ACIL ALLEN CONSULTING

REPORT TO
ELECTRANET

11 FEBRUARY 2019

SOUTH AUSTRALIA NEW SOUTH WALES INTERCONNECTOR

UPDATED ANALYSIS OF POTENTIAL IMPACT ON ELECTRICITY PRICES AND ASSESSMENT OF BROADER ECONOMIC BENEFITS

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EXECUTIVE SUMMARY

ACIL Allen Consulting was engaged by ElectraNet to update preliminary estimates prepared in July 2018 of the impact a new interconnector between New South Wales and South Australia would have on wholesale electricity prices and, therefore, on retail electricity bills:

— for residential and small business customers
— in South Australia and New South Wales.

The update differs from the preliminary analysis only in respect of the input assumptions, which were modified to:

— align more closely with the Australian Energy Market Operator's (AEMO) Integrated System Plan[1]
— include the Redcliffs to Buronga line
— reflect other updates to ACIL Allen's standard assumption set.

The modelling was conducted using *PowerMark*, ACIL Allen's proprietary model of the National Electricity Market, wholesale spot market. and was based on updated assumptions which align broadly with the Australian Energy Market Operator's Integrated System Plan.

As with the preliminary analysis, the modelling indicates that the new interconnector is projected to place downward pressure on the wholesale spot price of electricity in both South Australia and New South Wales, though the extent of that pressure has now changed due to the different input assumptions.

[1] The ISP had not been published when the preliminary analysis was done.

Impact on retail electricity bills

The projected impact of the new interconnector on customers' electricity bills is consistent with the projected change in wholesale spot prices in both states across the forecast period as a result of the new interconnector. It is summarised in Figure ES 1 and Table ES 1.

FIGURE ES 1 PROJECTED RETAIL BILL IMPACT – NSW AND SA RESIDENTIAL AND SMALL BUSINESS CUSTOMERS

SOURCE: ACIL ALLEN CONSULTING

TABLE ES 1 PROJECTED RETAIL BILL IMPACT – NSW AND SA RESIDENTIAL AND SMALL BUSINESS CUSTOMERS

	Representative residential customer		Small business customer	
	SA	NSW	SA	NSW
Transmission network cost impact ($ /annum)[2]	9	5	18	12
Average saving in wholesale component of bill ($/annum)	$(75)	$(35)	$(151)	$(84)
Net bill saving ($/annum)	$(66)	$(30)	$(132)	$(71)
Annual consumption (kWh/annum)	5,000	4,215	10,000	10,000

SOURCE: ACIL ALLEN CONSULTING

As the figure and table show:

— residential and small business customers in South Australia are projected to experience a reduction in their electricity bills with the new interconnector

— the modelling indicates that, in nominal terms over the period to 2030, annual residential customer bills would reduce on average by $66 in South Australia and by $30 in New South Wales for a representative customer

— similarly, in the period to 2030, the modelling indicates that the annual retail bill of a representative small business customer would reduce on average by $132 in South Australia and $71 in New South Wales.

In all cases the projected impact on electricity bills is net of the cost of the interconnector itself. This cost is projected to be substantially outweighed by a reduction in wholesale electricity spot prices, with

[2] This reflects solely the additional network costs arising from the new interconnector (consistent with our July report). It does not include any additional network costs that could arise from the additional Buronga to Red Cliffs line.

the modelling indicating that the saving in energy costs will be around seven or eight times the cost of the interconnector on an annual basis in the period to 2030.

It was assumed to have bi-directional transfer capacity of 800 MW between New South Wales and South Australia with an aggregate transfer limit of 1,400 MW across the new interconnector and the existing Heywood interconnector. [3]

It was also assumed that an additional line is built between Buronga in New South Wales and Red Cliffs in Victoria, which we understand will increase transfer capacity between New South Wales and Victoria by 400 MW (and is modelled as such).

Economic impacts

In this update report, we were also asked to estimate the impact the new interconnector would have on affected economies due to:

— changes in wholesale, and therefore retail, electricity prices
— benefits accruing from construction of the interconnector.

These impacts were analysed in terms of their impact on:

— real economic output, commonly referred to as either Gross Domestic Product or Gross State Product
— real incomes, which is a measure of the welfare impact that changes in economic output has on people living in a region
— employment and real wages.

The analysis shows that, the changes in real economic output are broadly in line with the projected savings in electricity prices.

Over the longer term, in the period to 2040, the project is projected to increase the real income of:

— South Australia by a cumulative total of $4.4 billion relative to the Reference Case with a net present value of $2.4 billion, using a 7 per cent real discount rate
  – $163 million of the projected benefit occurs in the SA host regions primarily during the construction phase
— New South Wales by a cumulative total of $7.5 billion relative to the Reference Case with a net present value of $4.0 billion, using a 7 per cent real discount rate
  – $209 million of the projected benefit occurs in the NSW host regions primarily during the construction phase.

Impact on real income

The discounted present values are equivalent to a *one-off* increase in the average real income of all current residents of:

— South Australia by approximately $1,300 per person
— New South Wales by approximately $500 per person.

Further, the additional construction activity associated with the project has a noticeable effect on the economies of the host regions due to a movement of economic activity into these regions.

Impact on employment

Over the period 2021 to 2040, it is projected that approximately 18,800 employee years[4] of full time equivalent (FTE) direct and indirect jobs will be created. More specifically, it is projected that the Project will increase employment in:

[3] We note that these capacity assumptions approximate ElectraNet's current expectations, which are that the Heywood Interconnector would be able to transfer up to 750 MW and that the joint capacity cannot exceed 1,300 MW. The differences were necessary to account for interdependencies between the two interconnectors that are not reflected in our model, but do not materially impact on the outcomes of the analysis.

[4] An employee year is equivalent to the employment of 1 FTE person for one year. Alternatively, it can represent employment of, say, two full-time people for half a year each, or one 0.5 FTE person for two years.

— *South Australia* by 4,947 employee years (approximately 250 FTE jobs a year on an ongoing basis)
  – with 470 employee years in the South Australian host regions during the 2-year construction phase, 400 of which will be directly employed through ElectraNet (equivalent to over 200 jobs a year during the construction phase)
— *New South Wales* by 13,841 employee years (approximately 700 FTE jobs a year on an ongoing basis)
  – with 1,650 employee years in the New South Wales host regions during the 2-year construction phase, 1,100 of which will be directly employed through TransGrid (equivalent to over 800 jobs a year during the construction phase).
— Real wages in South Australia and New South Wales are projected to increase by an average of 0.12 and 0.06 per cent respectively relative to the Reference Case. Given the size of the labour market, this is a significant increase generated by the interconnector project.

  We also note that there may be further benefits to South Australia and New South Wales accruing from construction of renewable energy projects given the opportunity to connect to the grid by the interconnector. However, we have not attempted to model those additional benefits here.

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1 INTRODUCTION

ElectraNet is the electricity Transmission Network Service Provider (TNSP) in South Australia.

ACIL Allen Consulting (ACIL Allen) was engaged by ElectraNet to provide updated modelling of the potential impact of a proposed the new interconnector between South Australia and New South Wales (new interconnector). Specifically, ACIL Allen was engaged to update preliminary modelling we conducted in July 2018 in which we project the impact the new interconnector would have on wholesale electricity spot prices in South Australia and New South Wales and, therefore, on customers' electricity bills in those states.

In undertaking this updated analysis we were also asked to estimate the broader impact the new interconnector would have on the economies of South Australia, New South Wales and the parts of those two States that will 'host' the new interconnector. Those economies would be impacted by:

— changes in wholesale, and therefore retail, electricity prices
— benefits accruing from construction of the interconnector.

They would also potentially benefit from construction of renewable energy projects given the opportunity to connect to the grid by the interconnector. However, this has not been modelled.

This report provides summary results of our analysis. The rest of this report is structured as follows:

— chapter 2 describes the methodology we used to model the potential impact of the new interconnector on electricity prices, both wholesale and retail, which centred around *PowerMark*, our proprietary model of the National Electricity Market (NEM) wholesale electricity market
— chapter 3 provides the results from our electricity market and retail modelling
— chapter 4 describes the methodology used to estimate the economic impact the interconnector would have
— chapter 5 summarises the results of the economic modelling.

2

METHODOLOGY

We have modelled the impact of the new interconnector on customers' electricity bills by considering the net impact of the new interconnector on the:

— wholesale electricity spot prices in South Australia and New South Wales

— the transmission network costs associated with the new interconnector.

The methodology for modelling the wholesale electricity market is discussed in section 2.1. The transmission network cost estimates were provided by ElectraNet.

The way these were brought together to produce estimates of bill impacts is discussed in section 2.2

2.1 Modelling the wholesale electricity market

The impact of the new interconnector on wholesale electricity spot prices was assessed using *PowerMark*, ACIL Allen's proprietary model of the NEM's wholesale electricity market.

At its core, *PowerMark* is a simulator that emulates the settlements mechanism of the NEM. *PowerMark* uses a linear program to settle the market, as does the Australian Energy Market Operator's (AEMO) NEM Dispatch Engine in its real time settlement process. *PowerMark* is part of an integrated suite of models, including models of the market for Renewable Energy Certificates and the wholesale gas market.

A distinctive feature of *PowerMark* is its iteration of generator bidding. *PowerMark* constructs an authentic set of initial offer curves for each unit of generating plant prior to matching demand and determining dispatch through the market clearing rules. Unlike many other models, *PowerMark* encompasses re-bids to allow each major thermal generation portfolio in turn to seek to improve its position — normally to maximise uncontracted revenue, given the specified demand and supply balance for the hourly period in question.

PowerMark has been developed over the past 17 years in parallel with the development of the NEM, NEMS (Singapore) and WESM (Philippines). We use the model extensively in simulations and sensitivity analyses conducted on behalf of industry and Government clients.

PowerMark routinely operates at *hourly* price resolution, unlike the NEM spot market which is settled on a half hourly basis. Half hourly modelling is possible, but our experience is that hourly modelling has very little impact on the outcomes, but simplifies the model run time and analytical task substantially.

PowerMark relies on a range of assumptions, which are set out in section 2.1.1.

The scenarios modelled are discussed in section 2.1.2.

2.1.1 Assumptions

PowerMark is based on a large number of detailed input assumptions. For the most part these are drawn from our understanding of the physical and other properties of generators in the NEM and other relevant sources. ACIL Allen's standard September 2018 reference case assumption set was adjusted for this exercise in two ways to better align with AEMO's Integrated System Plan (ISP):

— demand: aluminium smelters assumed to remain operational throughout the projection period, as per AEMO's 2018 Electricity Statement of Opportunities (ESOO) forecast

— emission abatement policy: assume the emissions trajectory from AEMO's "28% to 70% Emissions Reduction Target" scenario in the ISP.

Wholesale spot price impacts are presented to 2030. Beyond this period, modelling results become limited by the veracity of the assumptions that underpin them. The further into the future assumptions are made, the greater the risk that they are in error.

The key assumptions upon which the modelling is based are set out in Table 2.1.

TABLE 2.1 KEY ASSUMPTIONS

Item	Summary of assumption	Rationale
Macro-economic variables	– exchange rate of AUD to USD converging to 0.75 AUD/USD – inflation of 2.5% p.a.	– long term average – mid-point of RBA range
Greenhouse gas (GHG) emissions abatement policies	– assume an emissions pathway in line with AEMO's 2018 ISP "28% to 70% Emissions Reduction Target" – no emissions policy required to meet the implied carbon budget in FY2021-30 period – assume an Emissions Intensity Scheme from 1 July 2031 as a proxy for future carbon pricing in some form to achieve AEMO's ISP emissions trajectory – retention of the Large-scale Renewable Energy Target (LRET) in its current form with its current expiry date.	
	– no ongoing implementation of state based renewable energy schemes in Victoria and Queensland, beyond Victoria's reverse auction for renewable energy as announced in September 2018 and Queensland's "Renewables 400" reverse auction in 2017-18	– State-based schemes are likely to be absorbed if an effective national scheme is developed
Electricity demand	– AEMO 2018 ESOO Neutral POE50 forecast, with adjustments for ACIL Allen's projections of PV, storage uptake and electric vehicle uptake	– ACIL Allen projections used for internal consistency with assumed costs (e.g. macro-economic variables)

Item	Summary of assumption	Rationale
Supply side assumption	– named new entrant projects are included in the modelling where there is a high degree of certainty that these will go ahead (i.e. project has reached the Financial Investment Decision stage) – inclusion of third Queensland portfolio CleanCo from 1 July 2019 – does not include proposed 1,000 MW of additional capacity – 600 MW of "corporate PPA" across Queensland, New South Wales and Victoria – beyond this, only generic new entrants which we project to be commercial are introduced – committed or likely committed generator retirements included where the retirement has been announced by the participant (i.e. Liddell) – retirements of other existing generators where we project the generator to be unprofitable over an extended period of time – Snowy 2.0 not included.	– The number of announced projects far exceeds the requirements of the electricity market and hence only those that are firmly committed to go ahead are included in the modelling – Corporate PPA reflects market developments – The assessment of generator profitability under the modelled scenario provides a consistent method to assess closure decisions
Gas a fuel for electricity generation	– gas market is modelled in ACIL Allen's *GasMark Australia* model – gas prices for power generation are projected to rise from $ 9-11/GJ to $ 10-12 per GJ by 2030.	– the combined demand for gas from Australia's domestic gas users and the LNG export industry means higher cost gas resources need to be developed and possibly even imported LNG to satisfy demands.

Coal as a fuel for electricity generation	– the marginal price of coal for electricity generation is assessed considering the specific circumstances for each generator including:
	  – short term supply issues in New South Wales
	  – suitability of coal for export and the assumed international thermal coal price
	  – location of power station in relation to the mine and export terminals
	  – mining costs
	  – existing contractual arrangements
	– international thermal coal prices are assumed to converge to USD 60/t in the long term
		– International thermal coal prices are assumed to converge to their long term average price

Representation of bidding behaviour	– contracted capacity:
	  – minimum generation levels are offered at negative of zero price
	  – remaining contracted capacity offered at short run marginal cost
	– remaining capacity:
	  – maximisation of dispatch for price takers
	  – maximisation of net uncontracted revenue for price makers.
		– Observations of generator bidding behaviour in the NEM

Item	Summary of assumption	Rationale

New entrant capital costs
(AUD /kw, real 2018)
	– wind
	  – $ 2,000/kW in 2019
	  – $ 1,650/kW in 2030
	– solar (Single Axis Tracking)
	  – $ 1,470/kW in 2019
	  – $ 1,050/kW in 2030
	– storage (with four hours)
	  – $ 1,650/kW in 2019
	  – $ 950/kW in 2030
		– Near-term prices based on observations in the market from actual projects
		– Long-term projection based on an average of long-term projections by various forecasters for new technologies

SOURCE: ACIL ALLEN

2.1.2 Scenarios analysed

The analysis presented in this report comprises two scenarios:

— a *reference case* based on assumptions described above
— a *new interconnector* scenario.

For the purposes of this analysis, the new interconnector scenario is the same as the reference case with the exceptions that the new interconnector is introduced to the model from 1 July 2023 along with a small line that would connect Buronga in New South Wales with Red Cliffs in Victoria. It is also noted that early works underwritten by the South Australian Government are being undertaken to allow for delivery earlier than this.

For the purposes of this analysis, the new interconnector was assumed to have the following properties:

— transfer capacity of 800 MW in either direction
— Heywood interconnector limited to thermal capacity of 600 MW when the new interconnector is in place
— aggregate transfer limit of 1,400 MW across the new interconnector and the existing Heywood interconnector
— The Buronga to Red Cliffs line was assumed to increase transfer capacity between New South Wales and Victoria by 400 MW.

We note that these capacity assumptions only approximate ElectraNet's current expectations, which are that the Heywood Interconnector would be able to transfer up to 750 MW but that the joint capacity cannot exceed 1,300 MW. We made these adjustments to reflect the fact that in the model these two interconnectors are independent whereas in reality there are relationships between them. Our analysis indicates that these adjustments have had little or no material impact on the final results. Importantly in the modelling, the Heywood interconnector was very rarely 'constrained' by our lower capacity assumption.

We also note that updated loss factors are not yet available for the new interconnector. The modelling is based on the assumption that electrical losses on the new interconnector will be the same as those on the Heywood interconnector, relative to the different capacity of the interconnectors.

2.2 Modelling the impact on customers' electricity bills

We have modelled the impact of the new interconnector on residential and small business customers in South Australia and New South Wales.

We have assumed a representative residential customer consumes 5,000 kWh per annum in South Australia and 4,215 kWh per annum in New South Wales, consistent with assumptions made by the Australian Energy Market Commission in its 2017 electricity residential price trends report.

We have assumed a representative small business customer consumes 10,000 kWh per annum in South Australia, which is consistent with the approach the Essential Services Commission of South

Australia takes in its annual Energy Retail Offers Comparison Report.[5] We made the same usage assumption in New South Wales for ease of comparison.

The impact of the new interconnector on customers' electricity bills was assessed by considering the "building blocks" of retail electricity bills, namely:

— energy costs
— network costs
— retail operating costs and margin
— costs associated with environmental schemes

We have assumed that the new interconnector will impact on the:

— energy costs building block through the impact on the wholesale electricity market
— the network cost building block through ElectraNet's and TransGrid's recovery of the costs for building and operating the new interconnector.

The new interconnector is assumed to have no impact on the other building blocks, that is, the movement in the other costs will be the same under the reference case and with the new interconnector.

We note that changes in retail tariff structures and/ or the way customers use energy are quite possible over the timeframe. The former can be expected to flow from ongoing changes to the way distribution network services charge for the service they provide. Further changes in energy use at the residential level which may flow from improvements in energy efficiency, ongoing uptake of solar technology and the use of batteries could be expected. While we acknowledge that these changes might occur, we have not sought to incorporate them into the analysis, in part to allow comparison between our analysis and other presentations of retail bills, such as those in ESCOSA's Energy Retail Offers Comparison Report. Therefore, the indicative net impact on customer bills is presented in an aggregate form to 2030 in annual average terms.

The methodology for assessing the impact of the new interconnector on the wholesale electricity market was discussed in section 2.1.

ElectraNet provided estimates to us of the transmission network costs of building and operating the new interconnector.[6] Those estimates place the cost of the new interconnector at between $ 3.24 and $ 14.40 per customer per annum depending on their consumption and whether they are in South Australia or New South Wales.

This report presents the change in the customers' electricity bills rather than the level of the customers' electricity bills.

[5] https://www.escosa.sa.gov.au/news/energy-news/aug18-news-2018-e-rocr
[6] At this stage we have assumed that there will be no change in distribution network costs.

3 RESULTS

The results from the modelling are presented in this chapter. The results from the modelling of the wholesale electricity market are presented in section 3.1 and the projected changes in customers' electricity bills are presented in section 3.2.

All financial results in this section are in nominal terms (i.e. not adjusted for inflation).

3.1 Wholesale spot price

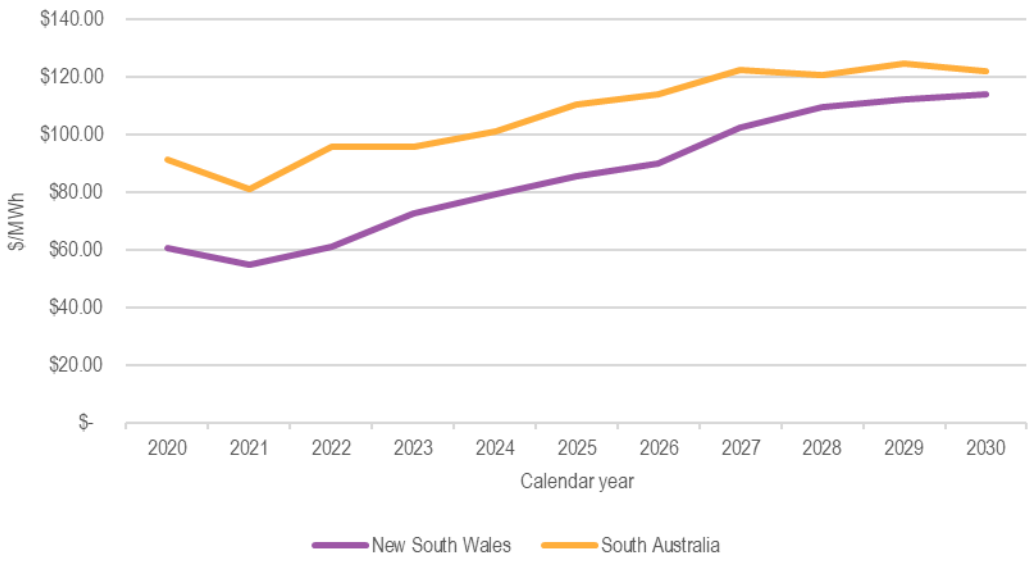
The results from the reference case are presented in section 3.1.1 and the results from the new interconnector scenario are presented in section 3.1.2.

3.1.1 Reference case

The projected annual average load weighted price of electricity[7] in South Australia and New South Wales, under the reference case, is summarised in Figure 3.1.

[7] Wholesale electricity price weighted by demand at the regional reference node

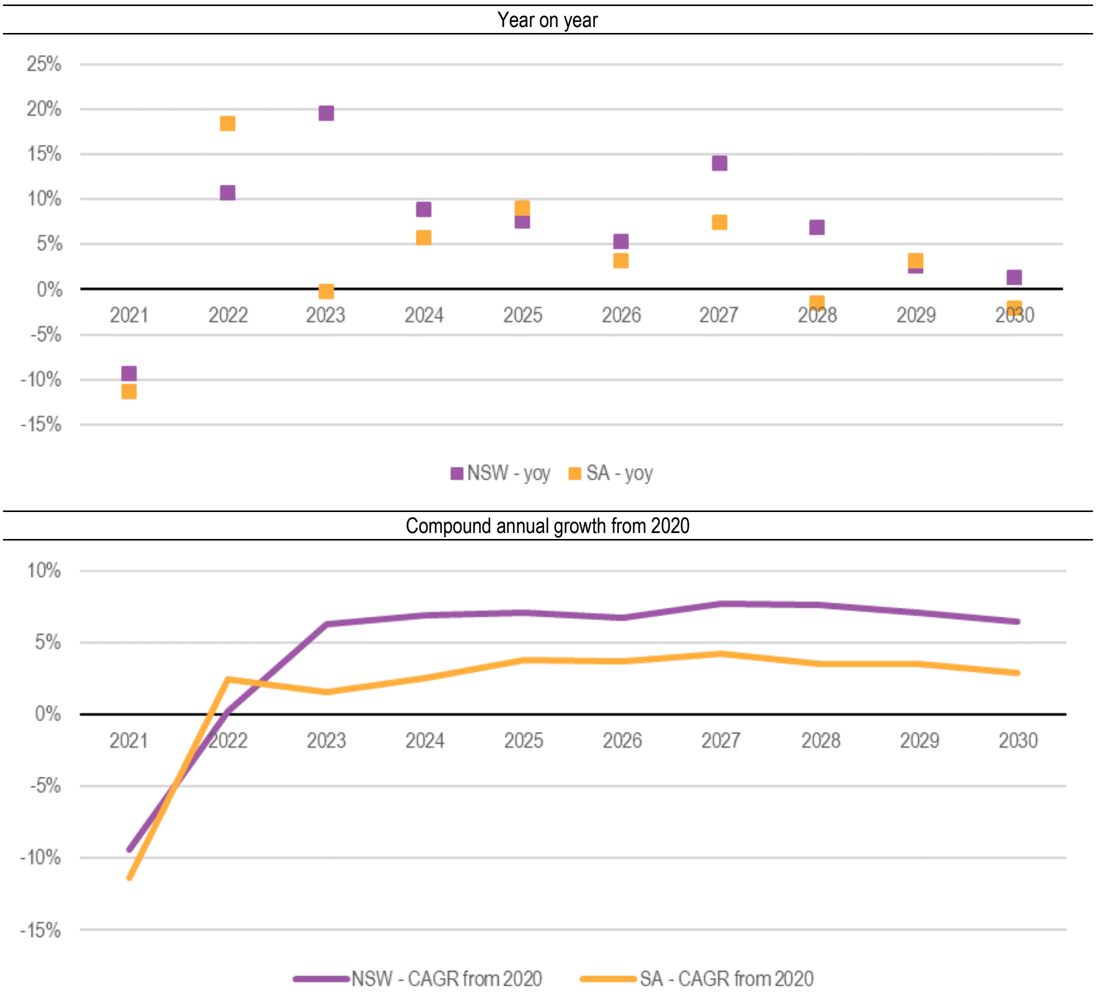
FIGURE 3.1 SUMMARY OF PROJECTED WHOLESALE SPOT PRICE OF ELECTRICITY, NOMINAL, CALENDAR YEARS – ANNUAL LOAD WEIGHTED AVERAGE, 2019 TO 2040, REFERENCE CASE – SOUTH AUSTRALIA AND NEW SOUTH WALES



NOTE: PROJECTED VALUES ARE ANNUAL TO 2035 AND FIVE YEARLY THEREAFTER.
SOURCE: ACIL ALLEN POWERMARK MODELLING

The figure illustrates our projection that wholesale electricity spot prices are likely to fall in the short term in both South Australia and New South Wales. This is due to a substantial uptake of renewable capacity. We project that they will then increase in the early to mid-part of the next decade as the supply demand balance tightens gradually. This is reflected in the growth rates, which are shown in Figure 3.2 in both year on year terms (upper pane) and as compound annual growth rates from 2020 (lower pane).

FIGURE 3.2 REFERENCE CASE – PROJECTED GROWTH IN WHOLESALE SPOT PRICE OF ELECTRICITY



SOURCE: ACIL ALLEN CONSULTING

Reference case - Comparison between preliminary and current modelling

As noted above, the modelling presented here is an update to the preliminary modelling that accompanied ElectraNet's Project Assessment Draft Report, which was presented in our report of 3 July 2018.

A number of relatively minor changes were made to the input assumptions used in this report as compared to those used in the earlier report. For the most part those changes were made to improve comparability between this report and analysis contained in AEMO's 2018 Integrated System Plan (ISP), which was published after our preliminary modelling.

The projected future electricity demand was updated using AEMO's August 2018 demand forecast. Compared to the preliminary modelling, the projected electricity demand is higher in most regions, particularly in New South Wales and Victoria. This reflects AEMO's assumption that Australia's aluminium smelters will continue to operate beyond their existing power supply contracts, which is in contrast to the assumption we made in our earlier report.

The NEM emissions budget for the 2020-21 to 2029-30 period was increased from 1,215 Mt CO2-e to 1,354 Mt CO2-e to align with the emissions trajectory used in the ISP. This assumes that the electricity sector achieves a 26 percent reduction in emissions below 2005 levels which is less than the sector's pro-rata share of the national emissions reduction task. In contrast to this the preliminary modelling was based on a smaller budget of 1,215 Mt CO_2-e, which represents the emissions task for the NEM assuming the electricity sector does its pro-rata share. With the more generous emissions budget there is no need for an emissions policy in the NEM to achieve the budget, in contrast to the preliminary modelling in which an emissions reduction policy was assumed.

Post 2030, the emissions policy settings are almost identical to those implemented in the preliminary modelling and have the effect of reducing emissions in the NEM on a trajectory that aligns with the "28% to 70% Emissions Reduction Target" of the ISP.

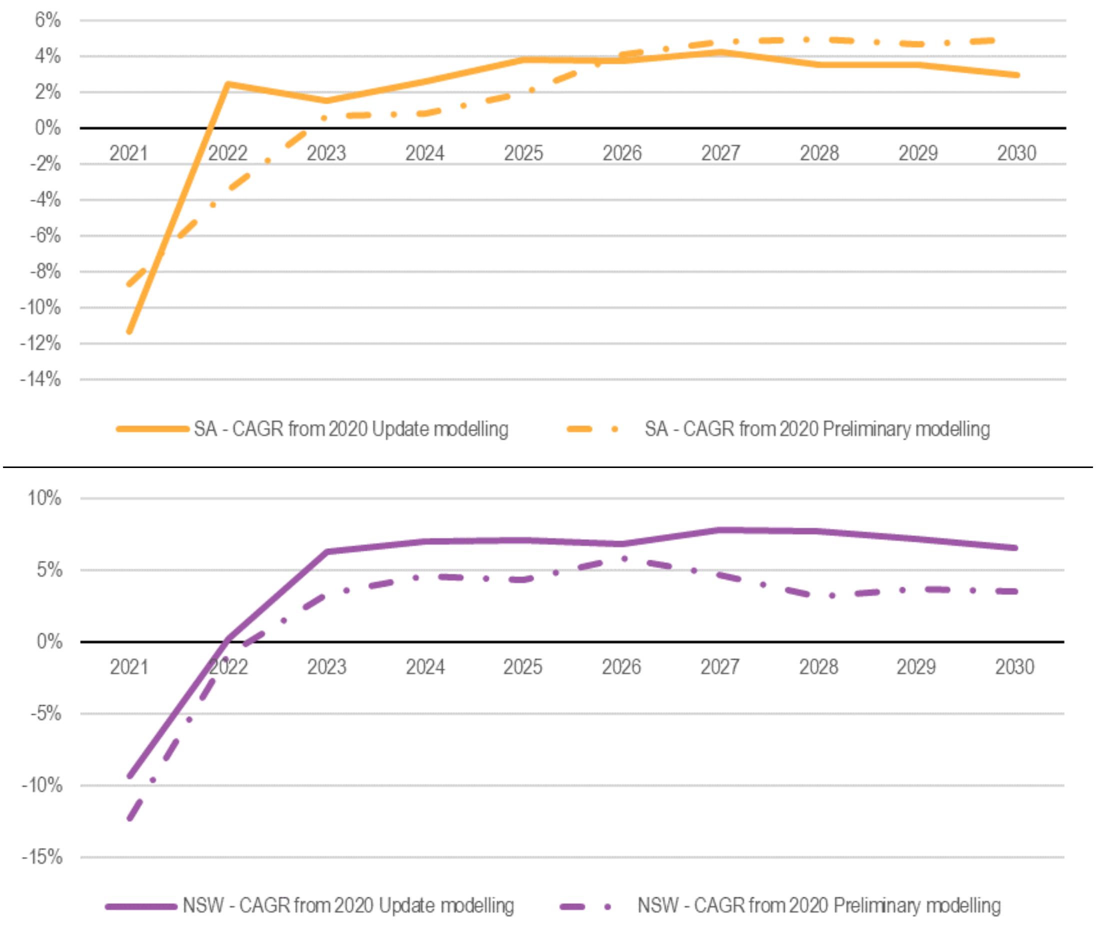
Changes were also made to reflect progress with the Victorian Renewable Energy Target (VRET). In July, the full scale of the first VRET auction was not yet known. The assumed VRET capacity has been updated from 650 MW in the preliminary modelling, to include the full VRET auction in this report. In addition, to reflect the recent growth in the corporate PPA market, an additional 600 MW of additional renewable capacity underpinned by corporate PPAs is assumed to be committed across the NEM in the next 12 months.

Finally, projected gas prices in the period to 2026 have been revised upward in the Reference Case. This reflects continued poor performance of coal seam gas wells in QLD, higher Asia-Pacific LNG spot pricing and the likely reliance on imported LNG to supplement supply in the early 2020's.

Another key difference between the preliminary modelling and this update is the inclusion of the additional line from Buronga to Red Cliffs within the scope of the new interconnector to increase transfer capacity between New South Wales and Victoria, which was not included in our modelling in July.

Figure 3.3 shows the impact these changes in input assumptions had on the projection of growth in wholesale spot electricity prices in the reference case. For the most part it shows that the current projections are for slightly more rapid growth, or smaller reductions, in electricity prices than we projected in July 2018. This is mostly attributable to the increased future demand for electricity in this round of modelling arising from the assumption that the aluminium smelters will remain open for longer.

FIGURE 3.3 COMPARING WHOLESALE SPOT PRICE PROJECTIONS – REFERENCE CASE BETWEEN PRELIMINARY AND CURRENT MODELLING

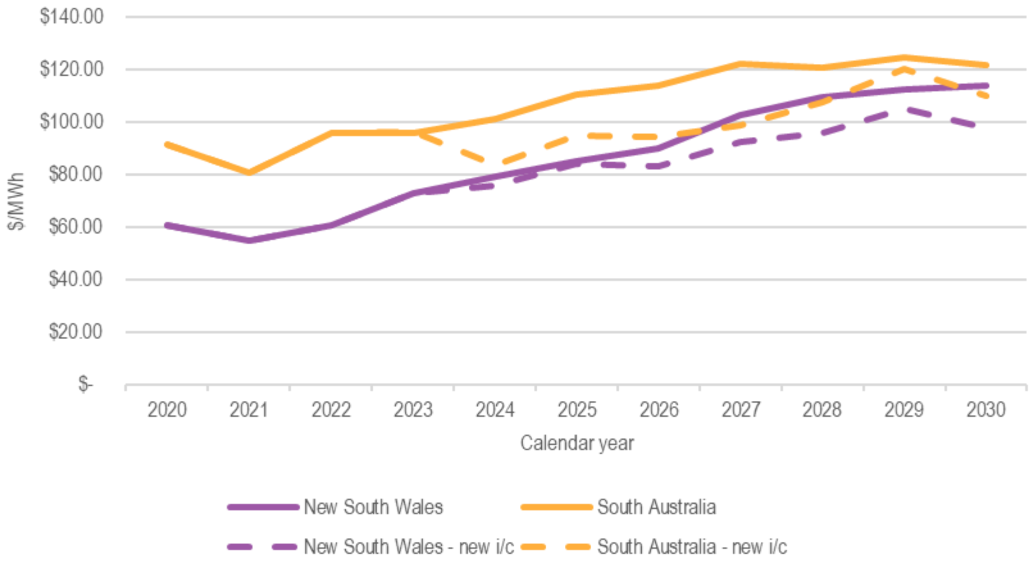


SOURCE: ACIL ALLEN CONSULTING

3.1.2 New Interconnector scenario

The projected wholesale price of electricity in South Australia and New South Wales under the new interconnector scenario is shown in Figure 3.4 This also shows the projected wholesale prices of electricity under the reference case scenario to highlight the difference between the two projections.

FIGURE 3.4 SUMMARY OF PROJECTED WHOLESALE SPOT PRICE OF ELECTRICITY, NOMINAL, CALENDAR YEARS – ANNUAL LOAD WEIGHTED AVERAGE, 2019 TO 2030, REFERENCE CASE AND NEW INTERCONNECTOR SCENARIO – SOUTH AUSTRALIA AND NEW SOUTH WALES



SOURCE: ACIL ALLEN POWERMARK MODELLING

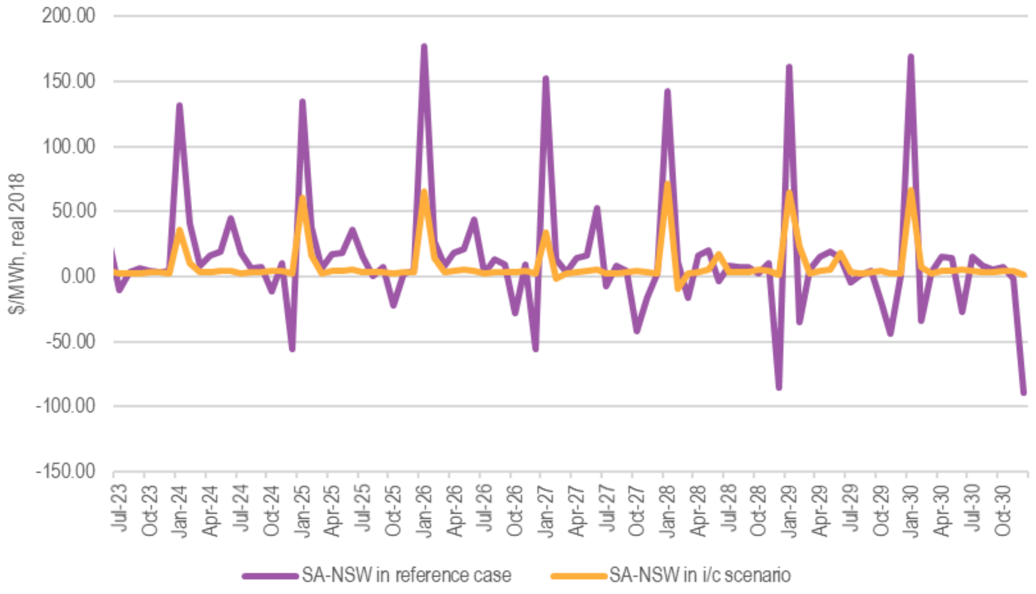
The analysis indicates that the new interconnector is projected to place downward pressure on the wholesale spot price of electricity in both South Australia and New South Wales.

In South Australia, the reduced spot price is evident from the new interconnector's first year of full operation (2024). In the first few years the reduction is projected to be quite substantial, in the order of $15 to $20 / MWh. If the early works program leads to the interconnector being introduced sooner than this, it would be reasonable to expect the results to be seen sooner as well.

Small reductions in the wholesale spot price of electricity are projected in New South Wales in the first few years of the interconnector's operation, increasing to around $13 /MWh in 2028.

The modelling shows that an interconnector between New South Wales and South Australia would tend to 'smooth' the price differential between those two regions. This is illustrated in Figure 3.5 which shows the difference in monthly average wholesale spot prices between the two regions – the New South Wales price is subtracted from the South Australian meaning that the South Australian price is higher to the extent that the curve is above the line.

FIGURE 3.5 MONTHLY LOAD WEIGHTED PRICE DIFFERENCES ($/MWH, REAL 2018) - 2022 - 2030



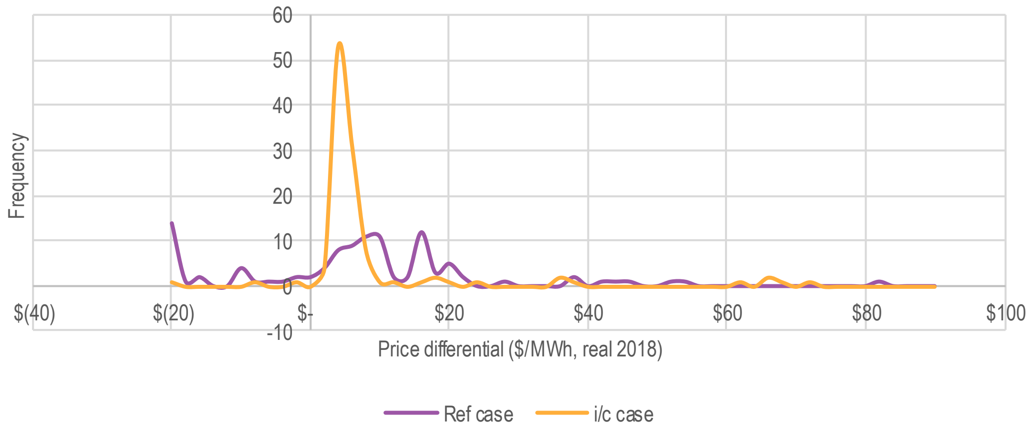
SOURCE: ACIL ALLEN POWERMARK MODELLING

The purple curve in Figure 3.5 shows that, in the reference case, the difference in the monthly average wholesale spot price between South Australia and New South Wales is projected to be volatile and often quite large. This is illustrated by the median difference, which is the value that is exceeded by half of the projected differences. In the reference case the median difference between the two regions is projected to be $7.34/MWh.

Adding an interconnector is projected to reduce the difference in price between the two regions, as illustrated by the gold curve in Figure 3.5. The difference is still present, but with the interconnector in place it is typically smaller. In this case, the median difference is projected to be $3.86/MWh, approximately half the level without the interconnector.

This 'smoothing' of the prices is shown in Figure 3.6, which shows density curves of the differences in projected monthly average prices to 2030. It shows a much higher 'peak' of price differences at near zero levels in the interconnector than the reference case.

FIGURE 3.6 DENSITY PLOT OF MONTHLY LOAD WEIGHTED PRICE DIFFERENCES IN REFERENCE AND INTERCONNECTOR CASES - ($/MWH REAL 2018) – 2022 TO 2030



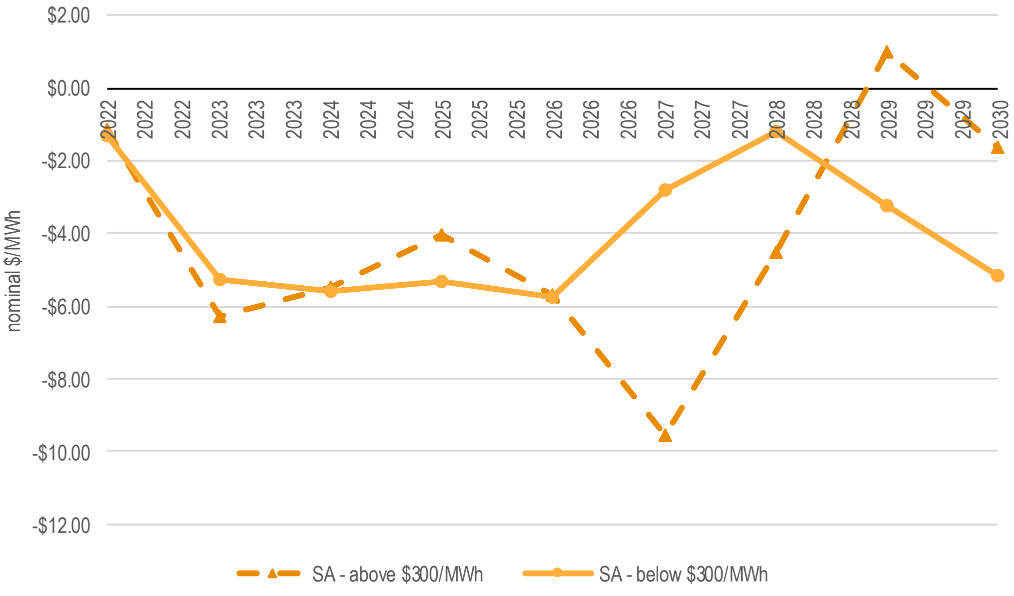
SOURCE: ACIL ALLEN POWERMARK MODELLING

It is well known that spot prices in the NEM are capable of 'spiking' to very high levels, which creates price risk for retailers and other customers buying electricity from the wholesale market. That risk can be managed in numerous ways including using exchange traded cap contracts, which can be used to limit exposure to prices greater than $300/MWh, which has come to be accepted as the line distinguishing 'high' and 'low' prices.

The modelling shows that 'high' time weighted prices, those above $300/MWh, are projected to be lower (closer to $300) in both regions with an interconnector in place. This reduction in high prices places downward pressure on price in both regions.

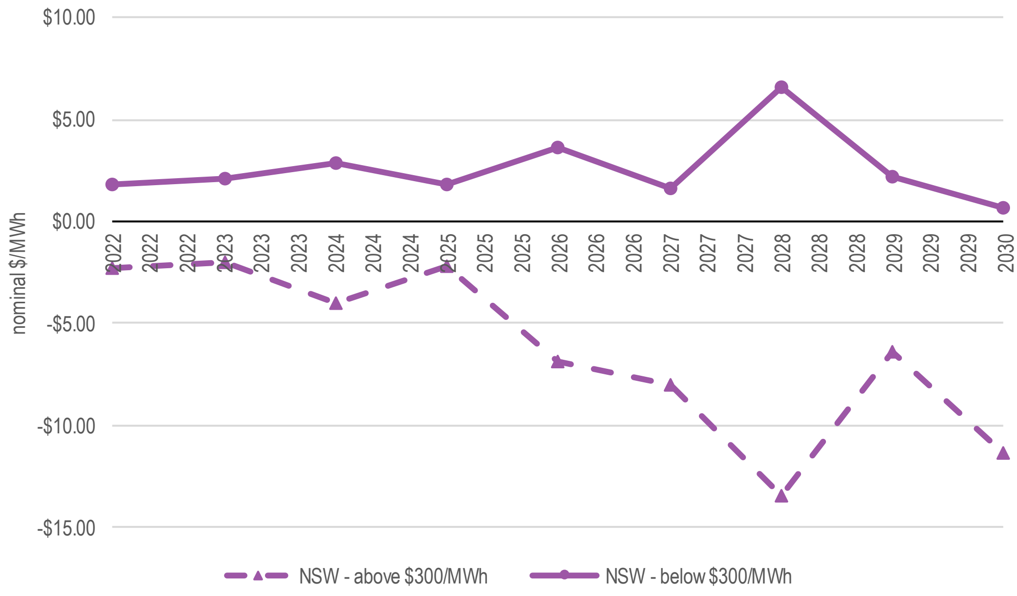
Figure 3.7 shows the projected impact on the extent of time weighted prices above, and below, $300/ MWh in South Australia. Figure 3.8 shows the corresponding information for New South Wales. In both cases the prices shown in the 'above $300/MWh' curves have had $300 subtracted – they show the amount by which prices above $300/MWh are projected to exceed $300/MWh on average each year.

FIGURE 3.7 SOUTH AUSTRALIA – IMPACT ON 'HIGH' AND 'LOW' TIME WEIGHTED PRICES



SOURCE: ACIL ALLEN POWERMARK MODELLING

FIGURE 3.8 NEW SOUTH WALES – IMPACT ON ‘HIGH’ AND ‘LOW’ TIME WEIGHTED PRICES



SOURCE: ACIL ALLEN POWERMARK MODELLING

Figure 3.7 shows that ‘low’ time weighted prices in South Australia are also projected to be lower with an interconnector than without. When both ‘high’ and ‘low’ prices are projected to fall, the logical conclusion is that total price must fall also, which is shown in Figure 3.5.

In New South Wales, though, the projection is different. Here, ‘low’ time weighted prices are projected to be higher with an interconnector in place than without. Therefore, in New South Wales, the projected impact of the interconnector is to reduce ‘high’ prices while increasing ‘low’ prices by around $2.00/MWh in most years.

Figure 3.4 shows, the ‘net effect’ is projected to be reductions in the price level in NSW as well as reductions in the volatility. We note that, while it is not modelled here, the decreased volatility is also likely to reduce hedging costs in both New South Wales and South Australia.

3.2 Projected customer bill impacts

The projected impact of the new interconnector on customers’ electricity bills is consistent with the projected change in wholesale spot prices in both states across the forecast period as a result of the new interconnector. The projected impact on retail bills is summarised in Figure 3.9 and Table 3.1.

FIGURE 3.9 PROJECTED RETAIL BILL IMPACT – NSW AND SA RESIDENTIAL AND SMALL BUSINESS CUSTOMERS

SOURCE: ACIL ALLEN CONSULTING

TABLE 3.1 PROJECTED RETAIL BILL IMPACT – NSW AND SA RESIDENTIAL AND SMALL BUSINESS CUSTOMERS

	Representative residential customer		Small business customer	
	SA	**NSW**	**SA**	**NSW**
Transmission network cost impact ($ /annum)[8]	9	5	18	12
Average saving in wholesale component of bill ($/annum)	$(75)	$(35)	$(151)	$(84)
Net bill saving ($/annum)	$(66)	$(30)	$(132)	$(71)
Annual consumption (kWh/annum)	5,000	4,215	10,000	10,000

SOURCE: ACIL ALLEN CONSULTING

The figure shows two impacts on retail bills separately. The first, shown in purple, is the annual cost to each customer of the interconnector, which was provided by ElectraNet. The second component, shown in gold, is the projected impact on the wholesale energy component of each annual bill, averaged over the period from 2024 to 2030.

In nominal terms, over the period to 2030, the modelling indicates that annual residential customer bills would reduce on average by $66 in South Australia and by $30 in New South Wales for a representative residential customer. As the figure shows, the saving attributable to projected reductions in the wholesale spot electricity price outweighs the assumed impact the interconnector would have on network use of system charges. The modelling indicates that the saving in energy costs will be around seven or eight times the cost of the interconnector on an annual basis in the period to 2030.

[8] This reflects solely the additional network costs arising from the new interconnector (consistent with our July report). It does not include any additional network costs that could arise from the additional Buronga to Red Cliffs line.

4 MODELLING ECONOMIC IMPACTS

This chapter provides an overview of the approach used to model the economic impact of the new interconnector. Further detail regarding the model is provided in Appendix A. Results are provided in chapter 5.

4.1 Introduction

To provide information on the broader economic impacts potentially arising from the addition of a new interconnector between South Australia and New South Wales ACIL Allen has undertaken computable general equilibrium (CGE) modelling. For this analysis we used ACIL Allen's CGE model, *Tasman Global*. *Tasman Global* is a multi-sector dynamic model of the Australian and world economy that has been used for many similar modelling projects including for other transmission line and electricity generation projects. An overview of the model is provided in Appendix A.

Modelling was conducted for South Australia and New South Wales as well as for the areas that will 'host' the interconnector.

The capital and operating expenses underlying *PowerMark* along with the projected electricity generation and prices from the reference case and scenarios described above were used to inform the *Tasman Global* Reference Case and the Scenario Case. The differences between the economic projections with and without the interconnector provide a forecast of the total economic impacts it will have. These include the wider economic impacts associated with the construction and ongoing operation of the interconnector and the impact of changes in the availability and price of electricity in relevant areas.

CGE models produce a wide variety of economic metrics. The metrics reported in this case are:

— **Real economic output** (as measured by real Gross Regional Product (GRP) and real Gross State Product (GSP)): GRP/GSP is defined as the sum of value added by all producers who are within the region/state, plus any product taxes (minus subsidies) not included in output. A positive deviation (i.e. an increase) of real economic output from the Reference Case implies that the proposed investment will enable the economy to produce more real goods and services potentially available for consumption.

— **Real income:** The change in real income in CGE models such as *Tasman Global* is a measure of the change in economic welfare of the residents of the region, state or country. The change in real income is equal to the change in real economic output plus the change in net foreign income transfers plus the change in terms of trade. In contrast to measures such as real economic output, real income accounts for any impacts of foreign ownership and debt repayments as well as changes in the purchasing power of residents as a result of a project or policy.

— **Employment and real wages:** *Tasman Global* also produces the net labour market impact of the construction and operations of a major project.

4.2 Assessment methodology

The macroeconomic impacts of a policy, project or other activity can be estimated using a variety of economic analysis tools. The most common methods utilised are input-output (I-O) multiplier analysis and computable general equilibrium (CGE) modelling. The selection of the right tool is critical to the accuracy of the estimated impacts and depends upon the characteristics of the project/industry. Sometimes a range of tools are required.

By their nature, input-output multipliers and CGE models focus on 'market impacts' across the economy (that is, impacts on activities with observed market prices). Analysis of various 'non-market impacts', such as property right infringements, potential loss of biodiversity, changes in air quality, social justice implications and so forth may also be relevant in assessing the full implications of a project or policy.

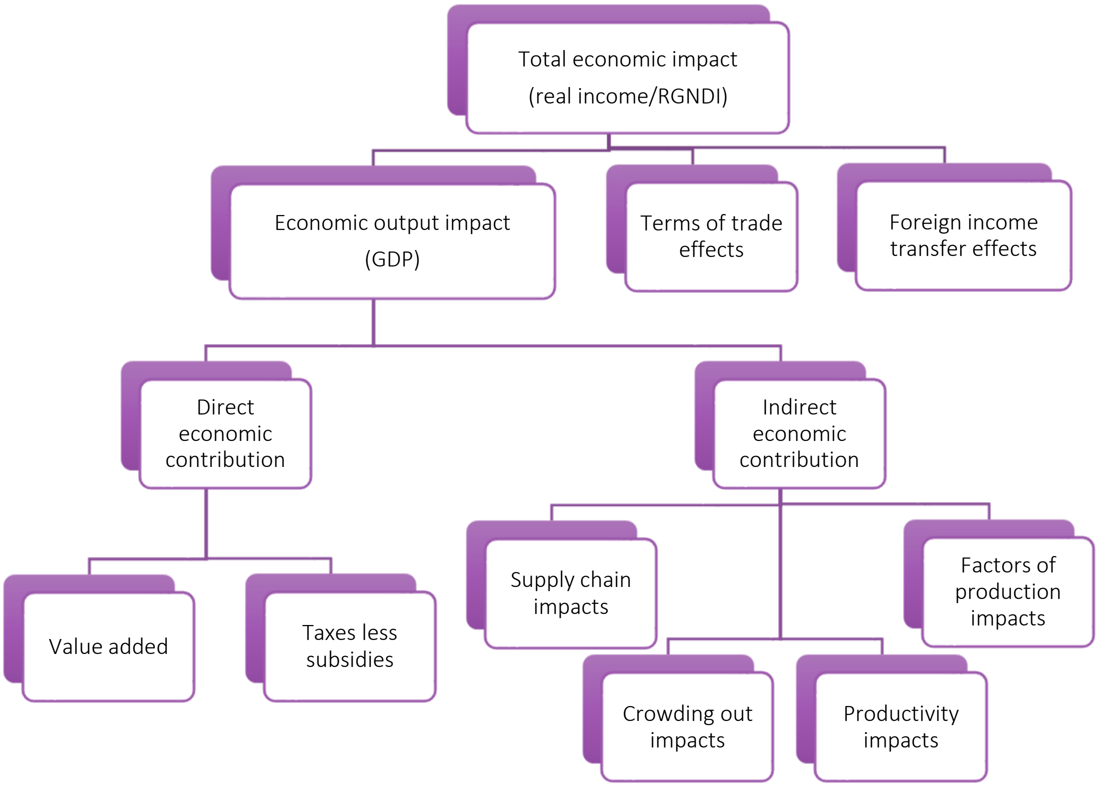
Fundamentally, although various aspects of a policy or project—such as the number of jobs or the size of the investment expenditure—are of relevance to certain stakeholders, the key aggregate measure of the macroeconomic impact of a project is the extent to which the total income of the economy changes as a result of the policy or project. Typically, this is measured by real gross national disposable income (RGNDI), although real gross domestic product (GDP) and consumer surplus (among others) can also be important aggregate measures depending on the nature of the policy or project being analysed.

The main factors that need to be considered when analysing the macroeconomic impacts of a project or policy include:

— the direct and indirect contribution to the economy as a result of the activities associated with the project
— any crowding out implications as resources are potentially diverted from other productive activities to undertake the project being analysed
— any productivity effects generated as a direct result of the policy or project activities – particularly any enduring productivity changes or productivity impacts on other activities not directly associated with the project or policy
— any changes to the factors of production in the economy
— any implications associated with changes in terms of trade or foreign income transfers
— whether there is a dynamic element to the size of any of the above effects (due to different phases of the project for example).

Figure 4.1 shows these components graphically. Some of these effects may be negligible while others may be very significant, and an understanding of the effects helps determine the most appropriate tool(s) for the analysis.

FIGURE 4.1 ESTIMATING THE MACROECONOMIC IMPACT OF A PROJECT OR POLICY



SOURCE: ACIL ALLEN CONSULTING

For many projects, static estimates of the direct economic contribution and supply chain implications can be obtained by using I-O multipliers. Estimating the size of other components using multiplier techniques is either not possible or very complex, as is estimating the economic impacts through time. In contrast, most CGE models can estimate all the components shown in Figure 4.1 with dynamic CGE models able to estimate the impacts through time.

A project of this size will have the potential for changing the cost and availability of electricity, as well as terms of trade effects. Consequently, CGE modelling has been used for this economic impact assessment.

For this analysis, ACIL Allen's CGE model, *Tasman Global*, was used to estimate the impacts of the construction activities and ongoing economic benefits associated with the new interconnector.

4.3 The *Tasman Global* CGE model

Tasman Global is a large scale, dynamic, CGE model of the world economy that has been developed in-house by ACIL Allen. *Tasman Global* is a powerful tool for undertaking economic analysis at the regional, state, national and global levels.

CGE models mimic the workings of the economy through a system of interdependent behavioural and accounting equations which are linked to an input-output database. These models provide a representation of the whole economy, set in a national and international trading context, starting with individual markets, producers and consumers and building up the system via demands and production from each component. When an economic shock or disturbance is applied to the model, each of the markets adjusts according to the set of behavioural parameters which are underpinned by economic theory. The generalised nature of CGE models enable a much broader range of analysis to be undertaken (generally in a more robust manner) compared to I-O multiplier techniques, which are also often applied in economic impact assessments

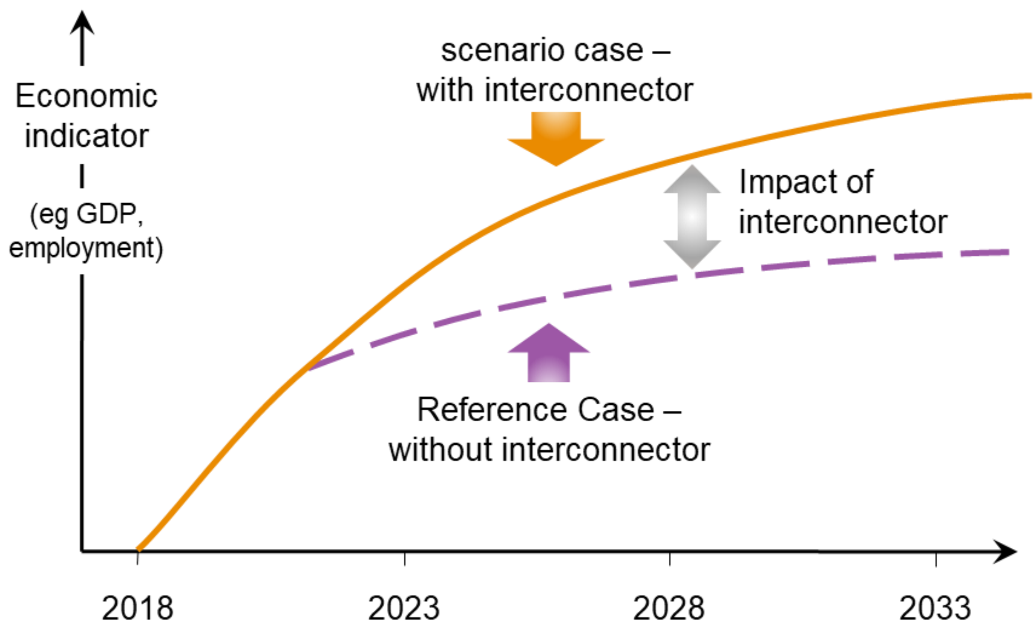
More detail on the *Tasman Global* model is provided in Appendix A of this report.

4.3.1 A dynamic model

Tasman Global is a model that estimates relationships between variables at different points in time. This is different from comparative static models, which compare two equilibriums (one before a policy change and one following). A dynamic model such as *Tasman Global* is useful when analysing issues where both the timing of economic impacts and the adjustment path that economies follow are relevant in the analysis.

In applications of the *Tasman Global* model, a Reference Case simulation forms a 'business-as-usual' basis with which to compare the results of various simulations. The Reference Case provides projections of growth in the absence of the Project (such as GDP, population, labour supply, industry output, etc.) and provides projections of endogenous variables such as productivity changes and consumer tastes. The scenario case assumes all productivity improvements, tax rates and consumer preferences change as per the Reference Case projections but also includes the proposed Project. The two scenarios give two projections of the economy and the net impact of the Project is then calculated as deviations from the Reference Case (see Figure 4.2).

FIGURE 4.2 ILLUSTRATIVE SCENARIO ANALYSIS USING TASMAN GLOBAL



Note: Indicative only. In reality the projected impacts of a project or policy can be positive, negative, neutral or mixed.
SOURCE: ACIL ALLEN CONSULTING

4.3.2 Database aggregation

The database which underpins the model contains a wealth of sectoral detail. The foundation of this information is the set of input-output tables that underpin the database. Industries in the model can be aggregated or disaggregated as required for a specific project. For this project the industries have been aggregated to 48 industries/commodities as presented in Table 4.1.

The aggregation was chosen to provide the detail relevant for this analysis.

TABLE 4.1 INDUSTRY/COMMODITY AGGREGATION USED FOR TASMAN GLOBAL MODELLING

	Industry/commodity		Industry/commodity
1	Vegetables, fruit and nuts	25	Wood and paper products; publishing and printing (excluding furniture)
2	Other crops	26	Fabricated metal products
3	Cattle	27	Motor vehicle and parts
4	Other livestock	28	Other transport equipment
5	Fishing	29	Electronic equipment
6	Forestry	30	Other machinery and equipment
7	Meat products	31	Other manufacturing
8	Other processed food and beverages	32	Water
9	Coal	33	Gas distribution
10	Oil	34	Electricity distribution
11	Gas	35	Construction
12	LNG	36	Trade services (includes all retail and wholesale trade, hotels and restaurants)
13	Iron ore	37	Road transport
14	Bauxite	38	Rail and pipeline transport
15	Other mining	39	Water transport
16	Iron & steel	40	Air transport
17	Alumina	41	Other transport services
18	Primary aluminium	42	Communications services
19	Petroleum & coal products	43	Insurance services
20	Electricity	44	Other financial services
21	Other nonferrous metals	45	Other business services
22	Non-metallic minerals (including cement, plaster, lime, gravel)	46	Recreational and other services
23	Chemicals, rubber, plastics	47	Government services (including public administration and defence)
24	Textiles, clothing and footwear	48	Dwellings

Note: Excludes micro industries developed specifically for this analysis

SOURCE: ACIL ALLEN CONSULTING

Tasman Global contains a detailed representation of the energy sector, particularly in relation to the interstate (trade in electricity and gas) and international linkages across the regions represented. To allow for more detailed electricity sector analysis, and to aid in linkages to *PowerMark*, electricity generation is separated from transmission and distribution in the model. In addition, the electricity sector in the model employs a 'technology bundle' approach that separately identifies up to twelve different electricity generation technologies:

1. brown coal (with and without carbon capture and storage)
2. black coal (with and without carbon capture and storage)
3. petroleum
4. base load gas (with and without carbon capture and storage)
5. peak load gas
6. hydro
7. geothermal

8. nuclear
9. biomass
10. wind
11. solar
12. other renewables.

To enable more accurate linking to *PowerMark* the generation cost of each technology is assumed to be equal to their long run marginal cost (LRMC) while the sales price in each region is matched to the average annual dispatch weighted prices projected by *PowerMark* – with any difference being returned as an economic rent to electricity generators. Fuel use and emissions factors by each technology are also matched to those projected in *PowerMark*. This representation enables the highly detailed market based projections from *PowerMark* to be incorporated as accurately as possible into *Tasman Global*.

4.3.3 Micro industry approach

To accurately assess the economic impacts or economic contribution of a major project such as this, the project must be accurately represented in *Tasman Global's* database. An accurate representation can be guaranteed by establishing the proposed project as a new 'micro' industry in the database.

The micro industry approach is so called because it involves the creation of one or more new, initially very small, industries in the *Tasman Global* database. The specifications of each of the micro industry's costs and sales structures are directly derived from the financial data for the project to be analysed. At the outset, the new industry is necessarily very small so that its existence in the *Tasman Global* database does not affect the database balance or the "business-as-usual" Reference Case outcomes.

Besides having a separate cost structure for the project of interest, a further challenge is to faithfully represent the time profile of the individual cost items. This is particularly important for the investment phase where there are typically large changes in demands for machinery, labour and imported components year on year. This challenge is met in *Tasman Global* through incorporating detailed year on year, input specific changes by source.

Using the micro industry approach for project evaluations is the most accurate way to capture the detailed economic linkages between the project and the other industries in the economy. This approach has been developed by ACIL Allen because each project is unique relative to the more aggregated industries in the *Tasman Global* database.

Consequently, in addition to the 47 industries identified in Table 4.1, the database also identifies the construction and operation phases of the project as separate industries with their own input cost structure, sales, employment, tax revenues and emissions based on detailed information generated as part of this analysis.

Another important aspect in the CGE modelling approach used for this analysis is to have separate identification of the capital stock created as part of the project's investment phase and isolating it until the capital is available for use, thereby preventing the economy gaining false benefits from, say, half a bridge. In the past, some CGE models potentially overstated the impact of an investment, because investment in one period was automatically added to capital stock in the next period and was made available to the rest of the economy, thereby spuriously increasing GDP.

4.4 Measures of macro-economic impacts

One of the most commonly quoted macroeconomic variables at a national level is real GDP, which is a measure of the aggregate output generated by an economy over a given period (typically a year). From the expenditure side, GDP is calculated by adding together total private and government consumption, investment and net trade. From the income side, GDP can be calculated as the sum of returns to the primary factors (labour, capital and natural resources) employed in the national economy plus indirect tax revenue. The regional level equivalent to GDP is Gross Regional Product (GRP) – at the state level it is called GSP (Gross State Product). To reduce the potential confusion with the various acronyms, the term **economic output** has been used in the discussion of the results presented in this report.

These measures of the real economic output of an economy should be distinguished from measures of the economy's real income, which provide a better indication of the economic welfare of the residents of a region. It is possible for real economic output to increase (that is, for GDP to rise) while at the same time real income (economic welfare) declines. In such circumstances people and households would be worse off despite economic growth.

In *Tasman Global*, the relevant measure of real income at the national level is RGNDI as reported by the Australian Bureau of Statistics (ABS).

The change in a region's real income as a result of a new project is the change in real economic output plus the change in net external income transfers plus the change in the region's terms of trade (which measure the change in the purchasing power of the region's exports relative to its imports). As Australians have experienced first-hand in recent years, changes in the terms of trade can have a substantial impact on residents' welfare independently of changes in real economic output.

In global CGE models such as *Tasman Global*, the change in real income is equivalent to the change in consumer welfare using the equivalent variation measure of welfare change resulting from exogenous shocks. Hence, it is valid to say that the projected change in real income (from *Tasman Global*) is also the projected change in consumer welfare.

5 ECONOMIC MODELLING – RESULTS

This chapter provides the results of the economic modelling.

The results are presented for the South Australian and New South Wales economies as a whole and also for the 'host regions', which are the areas of those two states that would 'host' the interconnector.

Results are presented for the metrics defined above, namely:

- economic contribution, measured in terms of both real economic output and real income, in section 5.1
- employment, in section 5.2
- real wages, in section 5.3.

It should be noted that, in contrast to the price and bill impacts presented in chapter 3, the economic impacts presented here are in real terms (i.e. they have been adjusted for inflation).

5.1 Real economic output and real income

As discussed in section 4.1, real economic output is the sum of value added by all producers in the relevant region/state, plus any product taxes (minus subsidies) not included in output. When calculated at a national level this is referred to as Gross Domestic Product (GDP) and as Gross State Product (GSP) at the State level.

In contrast, the change in real income is:

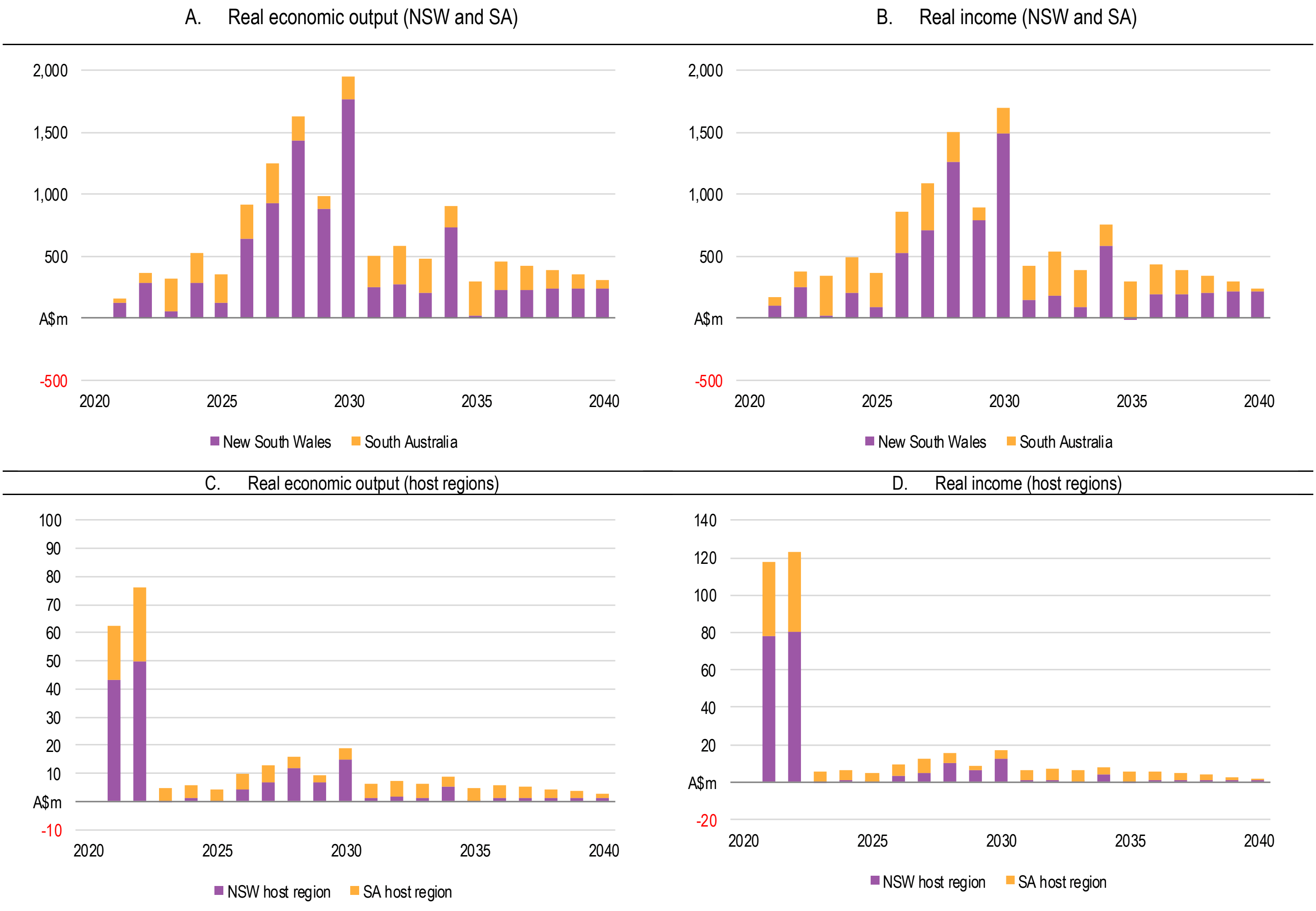
- the change in real economic output
- plus the change in net foreign income transfers
- plus the change in terms of trade

While real output is a useful indicator, our view is that real income provides a better measure of the welfare impact that changes in these aggregates have on people living in a region.[9]

Figure 5.1 shows the change in both real economic output and real income in New South Wales and South Australia, and in the Host regions, due to the introduction of the new interconnector. A summary of the aggregate projected impacts is presented in Table 5.1.

[9] In CGE models with the same framework as *Tasman Global*, it can be shown that the change in real income is equal to the 'equivalent variation' measure of welfare change. Hence, it is valid to say that the projected change in state or national real income is the projected change in consumer welfare at the state or national level.

FIGURE 5.1 CHANGE IN REAL ECONOMIC OUTPUT AND REAL INCOME AS A RESULT OF THE PROJECT, RELATIVE TO THE REFERENCE CASE (IN 2018 TERMS)



SOURCE: ACIL ALLEN CONSULTING

In general, the changes in real economic output are broadly in line with the projected savings in electricity prices as shown by comparing Figure 5.1A with Figure 3.4 while also proportional to the size and composition of the South Australian and New South Wales economies, with New South Wales experiencing a correspondingly greater benefit.

Further, the additional construction activity associated with the project has a noticeable effect on the economies of the host regions in the initial years due to a movement of economic activity into these regions during the construction period. This is shown in Figure 5.1C. These regions also experience ongoing benefits once the interconnector is in operation due to the impact of the projected savings in electricity prices on these local economies.

Importantly, this analysis focuses on the direct economic impacts of the interconnector and excludes the additional benefits that might be expected to flow to these regions through the construction and ongoing operation of any new renewable generation projects that develop in these regions as a result of the interconnector.

TABLE 5.1 PROJECTED CUMULATIVE CHANGE IN REAL ECONOMIC OUTPUT AND REAL INCOME IN EACH REGION AS A RESULT OF THE INTERCONNECTOR PROJECT, RELATIVE TO THE BASE CASE (IN 2018 TERMS)

	Real economic output			Real income		
	Total (2021 to 2040)	NPV (4% discount rate)	NPV (7% discount rate)	Total (2021 to 2040)	NPV (4% discount rate)	NPV (7% discount rate)
	2018 A$m	2018 A$m	2018 A$m	2018 A$m	2018 A$m	2018 A$m
SA host regions	120	93	79	163	133	117
Rest of SA	3,867	2,613	2,012	4,239	2,925	2,285
Total South Australia	**3,987**	**2,706**	**2,091**	**4,402**	**3,058**	**2,402**
NSW host regions	154	129	116	209	184	170
Rest of NSW	8,998	6,171	4,766	7,250	4,950	3,809
Total New South Wales	**9,153**	**6,301**	**4,882**	**7,459**	**5,134**	**3,978**

Note: NPV = net present value.

SOURCE: ACIL ALLEN CONSULTING

Real economic output

Over the period 2021 to 2040, the interconnector project is projected to increase the real economic output of:

— *South Australia* by a cumulative total of $4.0 billion relative to the Reference Case using a real discount of seven per cent this equates to a net present value of $2.1 billion
  – $120 million of the projected benefit occurs in the SA host regions: $45 million during the construction phase and an average annual benefit of $4 million a year during the operations phase due to the significantly lower South Australian electricity prices

— *New South Wales* by a cumulative total of $9.2 billion relative to the Reference Case using a real discount of seven per cent this equates to a net present value of $4.9 billion
  – $154 million of the projected benefit occurs in the NSW host regions: $93 million during the construction phase and an average annual benefit of $3 million a year during the operations phase due to lower New South Wales electricity prices.

To place the projected changes in economic output estimates in perspective, the discounted present value (using a 7 per cent discount rate) is equivalent to 1.9 per cent of South Australia's and 0.8 per cent of New South Wales' current GSP.

Real income

Real income is a measure of the ability to purchase goods and services, adjusted for inflation. A rise in real income indicates a rise in the capacity for current consumption, but also an increased ability to accumulate wealth in the form of financial and other assets. The change in real income from a development is a measure of the change in welfare of an economy.

The extent to which local residents will benefit from the additional economic output depends on the level of ownership of the capital (including the natural resources) utilised in the business as well as any wealth transfers undertaken by Australian governments as a result of the taxation revenues generated by the Project.

Unlike analyses for other large projects where revenues flow through the books of the project owner, the economic benefits associated with the interconnector are dispersed widely throughout the community through the reduction in electricity prices. This means that the ownership situation of the project is less important than other comparable analyses.

— The South Australian and New South Wales Governments will receive some additional taxes (such as payroll taxes) because of the project, while the Australian Government will receive higher taxes through higher personal income and company tax receipts. Where this additional income will be spent is unknown, but for this study we have assumed that it will be spent proportionately to the population in each region of Australia.

Over the period 2021 to 2040, the project is projected to increase the real income of:

- *South Australia* by a cumulative total of $4.4 billion relative to the Reference Case (with a net present value of $2.4 billion, using a 7 per cent real discount rate)
  - $163 million of the projected benefit occurs in the SA host regions: $82 million during the construction phase and an average annual benefit of $4 million a year during the operations phase
- *New South Wales* by a cumulative total of $7.5 billion relative to the Reference Case (with a net present value of $4.0 billion, using a 7 per cent real discount rate)
  - $209 million of the projected benefit occurs in the NSW host regions: $158 million during the construction phase and an average annual benefit of $3 million a year during the operations phase.

To place these projected changes in income in perspective, the discounted present values (using a 7 per cent discount rate) are equivalent to a one-off increase in the average real income of all current residents of:

- *South Australia* by approximately $1,300 per person
- *New South Wales* by approximately $500 per person.

5.2 Employment

As well as creating some ongoing employment in the New South Wales and South Australian economies, the project will generate jobs during the construction phase of the project. In addition to the direct jobs generated on-site, the construction and installation, and production phases will require a range of locally sourced goods and services. Production of these inputs will further increase the demand for labour across the New South Wales and South Australian economies.

A key issue when estimating the impact of a project is determining how the labour market will clear.[10] For this analysis, increases in the demand for labour can be met by three mechanisms: increasing migration from elsewhere in Australia; increasing participation rates and/or average hours worked; and by reducing the unemployment rate. In the model framework, the first two mechanisms are driven by changes in the real wages paid to workers in the local region while the third is a function of the additional labour demand relative to the Reference Case. Given the moderate unemployment rate assumed throughout the projection period, changes in the real wage rate account for the majority of the additional labour supply in the policy scenario relative to the Reference Case.

It should be noted that this analysis does not assume any change in net foreign migration as a result of the Project.

Compared to other industries, the operations of the interconnector are highly capital intensive rather than labour intensive.

Employment creation

Over the period 2021 to 2040, it is projected that approximately 18,800 employee years[11] of full time equivalent (FTE) direct and indirect jobs will be created across New South Wales and South Australia. More specifically, it is projected that the Project will increase employment in:

- *South Australia* by 4,947 employee years, which is approximately 250 FTE jobs on average over the modelling period
  - these jobs are mostly created during the construction phase in the host regions and in the rest of the State during the operations phase
  - we project that:

[10] As with other CGE models, the standard assumption within *Tasman Global* is that all markets clear (i.e. demand equals supply) at the start and end of each time period, including the labour market. CGE models place explicit limits on the availability of factors and the nature of the constraints can greatly change the magnitude and nature of the results. In contrast, most other tools used to assess economic impacts, including I-O multiplier analysis, do not place constraints on the availability of factors. Consequently, these tools tend to overestimate the impacts of a project or policy.

[11] An employee year is equivalent to the employment of 1 FTE person for one year. Alternatively, it can represent employment of, say, two full-time people for half a year each, or one 0.5 FTE person for two years.

    - employment in the South Australian host regions will increase by 470 employee years during the 2-year construction phase, which is equivalent to 235 FTE jobs each year during this phase
    - 400 of these employee years will be directly employed through ElectraNet
- *New South Wales* by 13,841 employee years, which is approximately 700 FTE jobs on average over the modelling period:
  - these jobs are mostly created during the construction phase in the host regions and in the rest of the State during the operations phase
  - we project that:
    - employment in the New South Wales host regions will increase by 1,650 employee years during the 2-year construction phase, which is equivalent to 825 FTE jobs each year during this phase
    - 1,100 of these employee years will be directly employed through TransGrid.

5.3 Real wages

The projected changes in real wages follow the changes in labour demand, with wages in each region acting to balance demand and supply in each year. In addition, the magnitude of the projected changes in real wages is a function of the relative size of the demand and supply imbalance with respect to the overall size of the labour market (that is, large percentage increases in labour demand relative to the Base Case will tend to result in large percentage increases in real wages relative to the Base Case). In the context of the project, average real wages are also affected by the higher average wages (including allowances) paid to direct employees compared to other industries.

Real wages in South Australia and New South Wales, respectively, are projected to increase by an average of 0.12 and 0.06 per cent relative to the Reference Case. Given the size of the labour market, this is a significant increase generated by the interconnector project.

A

OVERVIEW OF TASMAN GLOBAL

Tasman Global is a dynamic, global computable general equilibrium (CGE) model that has been developed by ACIL Allen for the purpose of undertaking economic impact analysis at the regional, state, national and global level.

A CGE model captures the interlinkages between the markets of all commodities and factors, taking into account resource constraints, to find a simultaneous equilibrium in all markets. A global CGE model extends this interdependence of the markets across world regions and finds simultaneous equilibrium globally. A dynamic model adds onto this the interconnection of equilibrium economies across time periods. For example, investments made today are going to determine the capital stocks of tomorrow and hence future equilibrium outcomes depend on today's equilibrium outcome, and so on.

A dynamic global CGE model, such as *Tasman Global*, has the capability of addressing total, sectoral, spatial and temporal efficiency of resource allocation as it connects markets globally and over time. Being a recursively dynamic model, however, its ability to address temporal issues is limited. In particular, *Tasman Global* cannot typically address issues requiring partial or perfect foresight, however, as documented in Jakeman et al (2001), it is possible to introduce partial or perfect foresight in certain markets using algorithmic approaches. Notwithstanding this, the model does have the capability to project the economic impacts over time of given changes in policies, tastes and technologies in any region of the world economy on all sectors and agents of all regions of the world economy.

Tasman Global was developed out of the 2001 version of the Global Trade and Environment Model (GTEM) developed by ABARE (Pant 2001) and has been evolving ever since. In turn, GTEM was developed out of the MEGABARE model (ABARE 1996), which contained significant advancements over the GTAP model of that time (Hertel 1997).

A.1 A dynamic model

Tasman Global is a model that estimates relationships between variables at different points in time. This is in contrast to comparative static models, which compare two equilibriums (one before a policy change and one following). A dynamic model such as *Tasman Global* is beneficial when analysing issues where both the timing of and the adjustment path that economies follow are relevant in the analysis.

A.2 The database

A key advantage of *Tasman Global* is the level of detail in the database underpinning the model. The database is derived from the Global Trade Analysis Project (GTAP) database. This database is a fully documented, publicly available global data base which contains complete bilateral trade information, transport and protection linkages among regions for all GTAP commodities. It is the most detailed database of its type in the world.

Tasman Global builds on the GTAP database by adding the following important features:

- a detailed population and labour market database
- detailed technology representation within key industries (such as electricity generation and iron and steel production)
- disaggregation of a range of major commodities including iron ore, bauxite, alumina, primary aluminium, brown coal, black coal and LNG
- the ability to repatriate labour and capital income
- explicit representation of the states and territories of Australia
- the capacity to represent multiple regions within states and territories of Australia explicitly.

Nominally, version 9.1 of the *Tasman Global* database divides the world economy into 150 regions (142 international regions plus the 8 states and territories of Australia) although in reality the regions are frequently disaggregated further. ACIL Allen regularly models Australian or international projects or policies at the regional level including at the provincial level for Papua New Guinea and Canada.

The *Tasman Global* database also contains a wealth of sectoral detail currently identifying up to 72 industries (Table A.1). The foundation of this information is the input-output tables that underpin the database. The input-output tables account for the distribution of industry production to satisfy industry and final demands. Industry demands, so-called intermediate usage, are the demands from each industry for inputs. For example, electricity is an input into the production of communications. In other words, the communications industry uses electricity as an intermediate input. Final demands are those made by households, governments, investors and foreigners (export demand). These final demands, as the name suggests, represent the demand for finished goods and services. To continue the example, electricity is used by households – their consumption of electricity is a final demand. Each sector in the economy is typically assumed to produce one commodity, although in *Tasman Global*, the electricity, transport and iron and steel sectors are modelled using a 'technology bundle' approach. With this approach, different known production methods are used to generate a homogeneous output for the 'technology bundle' industry. For example, electricity can be generated using brown coal, black coal, petroleum, base load gas, peak load gas, nuclear, hydro, geothermal, biomass, wind, solar or other renewable based technologies – each of which have their own cost structure.

TABLE A.1 STANDARD SECTORS IN THE TASMAN GLOBAL MODEL

no	Name	no	Name
1	Paddy rice	37	Wood products
2	Wheat	38	Paper products, publishing
3	Cereal grains nec	39	Diesel (incl. nonconventional diesel)
4	Vegetables, fruit, nuts	40	Other petroleum, coal products
5	Oil seeds	41	Chemical, rubber, plastic products
6	Sugar cane, sugar beef	42	Iron ore
7	Plant- based fibres	43	Bauxite
8	Crops nec	44	Mineral products nec
9	Bovine cattle, sheep, goats, horses	45	Ferrous metals
10	Pigs	46	Alumina
11	Animal products nec	47	Primary aluminium
12	Raw milk	48	Metals nec
13	Wool, silk worm cocoons	49	Metal products
14	Forestry	50	Motor vehicle and parts
15	Fishing	51	Transport equipment nec
16	Brown coal	52	Electronic equipment
17	Black coal	53	Machinery and equipment nec
18	Oil	54	Manufactures nec
19	Liquefied natural gas (LNG)	55	Electricity generation
20	Other natural gas	56	Electricity transmission and distribution
21	Minerals nec	57	Gas manufacture, distribution
22	Bovine meat products	58	Water
23	Pig meat products	59	Construction
24	Meat products nec	60	Trade
25	Vegetables oils and fats	61	Road transport
26	Dairy products	62	Rail and pipeline transport
27	Processed rice	63	Water transport
28	Sugar	64	Air transport
29	Food products nec	65	Transport nec
30	Wine	66	Communication
31	Beer	67	Financial services nec
32	Spirits and RTDs	68	Insurance
33	Other beverages and tobacco products	69	Business services nec
34	Textiles	70	Recreational and other services
35	Wearing apparel	71	Public Administration, Defence, Education, Health
36	Leather products	72	Dwellings

Note: nec – not elsewhere classified.

SOURCE: ACIL ALLEN CONSULTING

The other key feature of the database is that the cost structure of each industry is also represented in detail. Each industry purchases intermediate inputs (from domestic and imported sources) primary factors (labour, capital, land and natural resources) as well as paying taxes or receiving subsidies.

A.3 Model structure

Given its heritage, the structure of the *Tasman Global* model closely follows that of the GTAP and GTEM models and interested readers are encouraged to refer to the documentation of these models for more detail (namely Hertel 1997 and Pant 2001, respectively). In summary:

- The model divides the world into a variety of regions and international waters.
  - Each region is fully represented with its own 'bottom-up' social accounting matrix and could be a local community, an LGA, state, country or a group of countries. The number of regions in a given simulation depends on the database aggregation. Each region consists of households, a government with a tax system, production sectors, investors, traders and finance brokers.
  - 'International waters' are a hypothetical region where global traders operate and use international shipping services to ship goods from one region to the other. It also houses an international finance 'clearing house' that pools global savings and allocates the fund to investors located in every region.
  - Each region has a 'regional household'12 that collects all factor payments, taxes, net foreign borrowings, net repatriation of factor incomes due to foreign ownership and any net income from trading of emission permits.
- The income of the regional household is allocated across private consumption, government consumption and savings according to a Cobb-Douglas utility function, which, in practice, means that the share of income going to each component is assumed to remain constant in nominal terms.
- Private consumption of each commodity is determined by maximising utility subject to a Constant Difference of Elasticities (CDE) function which includes both price and income elasticities.
- Government consumption of each commodity is determined by maximising utility subject to a Cobb-Douglas utility function.
- Each region has *n* production sectors, each producing single products using various production functions where they aim to maximise profits (or minimise costs) and take all prices as given. The nature of the production functions chosen in the model means that producers exhibit constant returns to scale.
  - In general, each producer supplies consumption goods by combining an aggregate energy-primary factor bundle with other intermediate inputs and according to a Leontief production function (which in practice means that the quantity shares remain in fixed proportions). Within the aggregate energy-primary factor bundle, the individual energy commodities and primary factors are combined using a nested-CES (Constant Elasticity of Substitution) production function, in which energy and primary factor aggregates substitute according to a CES function with the individual energy commodities and individual primary factors substituting with their respective aggregates according to further CES production functions.
  - Exceptions to the above include the electricity generation, iron and steel and road transport sectors. These sectors employ the 'technology bundle' approach developed by ABARE (1996) in which non-homogenous technologies are employed to produce a homogenous output with the choice of technology governed by minimising costs according to a modified-CRESH production function. For example, electricity may be generated from a variety of technologies (including brown coal, black coal, gas, nuclear, hydro, solar etc.), iron and steel may be produced from blast furnace or electric arc technologies while road transport services may be supplied using a range of different vehicle technologies. The 'modified-CRESH' function differs from the traditional CRESH function by also imposing the condition that the quantity units are homogenous.
- There are four primary factors (land, labour, mobile capital and fixed capital). While labour and mobile capital are used by all production sectors, land is only used by agricultural sectors while the fixed capital is typically employed in industries with natural resources (such as fishing, forestry and mining) or in selected industries built by ACIL Allen.
- Land supply in each region is typically assumed to remain fixed through time with the allocation of land between sectors occurring to maximise returns subject to a Constant Elasticity of Transformation (CET) utility function.

[12] The term "regional household" was devised for the GTAP model. In essence it is an agent that aggregates all incomes attributable to the residents of a given region before distributing the funds to the various types of regional consumption (including savings).

— Mobile capital accumulates as a result of net investment. It is implicitly assumed in *Tasman Global* that it takes one year for capital to be installed. Hence, supply of capital in the current period depends on the last year's capital stock and investments made during the previous year.

— Labour supply in each year is determined by endogenous changes in population, given participation rates and a given unemployment rate. In policy scenarios, the supply of labour is positively influenced by movements in the real wage rate governed by the elasticity of supply. For countries where sub-regions have been specified (such as Australia), migration between regions is induced by changes in relative real wages with the constraint that net interregional migration equals zero. For regions where the labour market has been disaggregated to include occupations, there is limited substitution allowed between occupations by individuals supplying labour (according to a CET utility function) and by firms demanding labour (according to a CES production function) based on movements in relative real wages.

— The supply of fixed capital is given for each sector in each region.

The model has the option for these assumptions to be changed at the time of model application if alternative factor supply behaviours are considered more relevant.

— It is assumed that labour (by occupation) and mobile capital are fully mobile across production sectors implying that, in equilibrium, wage rates (by occupation) and rental rates on capital are equalised across all sectors within each region. To a lesser extent, labour and capital are mobile between regions through international financial investment and migration, but this sort of mobility is sluggish and does not equalise rates of return across regions.

— For most international regions, each consumer (private, government, industries and the local investment sector), consumption goods can be sourced either from domestic or imported sources. In any country which has disaggregated regions (such as Australian), consumption goods can also be sourced from other intrastate or interstate regions. In all cases, the source of non-domestically produced consumption goods is determined by minimising costs subject to a Constant Ratios of Elasticities of Substitution, Homothetic (CRESH) utility function. Like most other CGE models, a CES demand function is used to model the relative demand for domestically-produced commodities versus non-domestically produced commodities. The elasticities chosen for the CES and CRESH demand functions mean that consumers in each region have a higher preference for domestically produced commodities than non-domestic and a higher preference for intrastate or interstate produced commodities versus foreign.

— The capital account in *Tasman Global* is open. Domestic savers in each region purchase 'bonds' in the global financial market through local 'brokers' while investors in each region sell bonds to the global financial market to raise investible funds. A flexible global interest rate clears the global financial market.

— It is assumed that regions may differ in their risk characteristics and policy configurations. As a result, rates of return on money invested in physical capital may differ between regions and therefore may be different from the global cost of funds. Any difference between the local rates of return on capital and the global cost of borrowing is treated as the result of the existence of a risk premium and policy imperfections in the international capital market. It is maintained that the equilibrium allocation of investment requires the equalisation of changes in (as opposed to the absolute levels of) rates of return over the base year rates of return.

— Any excess of investment over domestic savings in a given region causes an increase in the net debt of that region. It is assumed that debtors service the debt at the interest rate that clears the global financial market. Similarly, regions that are net savers gives rise to interest receipts from the global financial market at the same interest rate.

— Investment in each region is used by the regional investor to purchase a suite of intermediate goods according to a Leontief production function to construct capital stock with the regional investor cost minimising by choosing between domestic, interstate and imported sources of each intermediate good via the CRESH production function. The regional cost of creating new capital stock versus the local rates of return on mobile capital is what determines the regional rate of return on new investment.

— In equilibrium, exports of a good from one region to the rest of world are equal to the import demand for that good in the remaining regions. Together with the merchandise trade balance, the net payments on foreign debt add up to the current account balance. *Tasman Global* does not require that the current account be in balance every year. It allows the capital account to move in a compensatory direction to maintain the balance of payments. The exchange rate provides the flexibility to keep the balance of payments in balance.

— Emissions of six anthropogenic greenhouse gases (namely, carbon dioxide, methane, nitrous oxide, HFCs, PFCs and SF_6) associated with economic activity are tracked in the model. Almost all sources and sectors are represented; emissions from agricultural residues and land-use change and forestry activities are not explicitly modelled but can be accounted for externally. Prices can be applied to emissions which are converted to industry-specific production taxes or commodity-specific sales taxes that impact on demand. Abatement technologies similar to those adopted in Australian Government (2008) are available and emission quotas can be set globally or by region along with allocation schemes that enable emissions to be traded between regions.

More detail regarding specific elements of the model structure are discussed in the following sections.

A.4 Population growth and labour supply

Population growth is an important determinant of economic growth through the supply of labour and the demand for final goods and services. Population growth for each region represented in the *Tasman Global* database is projected using ACIL Allen's in-house demographic model. The demographic model projects how the population in each region grows and how age and gender composition changes over time and is an important tool for determining the changes in regional labour supply and total population over the projection period.

For each of region, the model projects the changes in age-specific birth, mortality and net migration rates by gender for 101 age cohorts (0-99 and 100+). The demographic model also projects changes in participation rates by gender by age for each region, and, when combined with the age and gender composition of the population, endogenously projects the future supply of labour in each region. Changes in life expectancy are a function of income per person as well as assumed technical progress on lowering mortality rates for a given income (for example, reducing malaria-related mortality through better medicines, education, governance etc.). Participation rates are a function of life expectancy as well as expected changes in higher education rates, fertility rates and changes in the work force as a share of the total population.

Labour supply is derived from the combination of the projected regional population by age by gender and the projected regional participation rates by age by gender. Over the projection period labour supply in most developed economies is projected to grow slower than total population as a result of ageing population effects.

For the Australian states and territories, the projected aggregate labour supply from ACIL Allen's demographics module is used as the base level potential workforce for the detailed Australian labour market module, which is described in the next section.

A.4.1 The Australian labour market

Tasman Global has a detailed representation of the Australian labour market which has been designed to capture:

— different occupations

— changes to participation rates (or average hours worked) due to changes in real wages

— changes to unemployment rates due to changes in labour demand

— limited substitution between occupations by the firms demanding labour and by the individuals supplying labour, and

— limited labour mobility between states and regions within each state.

Tasman Global recognises 97 different occupations within Australia – although the exact number of occupations depends on the aggregation. The firms who hire labour are provided with some limited scope to change between these 97 labour types as the relative real wage between them changes. Similarly, the individuals supplying labour have a limited ability to change occupations in response to the changing relative real wage between occupations. Finally, as the real wage for a given occupation rises in one state relative to other states, workers are given some ability to respond by shifting their location. The model produces results at the 97 3-digit ANZSCO (Australian New Zealand Standard Classification of Occupations) level which are presented in Table A.2.

The labour market structure of *Tasman Global* is thus designed to capture the reality of labour markets in Australia, where supply and demand at the occupational level do adjust, but within limits.

Labour supply in *Tasman Global* is presented as a three-stage process:

13. labour makes itself available to the workforce based on movements in the real wage and the unemployment rate;
14. labour chooses between occupations in a state based on relative real wages within the state; and
15. labour of a given occupation chooses in which state to locate based on movements in the relative real wage for that occupation between states.

By default, *Tasman Global*, like all CGE models, assumes that markets clear. Therefore, overall, supply and demand for different occupations will equate (as is the case in other markets in the model).

TABLE A.2 OCCUPATIONS IN THE *TASMAN GLOBAL* DATABASE, ANZSCO 3-DIGIT LEVEL (MINOR GROUPS)

ANZSCO code, Description	ANZSCO code, Description	ANZSCO code, Description
1. MANAGERS 111 Chief Executives, General Managers and Legislators 121 Farmers and Farm Managers 131 Advertising and Sales Managers 132 Business Administration Managers 133 Construction, Distribution and Production Managers 134 Education, Health and Welfare Services Managers 135 ICT Managers 139 Miscellaneous Specialist Managers 141 Accommodation and Hospitality Managers 142 Retail Managers 149 Miscellaneous Hospitality, Retail and Service Managers **2. PROFESSIONALS** 211 Arts Professionals 212 Media Professionals 221 Accountants, Auditors and Company Secretaries 222 Financial Brokers and Dealers, and Investment Advisers 223 Human Resource and Training Professionals 224 Information and Organisation Professionals 225 Sales, Marketing and Public Relations Professionals 231 Air and Marine Transport Professionals 232 Architects, Designers, Planners and Surveyors 233 Engineering Professionals 234 Natural and Physical Science Professionals 241 School Teachers 242 Tertiary Education Teachers 249 Miscellaneous Education Professionals 251 Health Diagnostic and Promotion Professionals 252 Health Therapy Professionals 253 Medical Practitioners 254 Midwifery and Nursing Professionals 261 Business and Systems Analysts, and Programmers 262 Database and Systems Administrators, and ICT Security Specialists 263 ICT Network and Support Professionals 271 Legal Professionals 272 Social and Welfare Professionals	**3. TECHNICIANS & TRADES WORKERS** 311 Agricultural, Medical and Science Technicians 312 Building and Engineering Technicians 313 ICT and Telecommunications Technicians 321 Automotive Electricians and Mechanics 322 Fabrication Engineering Trades Workers 323 Mechanical Engineering Trades Workers 324 Panel beaters, and Vehicle Body Builders, Trimmers and Painters 331 Bricklayers, and Carpenters and Joiners 332 Floor Finishers and Painting Trades Workers 333 Glaziers, Plasterers and Tilers 334 Plumbers 341 Electricians 342 Electronics and Telecommunications Trades Workers 351 Food Trades Workers 361 Animal Attendants and Trainers, and Shearers 362 Horticultural Trades Workers 391 Hairdressers 392 Printing Trades Workers 393 Textile, Clothing and Footwear Trades Workers 394 Wood Trades Workers 399 Miscellaneous Technicians and Trades Workers **4. COMMUNITY & PERSONAL SERVICE** 411 Health and Welfare Support Workers 421 Child Carers 422 Education Aides 423 Personal Carers and Assistants 431 Hospitality Workers 441 Defence Force Members, Fire Fighters and Police 442 Prison and Security Officers 451 Personal Service and Travel Workers 452 Sports and Fitness Workers	**5. CLERICAL & ADMINISTRATIVE** 511 Contract, Program and Project Administrators 512 Office and Practice Managers 521 Personal Assistants and Secretaries 531 General Clerks 532 Keyboard Operators 541 Call or Contact Centre Information Clerks 542 Receptionists 551 Accounting Clerks and Bookkeepers 552 Financial and Insurance Clerks 561 Clerical and Office Support Workers 591 Logistics Clerks 599 Miscellaneous Clerical and Administrative Workers **6. SALES WORKERS** 611 Insurance Agents and Sales Representatives 612 Real Estate Sales Agents 621 Sales Assistants and Salespersons 631 Checkout Operators and Office Cashiers 639 Miscellaneous Sales Support Workers **7. MACHINERY OPERATORS & DRIVERS** 711 Machine Operators 712 Stationary Plant Operators 721 Mobile Plant Operators 731 Automobile, Bus and Rail Drivers 732 Delivery Drivers 733 Truck Drivers 741 Storepersons **8. LABOURERS** 811 Cleaners and Laundry Workers 821 Construction and Mining Labourers 831 Food Process Workers 832 Packers and Product Assemblers 839 Miscellaneous Factory Process Workers 841 Farm, Forestry and Garden Workers 851 Food Preparation Assistants 891 Freight Handlers and Shelf Fillers 899 Miscellaneous Labourers

SOURCE: ABS (2009), ANZSCO – AUSTRALIAN AND NEW ZEALAND STANDARD CLASSIFICATIONS OF OCCUPATIONS, FIRST EDITION, REVISION 1, ABS CATALOGUE NO. 1220.0.

Labour market database

The *Tasman Global* database includes a detailed representation of the Australian labour market which has been designed to capture the supply and demand for different skills and occupations by industry. To achieve this, the Australian workforce is characterised by detailed supply and demand matrices.

On the supply side, the Australian population is characterised by a five-dimensional matrix consisting of:

— 7 post-school qualification levels
— 12 main qualification fields of highest educational attainment
— 97 occupations
— 101 age groups (namely 0 to 99 and 100+)
— 2 genders.

The data for this matrix is measured in persons and was sourced from the ABS 2011 Census. As the skills elements of the database and model structure have not been used for this project, it will be ignored in this discussion.

The 97 occupations are those specified at the 3-digit level (or Minor Groups) under the Australian New Zealand Standard Classification of Occupations (ANZSCO) (see Table A.2).

On the demand side, each industry demands a particular mix of occupations. This matrix is specified in units of full-time equivalent (FTE) jobs where an FTE employee works an average of 37.5 hours per week. Consistent with the labour supply matrix, the data for FTE jobs by occupation by industry was also sourced from the ABS 2011 Census and updated using the latest labour force statistics.

Matching the demand and supply side matrices means that there is the implicit assumption that the average hours per worker are constant, but it is noted that mathematically changes in participation rates have the same effect as changes in average hours worked.

A.4.2 Labour market model structure

In the model, the underlying growth of each industry in the Australian economy results in a growth in demand for a particular set of skills and occupations. In contrast, the supply of each set of skills and occupations in a given year is primarily driven by the underlying demographics of the resident population. This creates a market for each skill by occupation that (unless specified otherwise) needs to clear at the start and end of each time period.[13] The labour markets clear by a combination of different prices (i.e. wages) for each labour type and by allowing a range of demand and supply substitution possibilities, including:

— changes in firms demand for labour driven by changes in the underlying production technology:
  – for technology bundle industries (electricity, iron and steel and road transportation) this occurs due to changes between explicitly identified alternative technologies
  – for non-technology bundle industries this includes substitution between factors (such as labour for capital) or energy for factors
— changes to participation rates (or average hours worked) due to changes in real wages
— changes in the occupations of a person due to changes in relative real wages
— substitution between occupations by the firms demanding labour due to changes in the relative costs
— changes to unemployment rates due to changes in labour demand, and
— limited labour mobility between states due to changes in relative real wages.

All of the labour supply substitution functions are modified-CET functions in which people supply their skills, occupation and rates of participation as a positive function of relative wages. However, unlike a standard CET (or CES) function, the functions are 'modified' to enforce an additional constraint that the number of people is maintained before and after substitution.[14]

13 For example, at the start and end of each week for this analysis. *Tasman Global* can be run with different steps in time, such as quarterly or bi-annually in which case the markets would clear at the start and end of these time points.
14 As discussed in Dixon et al (1997), a standard CES/CET function is defined in terms of *effective units*. Quantitatively this means that, when substituting between, say, X_1 and X_2 to form a total quantity X using a CET function a simple summation generally does not actually

Although technically solved simultaneously, the labour market in *Tasman Global* can be thought of as a five-stage process:

1. labour makes itself available to the workforce based on movements in the real wage (that is, it actively participates with a certain number of average hours worked per week)
2. the age, gender and occupations of the underlying population combined with the participation rate by gender by age implies a given supply of labour (the potentially available workforce)
3. a portion of the potentially available workforce is unemployed implying a given available labour force
4. labour chooses to move between occupations based on relative real wages
5. industries alter their demands for labour as a whole and for specific occupations based on the relative cost of labour to other inputs and the relative cost of each occupation.

By default, *Tasman Global*, like all CGE models, assumes that markets clear at the start and end of each period. Therefore, overall, supply and demand for different occupations will equate (as is the case in other markets in the model). In principle, (subject to zero starting values) people of any age and gender can move between any of the 97 occupations while industries can produce their output with any mix of occupations. However, in practice the combination of the initial database, the functional forms, low elasticities and moderate changes in relative prices for skills, occupations etc. means that there is only low to moderate change induced by these functions. The changes are sufficient to clear the markets, but not enough to radically change the structure of the workforce in the timeframe of this analysis.

Factor-factor substitution elasticities in non-technology bundle industries are industry specific and are the same as those specified in the GTAP database[15], while the fuel-factor and technology bundle elasticities are the same as those specified in GTEM.[16] The detailed labour market elasticities are ACIL Allen assumptions, previously calibrated in the context of the model framework to replicate the historical change in the observed Australian labour market over a five year period[17]. The unemployment rate function in the policy scenarios is a non-linear function of the change in the labour demand relative to the reference case with the elasticity being a function of the unemployment rate (that is, the lower the unemployment rate the lower the elasticity and the higher the unemployment rate the higher the elasticity).

A.5 Detailed energy sector and linkage to *PowerMark* and *GasMark*

Tasman Global contains a detailed representation of the energy sector, particularly in relation to the interstate (trade in electricity and gas) and international linkages across the regions represented. To allow for more detailed electricity sector analysis, and to aid in linkages to bottom-up models such as ACIL Allen's *GasMark* and *PowerMark* models electricity generation is separated from transmission and distribution in the model. In addition, the electricity sector in the model employs a 'technology bundle' approach that separately identifies up to twelve different electricity generation technologies:

1. brown coal (with and without carbon capture and storage)
2. black coal (with and without carbon capture and storage)
3. petroleum
4. base load gas (with and without carbon capture and storage)
5. peak load gas
6. hydro
7. geothermal
8. nuclear

equal X. Use of these functions is common practice in CGE models when substituting between substantially different units (such as labour versus capital or imported versus domestic services) but was not deemed appropriate when tracking the physical number of people. Such 'modified' functions have long been employed in the technology bundles of *Tasman Global* and GTEM. The Productivity Commission have proposed alternatives to the standard CES to overcome similar and other weaknesses when applied to internationally traded commodities.

[15] Narayanan et al. (2012).

[16] Pant (2007).

[17] This method is a common way of calibrating the economic relationships assumed in CGE models to those observed in the economy. See for example Dixon and Rimmer (2002).

9. biomass
10. wind
11. solar
12. other renewables.

To enable more accurate linking to *PowerMark* the generation cost of each technology is assumed to be equal to their long run marginal cost (LRMC) while the sales price in each region is matched to the average annual dispatch weighted prices projected by *PowerMark* – with any difference being returned as an economic rent to electricity generators. Fuel use and emissions factors by each technology are also matched to those projected in *PowerMark*. This representation enables the highly detailed market based projections from *PowerMark* to be incorporated as accurately as possible into *Tasman Global*.

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