, except where otherwise stated.

Where provision has been made for copies of this report to be made available to the public these copies are subject to the conditions described within our Terms of Business. We will not accept any duty of care (whether in contract, tort (including negligence) or otherwise) to any person other than you, except under the arrangements described in the Letter of Engagement and Terms of Business.

Yours sincerely,

Mark Coughlin
Energy, Utilities and Mining Leader

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The current state of the South Australian Electricity Market

Three fundamentals of a robust electricity system are increasingly at risk in South Australia

The three fundamentals

Increasingly industry commentators and policy makers consider the three fundamentals of the electricity market when discussing the robustness of the market. In short these fundamentals are reliability, affordability and sustainability. What is also clear is that we observe an electricity market in transition between old world thinking and business models to newer technologies and increasingly innovative business models. In our view the transition still has many years to play out. We do however expect to see increased use of new technologies over the next 10 years and an electricity market in Australia fully transitioned by 2040.

Markets in transition

One of the challenges of markets in transition is that outcomes can be less predictable. We are seeing this in electricity markets across the globe. There are multiple drivers for this including the introduction of renewable generation (eg wind and solar), the closure of fossil fuel generators (eg coal-fired) and movements in commodity prices (eg oil, gas and coal) which are increasingly volatile. In a number of markets we are seeing dramatic and sudden impacts as a result of these drivers. The Australian electricity market is starting to see these impacts and it appears that South Australia is perhaps seeing this most acutely at this point in time. We hypothesise that South Australia is 'the canary in the coalmine' as there are early indications of other stresses across other Australian states and territories.

We have assessed a number of factors that highlight the current challenges South Australia and the rest of the country is facing, specifically relative wholesale electricity prices, price volatility and the incidence of wholesale price spikes.

NSW to SA interconnection

We understand that TransGrid together with ElectraNet is considering the construction of an interconnector between NSW and SA. While early in the assessment process we understand that the current plan is to construct a 275kV single circuit transmission line between current transmission lines in Buronga in South West NSW and Robertson in SA. There will be some upgrading of existing New South Wales transmission lines to provide a 'backbone' between the States. The project is expected to provide 2 way flows between the States and to pass through several renewables precincts to facilitate their connection to the national market.

We observe that this project has been widely commented upon in recent market commentary. There are many views on whether or not such an interconnector is required and whether it can be justified using the existing regulatory regime. We are not providing any views or comments on these dynamics. We are however providing analyses that we hope will provide useful 'grist' to this important discussion. In addition to the pricing analyses described earlier we have also analysed the extent to which there is current and potentially future capacity in the NSW generation market to facilitate an interconnector to SA and not compromise the market fundamentals in NSW. We have also assessed potential wholesale price impacts in both SA and NSW notwithstanding the challenge of assessing with any certainty the impact of a significant new asset in the National Electricity Market ('NEM') on pricing and market participant behaviour. Finally we have considered the economic impacts of constructing the proposed interconnector.

Benefits and costs from a new interconnector from New South Wales to South Australia

Price volatility in South Australia

We analysed wholesale prices across the NEM between January 2013 and August 2016. The objective was to assess those States that had emerging wholesale price issues. We looked at 3 elements – average half hourly price in each State, price volatility (a measure of half hourly price variations from the average price) and the number of price 'spikes' (i.e. wholesale prices of greater than $300 MWh). We observe that both Queensland and South Australia are experiencing challenges in each of these three areas but that the situation in South Australia worsened over the period of our analysis. In particular we observe that SA has the highest average wholesale price over the period, over 29% more than the average NSW price for example. South Australia had significantly more price spikes over the analysis period and an increasing number of spikes in the last 12 months. Queensland has the most volatile prices in the NEM with SA the second most impacted State. All of these factors point to electricity prices being less predictable in South Australia with a worsening trend line in both price spikes and volatility. Ongoing higher prices are likely. We observe that the Heywood interconnector between Victoria and South Australia is in the process of being upgraded which is expected to address some of these issues in the immediate term. We hypothesize that price volatility and price spikes will remain in SA though and potentially worsen as additional renewable generation is added in both South Australia and Victoria as is targeted by both State governments over the next 10 years.

Ability of the New South Wales generation sector to support increased export to South Australia

Our analysis is informed by the recent AEMO Electricity Statement of Opportunities[1] ('ESOO') report which outlined the current and future 'headroom' likely in the generation market in Australia. The AEMO analysis is very timely in that it provides a summary of the future market post announced generating plant closures. In NSW this sees 2,171 MW of generation capacity being closed over the next 10 years. We observe though that the AEMO analysis excludes a large amount of possible new generation plants being introduced into the NEM – this is by no means a criticism of the AEMO analysis merely that the AEMO data is taking a conservative view on new plant construction. The ESOO outlines that approximately 41GW of additional capacity is being considered by project proponents across the NEM. We do expect some of this generation capacity to come online next decade as the generation market tightens across the country as more fossil fuel base load plants are retired from service. From our analysis we see that NSW has excess generation capacity that will support the proposed SA interconnector until 2022. After that time there is likely to be some tightness in NSW generation without new generation being commissioned. We estimate that should 32% of the proposed generation capacity planned for NSW be commissioned that the NSW generation sector will remain in an overcapacity state until the middle of next decade. We anticipate that new plant being commissioned will be made up of smaller modular generation units to maximise flexibility as the NEM continues to transition during next decade.

1. Electricity Statement of Opportunities (August 2016), AEMO

Benefits and costs from a new interconnector from New South Wales to South Australia

Potential to ameliorate wholesale prices in SA

Development of an interconnector between NSW and SA assists with the utilisation of excess capacity in a region with low volatility and the lowest number of prices spikes and makes use of it in a region with high volatility and the highest number of price spikes. As a mechanism, interconnectors allow a greater equilibrium of market conditions and improve the capability of supply to meet demand.

Our initial analysis suggests that an interconnector between NSW and SA would result in a substantial reduction of negative market characteristics that drive increased price in South Australia. This ultimately translates into a substantial reduction in overall electricity costs for SA. As this additional capacity is sourced from a State with excess capacity, low volatility and the lowest number of price spikes it results in a far lesser impact on the NSW wholesale price.

Our initial analysis suggests an estimated overall reduction in the South Australian average half-hourly electricity price of $16.75 per MWh and a slight increase to the New South Wales average half-hourly electricity price of $1.06 per MWh.

Modelling has been performed based on a number of assumptions and considerations (i.e. aggregations and averaging of pricing information). Our analysis has not taken into account any of the benefits of potential interconnector flows from SA to NSW. We anticipate that the cost impact on NSW is at the conservative end of the spectrum as we have assumed that all supply exported from NSW to SA is at marginally higher prices than would have occurred historically. Should excess capacity be available at lower prices the cost to NSW may be reduced further.

Economic benefits from construction of the proposed interconnector

The potential economic benefits of the interconnector from NSW to SA are numerous. The factors of underutilised generation assets in NSW, unserved energy demand in SA and the diverging wholesale prices between the two state each alone suggest there are economic efficiencies from increased trade. If the interconnector also avoids the need for further generation or network expansion in SA, improves reliability and security of supply in SA and the NEM, and increases utilisation of SA's wind power potentially affecting CO^2 emissions across the NEM, then there are further economic benefits to consider.

In the interim, our initial analysis estimates the immediate economic effects of investment in the NSW and SA transmission networks. Within the context of an economic model that does not include assumptions about the above potential efficiency gains, we estimate the additional investment in the network will lead to SA's Gross State Product ('GSP') being **at least** $190 million higher and Australia's Gross Domestic Product ('GDP') to be **at least** $310 million higher (in present value terms over a ten year period).

The actual impact on the electricity market, SA and Australia more broadly is expected to be significantly higher than these initial estimates. Currently, the results only project out 10 years and hence the present value has not taken into account longer term benefits, nor have longer term productivity gains and investment gains been taken into account. Moreover, the analysis undertaken has yet to consider the current market structure in NSW (excess supply) and SA (excess demand) to assess the impact of a wider, more robust electricity market across Australia. Further work is therefore recommended.

Emerging energy sector trends

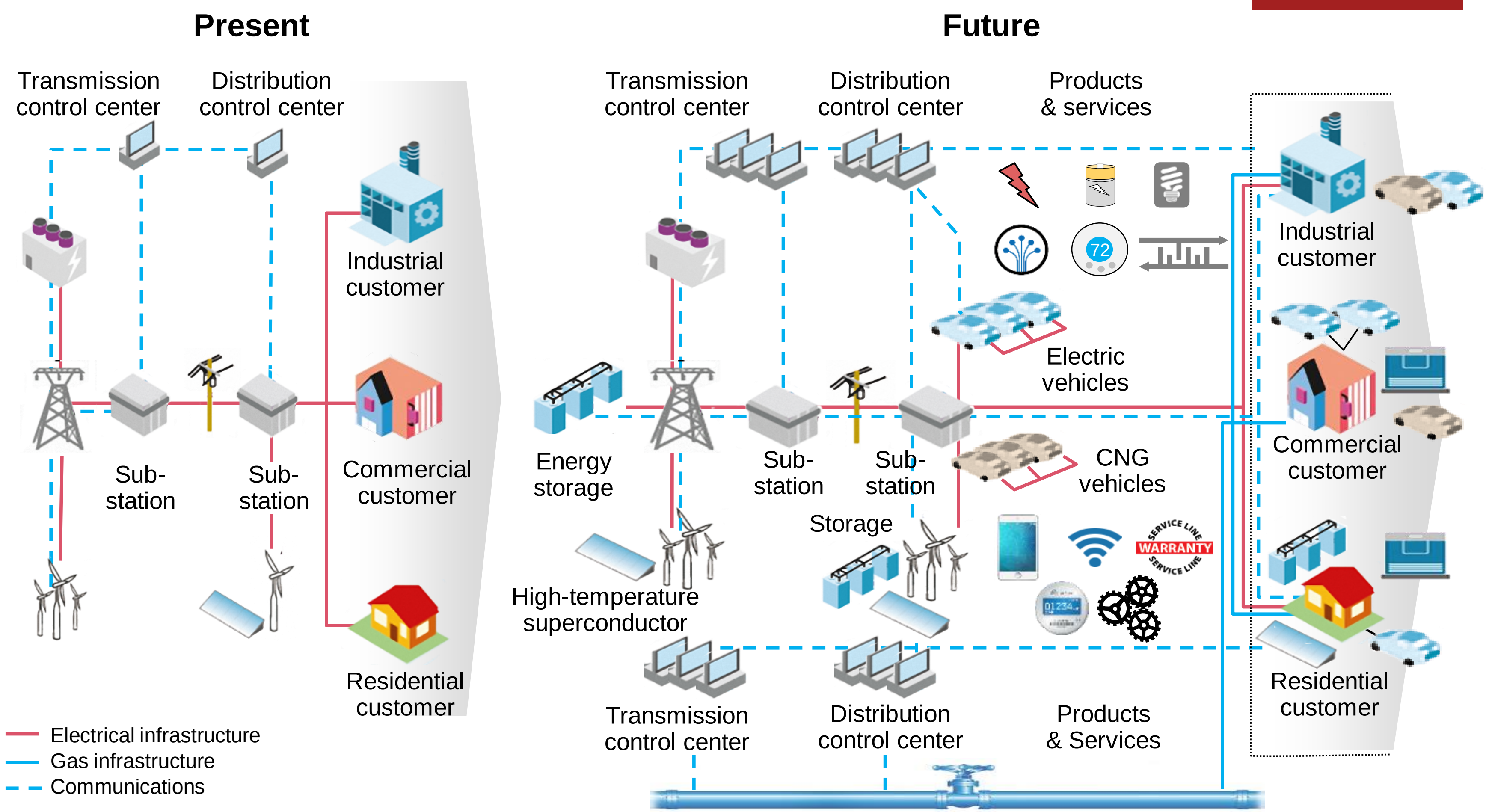
An interconnected network is likely to be a key part of the future customer-centric electricity market

As we look to the future and consider investments such as the proposed NSW to SA interconnector it is useful to reflect first on whether technologies and the emerging future shape of the energy market will lead to stranded asset risk. In short it is impossible to pick winners as we look to the future. Our expectation is that in the long term there will be increased value to asset owners from services that are beginning to emerge, for example, frequency control services and other ancillary services. We expect increased usage of renewables and that centralised generation will be utilising a more modular asset set which will be more market agile. We (and AEMO) see that distributed generation will continue to impact the market and reduce demand and in time with the use of storage (both utility scale and small scale) will have a real impact on energy flows and peak demand.

	Today	Intermediate Term	Longer Term
Business model	**Traditional Utility Model**	**Value-added Model**	**Energy Enabler Model**
Business model characteristics	• Electricity as a commodity • Supply-driven system • Competition: Price-fighters, pure-play green energy retailers	• Value-add services – solar PV installation, EV charging, visualization • HVAC & EV-based flexibility • Competition: Innovative service offerings	• Platform-based balancing and demand response services • Behind-the-meter data becomes a key asset • Competition: Innovative contracts, real time pricing, platform offerings, cross-bundling
Customer typology	**Traditional customer**	**Connected consumer**	**Prosumer**
	• Commodity market • Intense competition • Low barriers for switching	• Customers sensitive to technology adoption • Significant investment in new services	• Customer in control - negotiating power increases significantly • Disruptors entering the market • Customer trust becomes a competitive factor
Why customer centricity is key	*Customer focused on cost and reliability – commodity centricity*	*Customer alignment required to maximize RoI and lock-in*	*Customer centricity and agility are key to staying relevant*

The interconnected network is rapidly evolving to a distributed and digital micro-network that more directly engages customers …

ILLUSTRATIVE



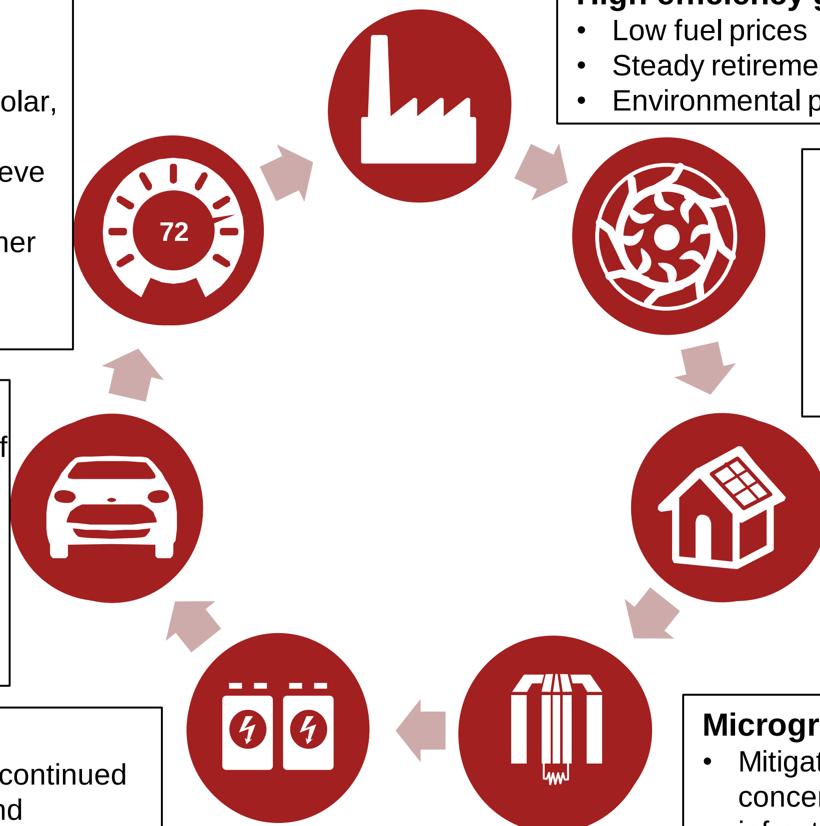
Sources: IEA; Strategy& analysis

Several innovative technologies, with unique growth drivers, have the potential to disrupt the electricity value chain

NOT EXHAUSTIVE

Behind the meter energy services
- Integration requirements of solar, EV, and storage
- Improved automation to achieve energy efficiency savings
- New entrants looking to partner with utilities and consolidate offerings

High efficiency gas turbines
- Low fuel prices
- Steady retirement of coal plants
- Environmental policy pressures



Small modular reactors
- Reduced capital needs compared to ‘big-box’ nuclear
- More flexible production profile to match load
- Potential path to decarbonization

Distributed generation
- Falling component, soft, and financing costs
- Cost savings vs. retail electricity rates in more markets

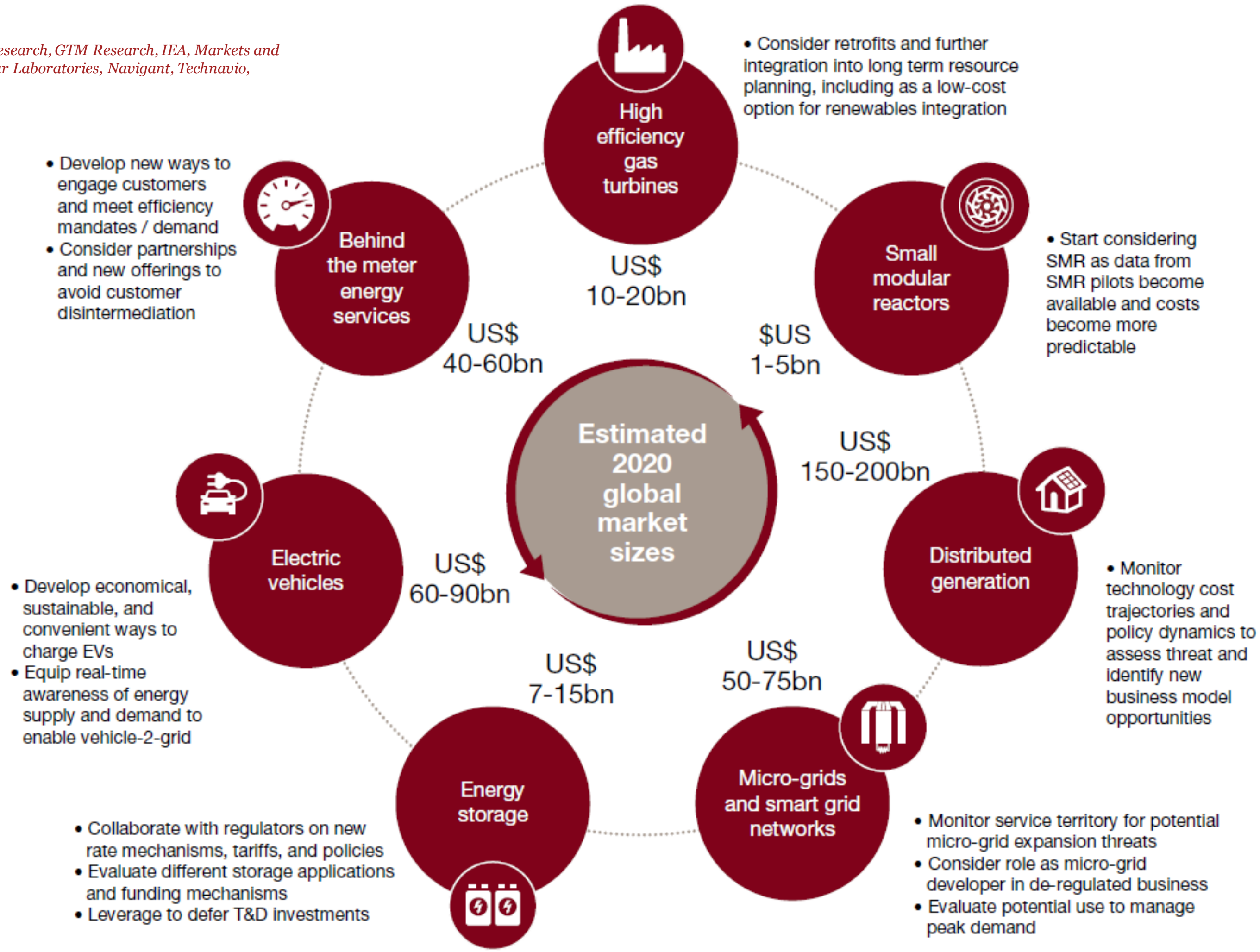
Microgrids and networks
- Mitigation of outage risks on large concentrated load or critical infrastructure
- Initial uptake in university, military, and corporate campuses

Energy storage
- Rapid reduction in cost – continued innovation in chemistry and applications
- Evolving tariff structures, gov’t mandates, and incentives supporting market

Electric vehicles
- Increased number / variety of electric vehicles with improved range and performance
- Cost declines, gov’t mandates / incentives, and charging station penetration

Utilities will need to adapt specific approaches to each new technology…

Sources: Allied market research, GTM Research, IEA, Markets and Markets, National Nuclear Laboratories, Navigant, Technavio, Strategy& analysis

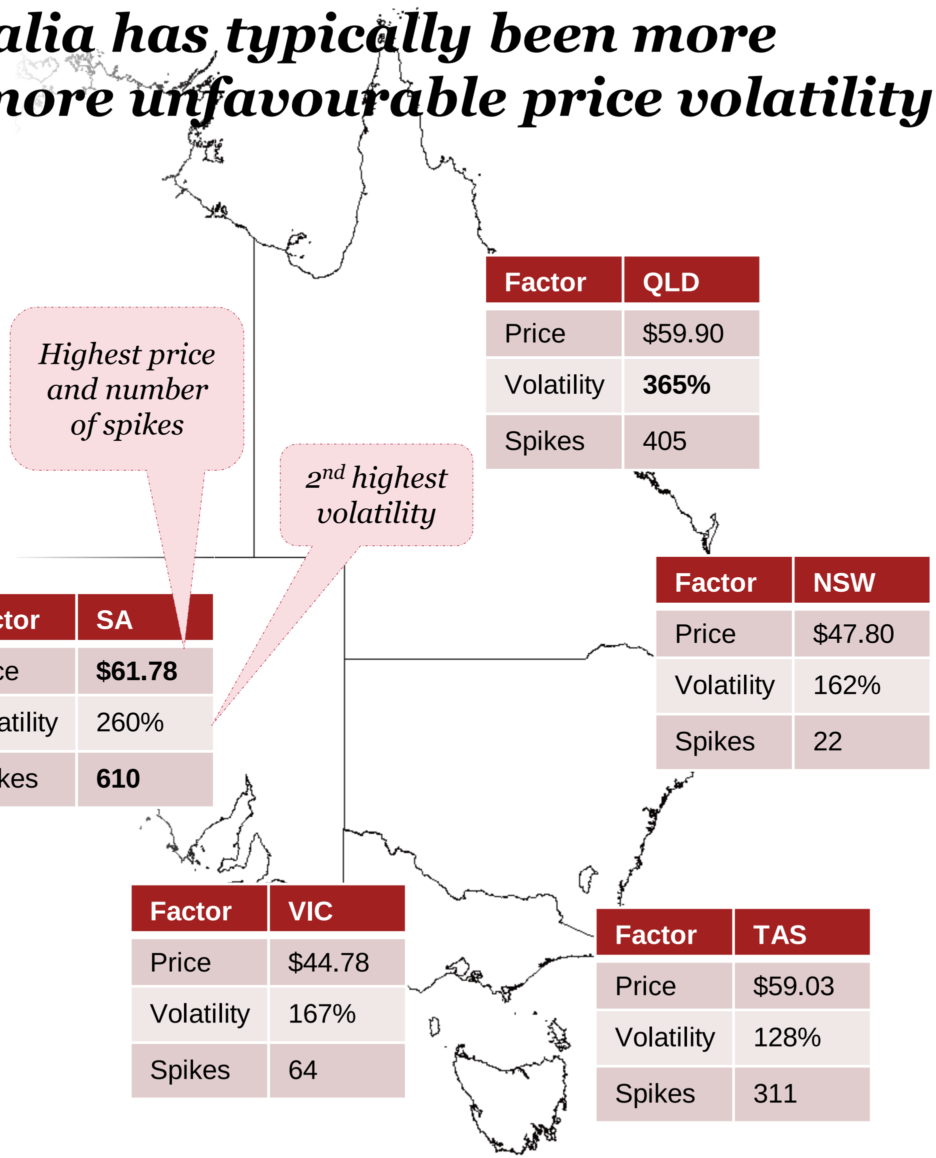


Analysis of the impacts on the electricity market

Electricity in South Australia has typically been more expensive and subject to more unfavourable price volatility

Over the period from January 2013 to August 2016 South Australia, on average, has had the most expensive wholesale price of electricity in the NEM. It has also has the highest number of price 'spikes' ' (defined here as half-hourly wholesale prices of greater than $300 per MWh) over that period. When these factors are combined with high price volatility it is apparent that there are some major price challenges in SA. We have estimated that the cost of these 'spikes' to the SA economy over the past 3.5 years is approximately $489m. We have assessed this through analysis of half hourly market data and calculating the cost of these spike events as the difference between the actual price for each event and $300 per MWh. We acknowledge that this is an estimate only. We have excluded the effects of hedging which may have been in place within the trading books of generators/retailers.

We observe that price volatility is higher in Queensland than in South Australia but that this has not produced a higher number of spikes or a higher average price.



Factor	QLD
Price	$59.90
Volatility	**365%**
Spikes	405

Factor	SA
Price	**$61.78**
Volatility	260%
Spikes	**610**

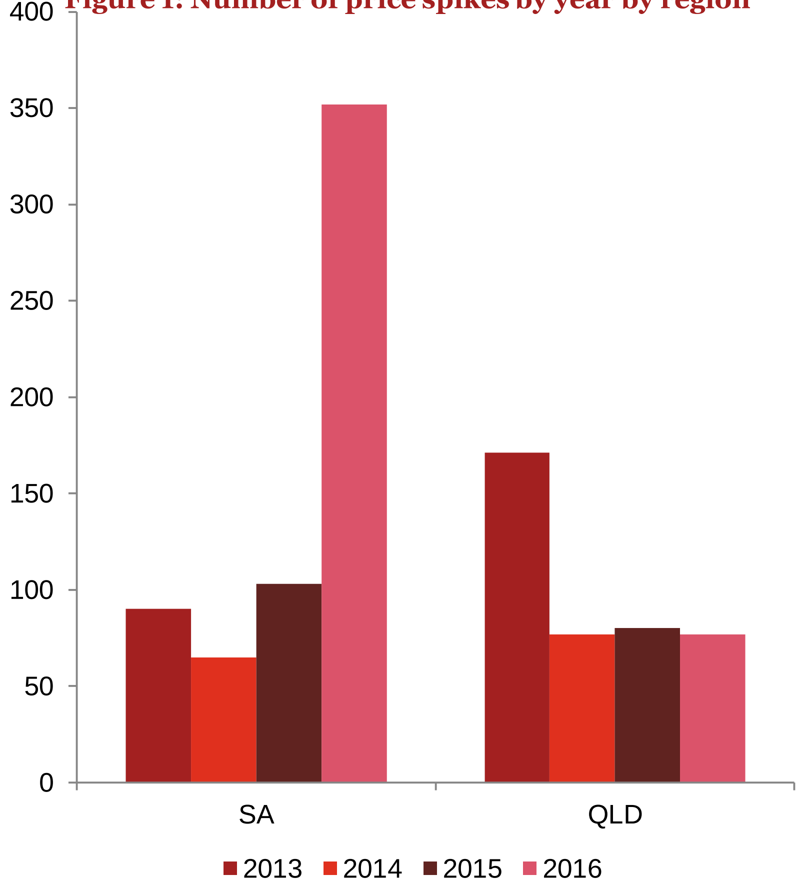
Factor	NSW
Price	$47.80
Volatility	162%
Spikes	22

Factor	VIC
Price	$44.78
Volatility	167%
Spikes	64

Factor	TAS
Price	$59.03
Volatility	128%
Spikes	311

South Australia has seen increased volatility and an increased number of price spikes since 2013

Figure 1: Number of price spikes by year by region



Price spikes and volatility

Volatility is measured here as the standard deviation of half hourly prices and presented as a percentage of average prices. The higher the volatility the more likely pricing outcomes are going to be removed from the average price. We observe that excessive volatility can be just as detrimental to the overall cost of electricity to consumers as underlying standard high prices given the risk coverage that needs to be built into customer price offers.

As mentioned previously, we have assumed that price spike events are those half-hourly prices that exceed $300 per MWh. We have utilised this price as a benchmark based on a common hedging instrument designed to limit exposure to price spike events. This instrument is a cap struck at $300 per MWh. With the $300 cap being the most liquid cap instrument and $300 per MWh as the generally accepted minimum definition of a price spike in many electricity risk modelling analytics, this definition is consistent with market convention.

As can be seen from the chart, SA typically has more price spikes in any given year (with the exception of 2014) than Queensland. We have compared South Australia to Queensland for this analysis as it is the other most price-risk exposed State in the NEM.

Higher average prices, high volatility and the greatest number of price spikes in the NEM all contribute to South Australia being a more expensive region to purchase and retail electricity. Factors potentially contributing to this are discussed on the following page.

SA average daily electricity prices are trending upwards more quickly than NSW while also exhibiting an increase in price spikes

The last year has seen electricity prices in South Australia trend upward

The figure to the right shows the last year of daily electricity prices for both SA and NSW. Both States show an upward trend in the price of electricity. SA however shows a far steeper increase in average prices. While this is only a single year and too narrow to draw long-term conclusions from it is notable.

Contributing factors

AEMO notes that "the withdrawal of the Northern Power Station (546MW) in May 2016 has increased South Australia's reliance on imports of energy and support services from Victoria during high demand periods"[2]. We hypothesise that the withdrawal of Northern has impacted wholesale prices in SA unfavourably.

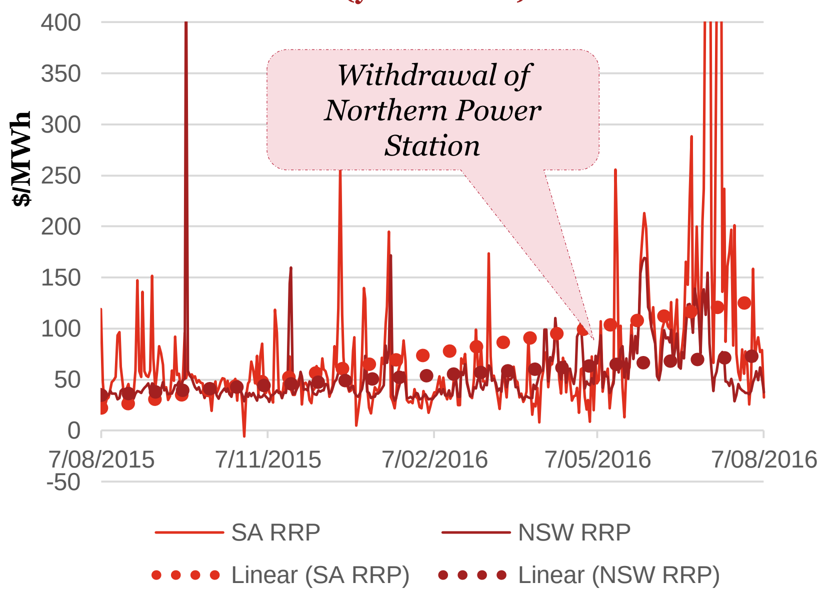
There is also a major price effect from numerous outages of the Heywood interconnector over the year. We note that this interconnector is close to completing a capacity uplift project which will expand its capacity. We would expect this capacity uplift to ameliorate some of the recent price volatility in SA but it is not going to be sufficient to completely offset recent capacity withdrawals. We estimate that the price spikes associated with multiple Heywood outages in 5 days in early July cost over $50m.

The loss of Northern, Playford B and other scheduled generation and greater reliance on non-scheduled (i.e. renewable) generation in SA is a possible case study in how markets will transition.

2. Electricity Statement of Opportunities (August 2016), AEMO

All these factors have reduced control over supply and reduced diversity of generation (by fuel type, and scheduled vs. non-scheduled) in the South Australian electricity market, making it far more susceptible to shocks from individual events. Further to this point, with gas now as the only schedulable plant within the market there is an increased likelihood of convergence between the South Australian electricity price and gas prices.

Figure 2: SA vs. NSW daily electricity prices and trends (year to date)



NSW has excess capacity presently which will continue for the next decade provided some new generation is built post closure of Liddell

Historic excess capacity in the New South Wales market would have been sufficient to support the additional 650MW demand of the proposed interconnector

We performed an analysis over actual availability from January 2013 to August 2016 running a number of different scenarios. As part of this analysis we included interconnector flows and actual historical generation from non-scheduled plant. Our analysis focused on half-hourly instances where if an additional 650MW of demand were added to existing New South Wales demand there would be a resultant shortfall in supply, defined by AEMO as Unserved Energy ('USE').

Scenario 1:

- Historic capacity
- An additional 650MW of demand

As a baseline we performed a simple scenario where an additional 650MW of demand was added to historic demand and compared with historic capacity. Analysis revealed that over this period of time, had an additional 650MW of demand been present in the New South Wales market that there would have been only 2 single half-hours of USE in the entire period back to January 2013.

As the analysis suggests this is with the assumption that at all half hours the interconnector was exporting at full capacity which is almost certainly conservative.

Scenario 2:

- Historic capacity
- Announced withdrawals
- Comparative interconnector flows
- Additional non-scheduled capacity from proposed generation

In the ESOO, AEMO detailed announced withdrawals of capacity and proposed developments of new capacity into the future by fuel type. While all these figures refer to forecast future changes to the level of capacity in New South Wales it is useful to understand, based on a historic period, what impact these adjustments could have had on excess capacity had they been enacted prior to our analysis period.

In this scenario we have used historic capacity as described previously and reduced this amount for the 2,171MW of announced capacity withdrawals. We have then taken historic interconnector flows on the Heywood interconnector and assumed that the proposed interconnector would have similar flows scaled for capacity. We have then assumed that 100% of proposed scheduled capacity is installed and only 50% of proposed non-scheduled capacity is installed. For actual generation production of non-scheduled capacity we have assumed generation levels consistent with historic generation levels from installed non-scheduled capacity.

Under the above conditions this would have resulted in 0.62% of total annual half hours or 108 half-hour periods where USE would have occurred each year.

NSW has excess capacity presently which will continue for the next decade provided some new generation is built post closure of Liddell

Under certain scenarios New South Wales will continue to have excess capacity into the future

The previous analysis used historic actual demand and capacity adjusting for some known factors (such as announced withdrawals). The purpose of this analysis was to capture historic factors that are unable to be forecasted with any accuracy (i.e. half-hourly profiles, half-hourly non-scheduled generation). It does not take into account estimates of future demand.

Additional analysis has been performed to better understand what changes to the market would be required for New South Wales to continue to have excess capacity into the future. This analysis has been performed using AEMO forecasts contained within the ESOO.

Using forecast demand and announced withdrawals from the New South Wales market based on AEMO data it is not anticipated that the addition of 650MW of demand would result in USE in New South Wales prior to 2022.

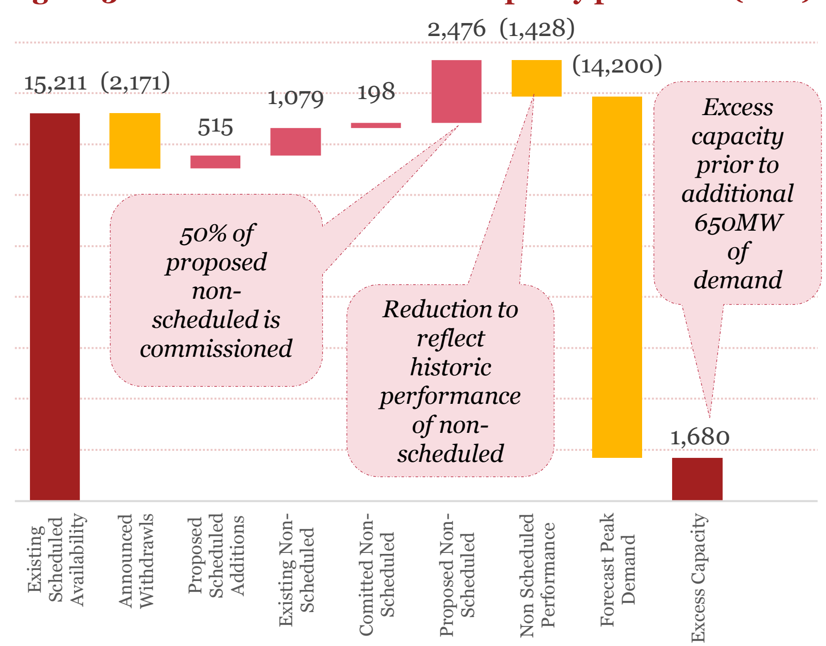
The figure to the right demonstrates that under certain assumptions, 1,030MW (1680MW of excess capacity less 650MW of additional demand) of excess capacity could still remain with an additional 650MW of demand introduced into the New South Wales market. The assumptions implicit in this scenario include:

- All accounted withdrawals are executed on time
- All proposed scheduled proposed capacity is installed
- 50% of proposed non-scheduled capacity is installed and generates at levels consistent with historic periods when peak demand occurs

We have assumed that all proposed scheduled capacity will be necessary to meet security requirements and that proposed non-scheduled capacity has an equal chance of installation.

With all previous assumptions holding; a minimum of 32% of proposed non-scheduled projects must succeed to ensure no instances of USE would occur prior to the limits of AEMO's current forecast. Analysis has not been performed past current AEMO forecasts.

Figure 3: New South Wales excess capacity post 2021 (MW)



Range of market price benefits from an NSW to SA interconnector

There is a potential substantial market benefit to South Australia and the NEM with a NSW to SA interconnector

The provision of excess capacity in New South Wales, a region with low volatility and the lowest number of price spikes historically, to South Australia, a region with high volatility and the highest level of price spikes historically, could be an efficient mechanism for neutralising negative market characteristics such as higher prices. As this is provided from a region with excess capacity and a larger market this results in a substantial reduction in price and volatility in South Australia but has a far lesser impact on New South Wales. It is important to note that there will be a small cost increase to NSW reflected in slightly higher wholesale prices based on our modelling.

What does the analysis show?

We have modelled the market implications from an additional supply of lower cost electricity from New South Wales into the South Australian market. We have estimated the impact on both markets using historical data acknowledging however that future market behaviour will invariably result in different outcomes.

Our analysis suggests and estimates a reduction in wholesale South Australian electricity prices on average of approximately $16.75 per MWh and a slight increase to the wholesale cost of electricity in New South Wales of approximately of $1.06 per MWh on average. The slight increase in cost to New South Wales assumes that all additional electricity generated is sourced under existing market conditions. Should excess capacity be available at the same or lower price point this number could be reduced further.

What does this mean for consumers?

As electricity retailers fix a portion of their purchase prices in varying degrees out until the market allows (typically not substantially further than 3 years), it is anticipated that the full effect of this cost saving may not be felt by consumers until recontracting occurs in future periods. However given the time to complete approval processes and construction timelines for the interconnector we would expect to see wholesale price impacts relatively soon after commissioning.

Provided this reduction in cost is fully passed on to consumers we would estimate an annual reduction in electricity costs of approximately $106 for an average home in South Australia. Given market impacts this would see an annual increase of approximately $8 to New South Wales households. Again should excess capacity be available at the same or lower price point this cost impact could be reduced further.

How has the impact been modelled?

Analysis has been performed on publicly available electricity prices and data sourced predominately from AEMO. We have analysed the period from January 2013 to August 2016. At a high level, modelling involved using historical market behaviour to infer reasonable instances where the addition of 650MW of demand to the New South Wales market would impact price. Assuming that South Australia would have access to this 650MW at the adjusted price we calculated the likely effect during this historical period assuming that all other factors remained constant. Sensitivities around the likely effect of an additional 650MW of demand on the New South Wales price were assessed.

Limitation of the modelling approach

Model assumptions

A number of key assumptions have been made in the modelling undertaken as part of this report:

- The model has been built using historical data and therefore assumes historical demand and market behaviour
- Aggregate generation bid stacks (i.e. the price at which generators are willing to supply electricity) have been used. A completely granular level of supply price may yield different results.
- Adjustments to New South Wales pricing are calculated on a full 650MW of demand
- Only instances where a lesser price for electricity in New South Wales result in an export of electricity to South Australia have been considered
- No benefits from importing of electricity from South Australia have been considered
- Correlation and diversity of load from other interconnection points while implied in historical data has not been explicitly modelled
- Average figures have been used as an approximation of the likely outcomes

Security and diversity of supply and international parallels are supporting arguments for interconnection

Recent AEMO commentary on security and diversity in relation to South Australia

The recent AEMO ESOO report provides a few indications of the security and reliability of supply issues emerging across the NEM. The following captures a few direct quotes from the report.

"The withdrawal of Northern Power Station in May of 2016 has increased South Australia's reliance on import of energy and support service from Victoria during high demand periods" ESOO, AEMO, August 2016

"As the generation mix continues to evolve, there is a risk that [adequate frequency control facilities] will not be operating should an islanding event occur. This risk is highest in South Australia" ESOO, AEMO, August 2016

"In the rare event of the unexpected concurrent loss of both Heywood interconnector lines there is a high likelihood of a full regional blackout in South Australia" ESOO, AEMO, August 2016

The ESOO report also highlights that SA has been islanded from the rest of the NEM four times since 1999.

International parallels

Multiple reports have been written over the last 2 years on the topic of interconnection between UK and mainland Europe. We have considered key reports published by National Grid, Pöyry and EirGrid covering:

- Evidence that interconnectors are being used to take advantage of price differentials between markets
- Qualitative justifications for developing new interconnectors
- How the growth in renewables has impacted use of and decisions for new interconnectors

Price differentials - there is evidence to support price differentials between markets as a key driver of interconnector usage and investment. Commentary covers pure wholesale price arbitrage, differing demand shapes between markets and resultant price arbitrage and managing price volatility. Each of these themes are consistent with those in Australia.

Qualitative arguments supporting interconnector investment – these centre around security of supply, increasing competitiveness and facilitation of ancillary services such as frequency response and black start capability.

Growth in renewables – similar arguments are mounted in Europe and the UK on the need for interconnectors to help manage load from intermittent supply from renewables and to facilitate the growth of renewable energy. It is argued in the Pöyry report that across the EU interconnectors are necessary to lower the cost of decarbonisation overall, reduce curtailment and avoid additional capacity build in already oversupplied markets.

Analysis of economic impacts

Economic analysis of the interconnector investment

Scope of economic analysis

The previous section of this report analyses the impact of the interconnector on prices in the wholesale electricity market. This is important as it goes to the heart of the purpose of the interconnector and therefore the intended benefits. It is also important to consider the broader impacts across the economy. This essentially represents the economy in total after responding to the change (i.e. a general equilibrium analysis of the economy rather than a partial equilibrium analysis of the electricity market). The economic analysis that follows therefore complements that by estimating the net impact on the economy.

There are a number of impacts that could be considered in an economic analysis of an interconnector, mainly around the potential productivity gains to industry from lower prices and improved utilisation of assets already employed.

Given time constraints, this economic analysis has been limited to the immediate effects of the interconnector's construction as an injection of capital into both NSW and SA. For this reason, we focus on the 10 year period to 2025, which allows for an analysis of the short term impacts in constructing the interconnector with about five years of operational impacts.

Overall result

Over a ten year period to 2025, within the context of assumptions set out below, we estimate the additional investment in the network will lead to SA's Gross State Product being **at least** $190 million higher and Australia's Gross Domestic Product to be **at least** $310 million higher (in present value terms using a 7% discount rate). The impact on the electricity market, SA and Australia more broadly is expected to be significantly higher than these initial estimates once the current market structure in NSW (excess supply) and SA (excess demand) are taken into account and the longer term productivity gains are also considered.

Approach

We have analysed the shorter term impact of investment into the electricity supply networks of NSW and SA using a computable general equilibrium (CGE) model. A CGE model is a simplified representation of the complex nature of the economy based on ABS data and standard economic concepts. It is commonly applied by Australian governments to estimate the economic impacts of policies and projects on the whole economy rather than the sector directly affected by the 'shock'. This approach is detailed in the appendix.

Caveats

One important caveat of the modelling is that it assumes the starting point of the economy is in equilibrium. As has been explored above (pages 16-17), we know that the NSW electricity market is arguably oversupplied and, in certain times the SA market undersupplied. Ideally, we would have had the time to build these issues into the base case, but this was not possible in this initial analysis. For that reason, in the following pages we discuss the efficiency gains we might expect from the interconnector which would be explored in any subsequent extension of this analysis.

Construction and lower prices support higher GDP

The economic impacts of the interconnector investment results in a SA economy that is almost $50 million per year larger and a national economy $70 million larger per year (Figure 4).

Drivers of impacts

The estimated economic impacts are driven by two major effects. In the investment years, the largest gains are felt in the construction industry, reflective of increased construction activity in building the interconnector. Once constructed, we would expect that the increased GDP is predominantly driven by a price effect as an interconnector is expected to result in lower prices for electricity in the region which will be a net importer (SA) and increased prices in the region which is a net exporter (NSW). Essentially, the interconnector should encourage price convergence. Lower prices will benefit all downstream industries who are consumers of electricity, increasing their capacity for output and their demand for electricity supply. Given the caveats discussed above, the model assumes an equilibrium starting point for NSW and as such prices fall in NSW under this initial modelling estimate.

SA economic impacts

The impacts of construction activity are felt in SA in line with the $200 million investment over 2019 and 2020. From 2021 onwards SA is estimated to enjoy lower electricity prices and a sustained increase in output of both the electricity supply industry and key consuming industries.

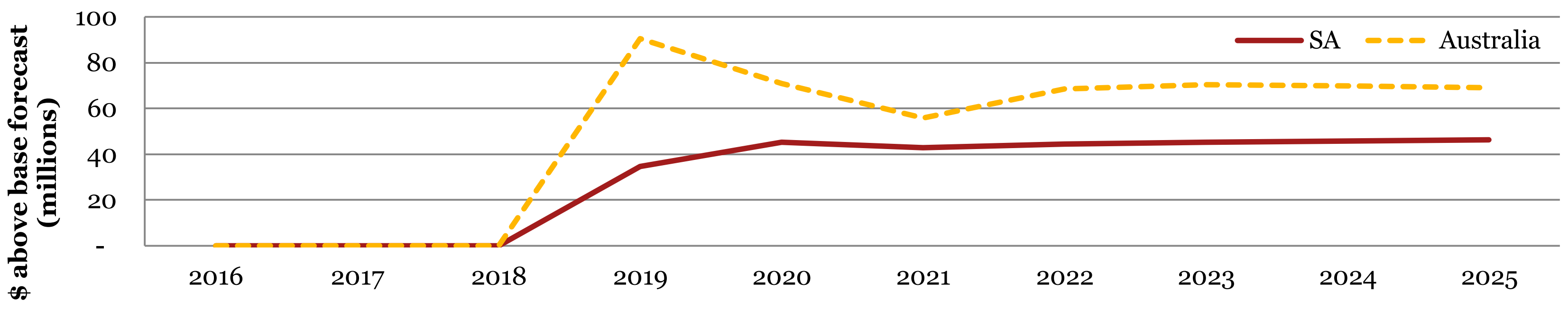
NSW economic impacts

The model applies a $300 million investment to the transmission network in NSW. GSP expands in 2019 and 2020 as a result of that construction effort. Once completed, (under the assumed starting point of equilibrium) the proposed investment is estimated to result in more downstream industries with capacity to capitalise on lower electricity prices.

National economic impacts

The net effect on the Australian economy follows the SA results which reflects additional gains from NSW on top of the SA gains, as well as some offsets from reductions compared to the baseline forecasts in other regions.

Figure 4: Net impact on GDP/GSP, Australia and SA (2016 dollars)



Next steps: analysis of potential productivity enhancing effects

Caveats to initial modelling

The results should be considered in light of the appropriate caveats. Most of these caveats flow from the assumptions taken in the modelling that the interconnector acts as additional capital in the electricity supply. Caveats that should be considered in interpreting these initial results include:

- It is assumed that prices move in response to capital availability, rather than in more nuanced inter-state interactions.
- A CGE model must by definition start in a state of equilibrium, although it is acknowledged that in reality there is an excess of electricity supply currently in NSW and excess demand in SA.
- The modelling assumes a downwards sloping international demand curve for Australia's exports, encouraging exports to increase when they are more price competitive on a global stage.
- The productivity gains through the interconnectedness between the two states (described below) are not captured in a pure capital increase.
- As the model does not incorporate a reduction in national consumption or changes to investment in other sectors, it is assumed that foreign capital inflow will fund the construction investment. It is also implied that the upfront foreign funding will be offset by lower future consumption. To the extent that transmission prices are allowed to increase enough to cover the return on and return of capital for the transmission network provider, this is reflective of lower future consumption.
- We have only considered the short term impacts out to 2025. The interconnector would be expected to have a useful life beyond this timeframe. Given our focus on the shorter term impacts of constructing the transmission line, we have not analysed the longer term impacts. This will be appropriate once the longer term productivity enhancing effects are considered.

Potential productivity enhancing effects of an interconnector

The general economic benefits of interconnection have been identified in past reports[3]. Many of these are relevant to the potential impacts of a NSW-SA interconnector which we would consider in subsequent analysis.

In general, the economic efficiency benefits of an interconnector can include:

- reduced degree of price separation between lower and higher priced regions and reduced overall price volatility
- increased competition between generators and retailers to the benefit of the consumers
- reduced capital and fixed operating and maintenance costs from the deferral of new investments in generation
- reduced capital costs from related network deferrals.

3 http://www.aemc.gov.au/getattachment/93c020d2-5f95-47fd-8b73-68e3ad6b4509/Attachment-1.aspx

Next steps: analysis of potential productivity enhancing effects

In addition to these benefits, which would largely accrue to SA in this context, there are broader benefits across the NEM:

- For the NSW generation market, which is currently oversupplied, there may be an efficiency gain from increased utilisation of existing generation assets.
- Greater security of supply across NEM regions through the provision of increased generation sources.
- With SA's larger share of electricity generation coming from renewable energy sources, an interconnector from NSW to SA may result in a change in fuel mix of generation dispatched into the NEM and so could have impacts on the carbon dioxide produced by the NEM.

Consideration of the experiences with interconnectors elsewhere

Interconnectors are in place in numerous electricity markets around the world. Considering the findings of economic impacts in other markets may indicate the impact of the interconnector on SA. For example, the Tasmanian interconnector with Victoria provides an example whereby a state that is largely dependent on renewable energy generation (hydroelectricity) gains security of supply. By building Basslink, Tasmania was able to secure its electricity supply in the face of drought-constrained energy shortages in the late 2000s; during the period 1 January 2007 to 31 December 2009 Tasmania imported 5,239.14 GWh through Basslink[4]. This is applicable to SA given the intermittency of wind as an energy source. Although in 2016 Basslink suffered an outage, the earlier experience provides some basis for considering the impacts on SA from an interconnector.

[4] http://www.basslink.com.au/basslink-interconnector/benefits-of-basslink/

Appendix

Appendix – Approach CGE modelling

Methodology

The economic impact assessment has been undertaken using a Computable Generated Equilibrium (CGE) model, specifically the Victoria University Regional Model (VURM) developed by the Centre of Policy Studies (CoPS) at Victoria University.

CGE modelling is a sophisticated, multi-variate computer-based model which measures the effect an investment or initiative has on the national, state/territory and/or regional economies. CGE models recognise that complex interactions occur and endeavour to replicate how the economy will behave given these complex interactions. PwC uses the models developed by the CoPS. These are preferred because they have been peer reviewed, meaning the inputs and assumptions are fully and publicly documented, providing greater modelling credibility. The Victoria University models have wide use in Australia by both government and the private sector.

The Victoria University Regional Model (VURM) is a multi-regional, dynamic CGE model. It distinguishes up to eight Australian regions (six States and two Territories) and up to 144 commodities/industries.

The model contains explicit representations of intra-regional, inter-regional and international trade flows based on regional input-output data developed at the Centre of Policy Studies (CoPS), and includes detailed data on state and Federal governments' budgets. As each region is modelled as a mini-economy, VURM is ideally suited to determining the impact of region-specific economic shocks. Second round effects are captured via the model's input-output linkages and account for economy-wide and international constraints.

Essentially, the model works by showing the impact on the equilibrium economy of certain ‘shocks’, or specific changes to inputs based on the nature of scenarios being explored.

Baseline assumptions

The baseline model of the economy used in the modelling for this analysis is based on long run projections of productivity, population and participation rates developed by PwC in our Intergenerational Fiscal and Economic Model (IFEM). This analysis is based on the most recent data on the Australian economy and is forecast using Australian Bureau of Statistics (ABS) population projections. The core projection is based on the ABS population projections – specifically, Series B of the ABS series 3222.0 ‘Population projections, Australia, 2012 to 2101’, which was released in November 2013. These have been updated by PwC to reflect actual population figures released since and so better reflect recent demographic trends.

Appendix – Approach CGE modelling

What we have modelled

Using input data for the proposed project provided by TransGrid in terms of construction, we have modelled a capital shock for the NSW-SA interconnector. The assumptions are as follows.

The construction of the NSW-SA interconnector will occur over a 18 month period.[1] Taking into account a 24 month planning period awaiting environmental and regulatory approvals as estimated by TransGrid, we assume the $500 million[2] investment will be apportioned equally from the beginning of 2019 to mid-2020. As discussed with TransGrid, an estimated 60 per cent of total costs will be attributable to activity in NSW with the remaining 40 per cent attributable to SA. We have modelled this in a dynamic CGE model of VURM.

The distribution of inputs for the interconnector costs (eg construction services and materials) leverages underlying assumptions within the CGE model and input-output database.

We assume the investment will be paid for by offsetting consumption. This is largely reflective of the regulated pricing regime in place for the transmission networks in the NEM.

Limitations

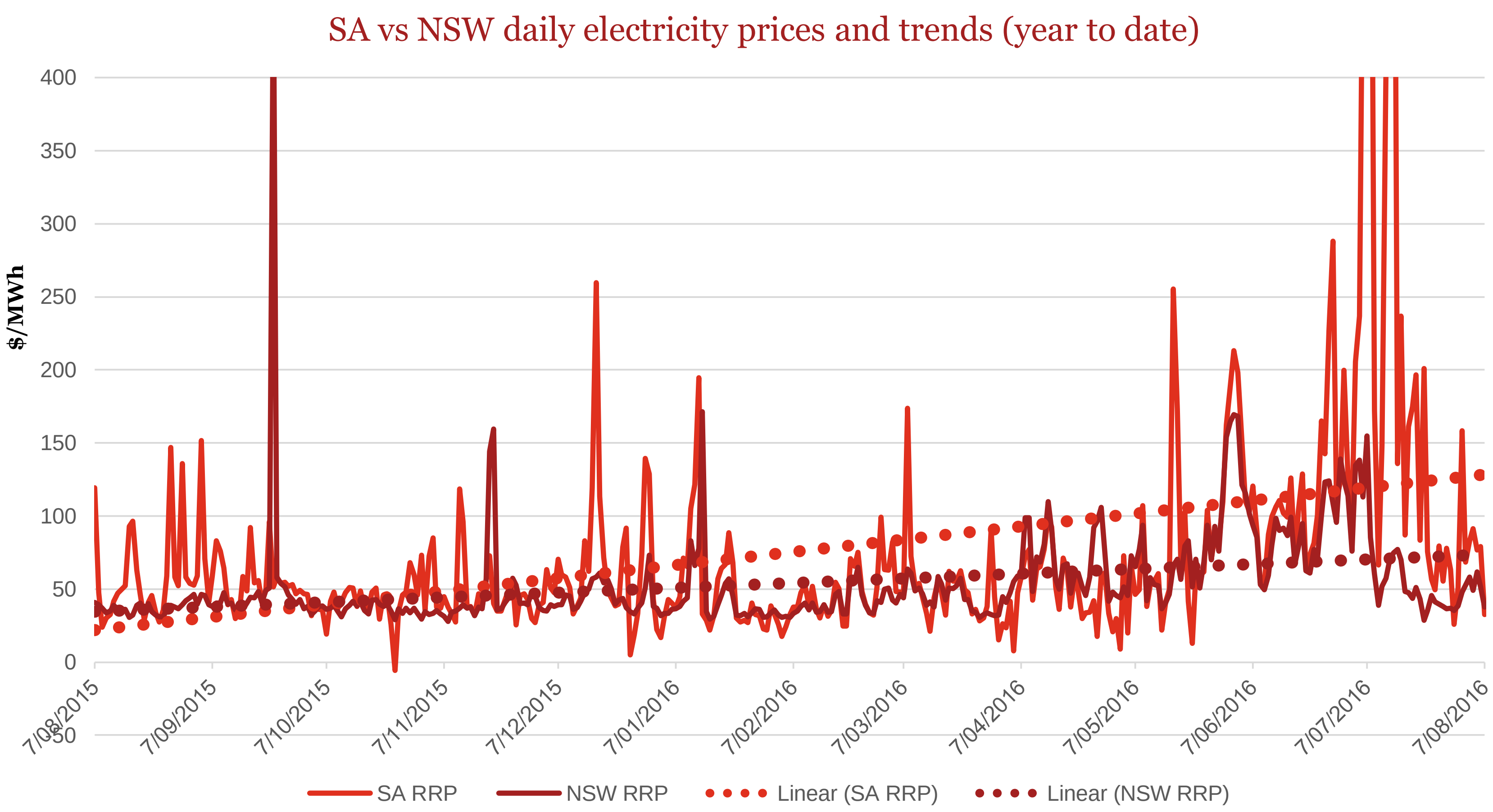
Estimates have been based upon initial high level analysis. In addition to the caveats described above on page 19, the CGE model's limitations include:

- assumed coefficients that have not been calculated based on econometric estimations
- it is assumed that the starting point of the economy is in equilibrium
- a lagged adjustment process in the labour market.

[1] http://www.afr.com/news/transgrid-backs-500m-nswsa-interconnector-to-ease-power-crisis-20160728-gqfms6

[2] ibid

Appendix – South Australia electricity prices have historically been higher and exhibit greater volatility than New South Wales prices



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