ACIL ALLEN

18 May 2021

Report to BEYOND ZERO EMISSIONS

Regional Economic Impact Analysis of Renewable Energy Industrial Precincts

Hunter Valley REIP

About ACIL Allen

ACIL Allen is a leading independent economics, policy, and strategy advisory firm, dedicated to helping clients solve complex issues. Our purpose is to help clients make informed decisions about complex economic and public policy issues. Our vision is to be Australia's most trusted economics, policy, and strategy advisory firm. We are committed and passionate about providing rigorous independent advice that contributes to a better world.

Beyond Zero Emissions

Beyond Zero Emissions (BZE) maintains an office on the traditional lands of the Wurundjeri-willam people of the Kulin Nations with staff contributing to this work from the lands of the Bunurong, Wadawurrung, Worimi, Eora and Meanjin peoples. BZE pays their respects to all First Nations Elders past, present and those emerging. BZE would like to acknowledge WWF Australia as a joint funder on this report. BZE would also like to thank the invaluable contributions from industry stakeholders, and it network of expert volunteers

Suggested citation for this report

ACIL Allen (2021) Economic Impact Analysis of Renewable Energy Industrial Precincts – Hunter Valley REIP, Prepared for the Beyond Zero Emissions. May 2021.

Contents

Figures

Contents

Executive summary

Introduction

Beyond Zero Emissions (BZE) commissioned ACIL Allen to estimate the potential economic impact of the Hunter Valley Renewable Energy Industrial Precinct (REIP) in the jurisdiction that it is located (Hunter Valley), the rest of New South Wales and on the Australian economy as a whole.

The REIP

According to BZE, REIPs will support a cluster of manufacturers powered by 100 per cent renewable energy. These precincts will either be located within REZ or connected to renewable energy generation through high voltage transmission lines. The potential capital and operational expenses of the Hunter Valley REIP is summarised in **Table ES 1**.

It is estimated that the shared infrastructure of the REIP would incur capital investment of $8.5 billion (excluding renewable electricity generation); this includes investment in storage/firming facilities, transmission lines, freight networks and export infrastructure. It is expected that a range of new activities will be potentially base their location in the region because of the presence of the REIP. Currently, these include:

— **Resource Recovery —** Circular economy, recycling, turning waste into products

— **Battery Manufacturing —** Manufacture of batteries, primarily Li-ion

— **Renewable hydrogen —** Production of hydrogen through renewables

— **Renewable Steel —** Production of steel via renewable hydrogen and electricity

— **Downstream renewable steel —** Value added steel via coatings/painting/metal forming etc.

— **Low carbon building materials —** Building materials made from fly-ash, low carbon processes and other new technologies

Table ES 1 Potential capital and gross operating surplus

	Total capital investment	Annual operational profits
	A$m	A$m
REIP infrastructure (excluding renewable electricity generation)	8,550	481
Potential new industries	19,353	1,088
TOTAL	**27,903**	**1,570**

Note: Asset life of 45 years with 5 per cent return is assumed to generate profit to meet the capital commitments.

Source: ACIL Allen estimates based on BZE data and assumptions

Additional capital will be incurred to base the above manufacturing firms in the Hunter Valley REIP. It is estimated that the additional investment to establish these new manufacturing activities will be around $19,353 million. The combined total expected investment in the region will therefore be around $27,903 million.

Given the preliminary nature of the discussions with potential participants in the REIP, the scheduling of the investment activities and the ramp-up of operations is uncertain.

The estimated revenue from the above new activities is summarised in **Figure ES 1**. They are based on public announcements and stakeholder engagement. By 2032, the revenue estimated from these new manufacturing activities is expected to total around $11 billion a year.

Figure ES 1 Estimated revenue from new manufacturing activities

Source: ACIL Allen estimates based on BZE data and assumptions

In addition, existing high energy intensive businesses such as steel, aluminium and chemical production would maintain their production in the region. The revenue of existing energy intensive manufacturing industries that will be supported by the REIP is conservatively estimated at around $6 billion.

Economic impact analysis

To estimate the potential net economic impacts of the REIP (excluding renewable generation), new manufacturing activities — hydrogen, steel, resource recovery, battery manufacturing and fly ash — and maintaining existing high energy intensive manufacturing activities, ACIL Allen employed its Computable General Equilibrium (CGE) model, *Tasman Global*. It is a regional economic model with detailed supply chain relationships within the region, rest of Australia, and the rest of the world. ACIL Allen has employed this model for many similar economic impact assessments for private and government clients over the past twenty years.

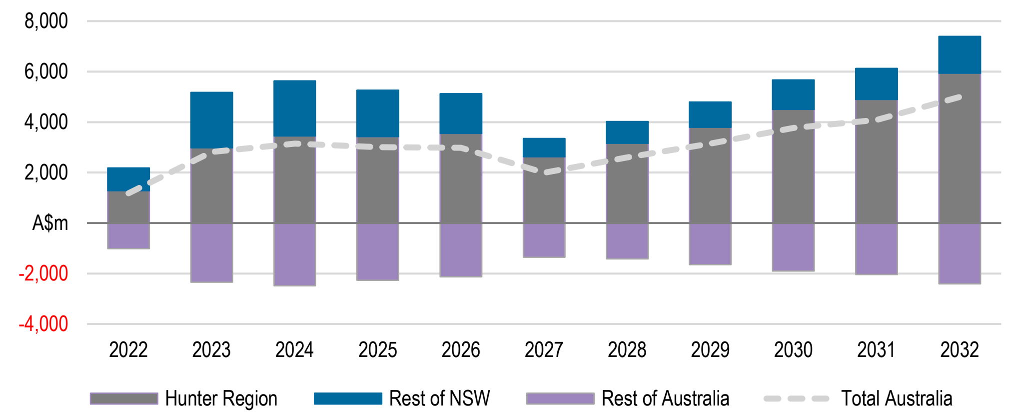
The estimated macroeconomic and employment impacts of the REIP and its supported existing and new activities are summarised below.

Real income impacts

A rise in real income indicates a rise in the capacity of residents to purchase goods and services and also to accumulate wealth in the form of financial and other assets. The change in real income arising from REIP and supporting industries is a measure of the change in the well-being of residents in the region.

Figure ES 2 shows the projected potential real income impact for the Hunter Valley region, the rest of NSW and the rest of Australia between the 2022 and 2032 financial years. This includes construction phase of the REIP infrastructure to 2025 and operation of the REIP, new industries and the sustainment of existing energy intensive industries in the region.

Figure ES 2 Real income impacts relative to a Reference Case, 2022–2032



Note: All dollars are in 2020 prices. Net impact of the REIP at Australia level is positive after accounting for labour mobility between the regions as a result of the REIP. It is assumed in this study that there will be a no change in net overseas migration as a result of the REIP.

Source: ACIL Allen modelling based on BZE data and assumptions

Table ES 2 Real income impacts relative to a Reference Case, 2022–2032

Regions	Annual average	Total (2022-2032)	Impact at 2032	NPV at 3%	NPV at 7%
	$2020, A$m	$2020, A$m	$2020, A$m	$2020, A$m	$2020, A$m
Hunter Valley	3,602	39,627	5,941	33,459	27,247
Rest of New South Wales	1,373	15,104	1,458	13,254	11,341
Rest of Australia	-1,909	-21,001	-2,403	-18,143	-15,220
Australia	3,066	33,731	4,996	28,570	23,368

Source: ACIL Allen modelling based on BZE data and assumptions

Over the period 2022 to 2032, the REIP is projected to increase the real income of:

— Hunter Valley *region residents* by a cumulative total of $39,627 million relative to the Reference Case (with a net present value of $27,247 million, using a 7 per cent real discount rate)

— *Rest of NSW residents* by a cumulative total of $15,104 million relative to the Reference Case (with a net present value of $11,341 million, using a 7 per cent real discount rate)

— *Rest of Australian residents* by a cumulative total of -$-21,001 million relative to the Reference Case (with a net present value of -$15,220 million, using a 7 per cent real discount rate).

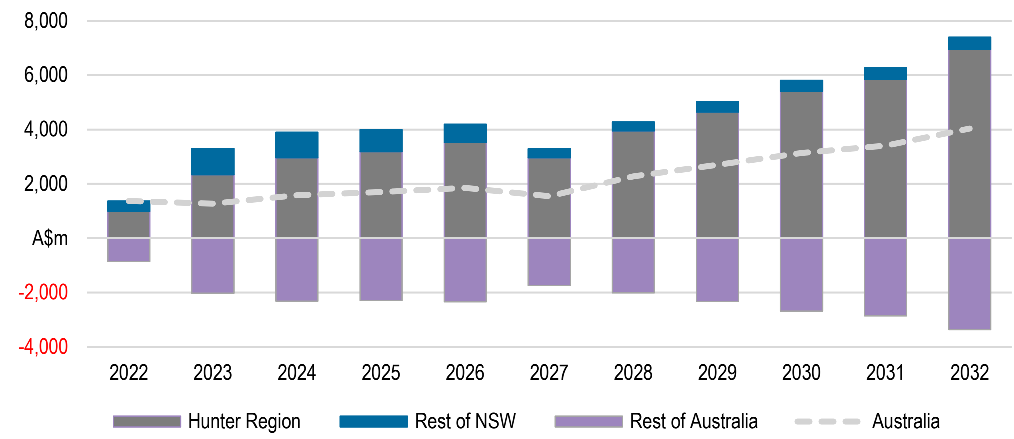
— *Total Australian residents* by a cumulative total of 33,731 million relative to the Reference Case (with a net present value of $23,368 million, using a 7 per cent real discount rate)

To place these projected changes in income in perspective, the discounted present values (using a 7 per cent real discount rate) are equivalent to a one-off increase in the *average* annual real income of all residents of Hunter Valley region by approximately $4,133 per person. This is a noticeable increase in real income of the residents.[1]

Real economic output impacts

Real economic output (real GDP) is one of the primary indicators used to estimate the economic impacts of a project. At the state level, this measure is defined as Gross State Product (GSP) and at the regional level, it is defined as Gross Regional Product (GRP). The projected changes in real economic output as a result of the REIP and related activities are presented in **Figure ES 3**.

Figure ES 3 Real economic output impacts relative to a Reference Case, 2022–2032



Note: All dollars are in 2020 prices.
Source: ACIL Allen modelling based on BZE data and assumptions

Table ES 3 Real economic output impacts relative to a Reference Case, 2022–2032

Regions	Annual average	Total (2022-2032)	Impact at 2032	NPV at 3%	NPV at 7%
	$2020, A$m	$2020, A$m	$2020, A$m	$2020, A$m	$2020, A$m
Hunter Valley	3,884	42,726	6,947	35,629	28,523
Rest of New South Wales	553	6,078	453	5,384	4,659
Rest of Australia	-2,254	-24,796	-3,366	-21,057	-17,274
Australia (GDP)	2,183	24,008	4,035	19,956	15,908

Source: ACIL Allen modelling based on BZE data and assumptions

Over the period 2022 to 2032, the REIP and related activities is projected to increase the real economic output of:

— Hunter Valley *region* (i.e. real GRP) by a cumulative total of $42,726 million relative to the Reference Case (with a net present value of $28,523 million, using a 7 per cent real discount rate)[2]

— *Rest of NSW* (i.e. real GSP) by a cumulative total of $6,078 million relative to the Reference Case (with a net present value of $4,659 million, using a 7 per cent real discount rate)

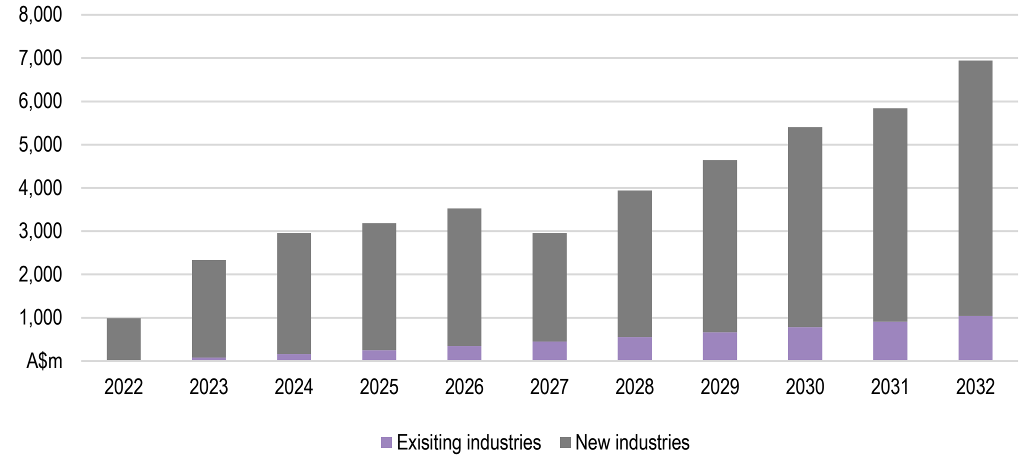
[1] According to ABS, estimated residential population of Hunter region (Hunter Valley including Newcastle and Lake Macquarie) in 2019 was 659,271.

[2] A 7 per cent real discount rate is based on the OBPR Guidelines on evaluation of projects.

— Rest of Australia would benefit to the extent that there is no crowding out effects related to the REIP.

To place these projected changes in economic output estimates in perspective, the discounted present values (using a 7 per cent discount rate) are equivalent to an annual additional increase of 0.45 per cent of Hunter Valley region's GRP, and nearly 0.08 per cent of rest of NSW's GSP for next 10 years.

Figure ES 4 Real economic output impacts in the Hunter Valley region by industry, 2022–2032



Note: All dollars are in 2020 prices.
Source: ACIL Allen modelling based on BZE data and assumptions

Employment impacts

The employment impacts from the REIP and related activities are shown in **Figure ES 5** and **Table ES 4**.

Table ES 4 Employment impacts relative to a Reference Case, 2022–2032

Regions	Annual average	Employment in 2032	Total (2022-2032)
	FTE	FTE	Employee years
Hunter Valley	23,415	33,958	257,568
Rest of New South Wales	2,271	-231	24,976
Rest of Australia	-9,621	-12,904	-105,827
Australia	16,065	20,822	176,717

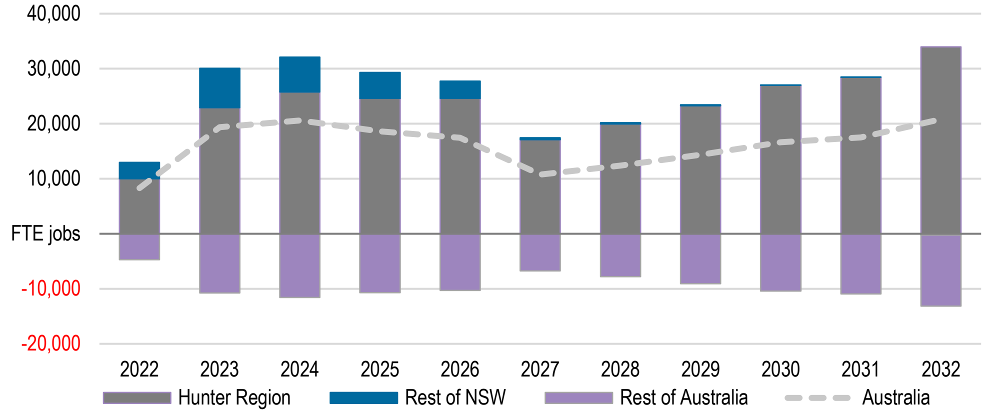
Source: ACIL Allen modelling based on BZE data and assumptions

As a result of the REIP and related activities, it is projected that full time equivalent employment within the:

— Hunter Valley Region will increase by a cumulative total of 257,568 additional employee years between 2022 and 2032 (or an annual average of 23,415 FTE jobs)

— Rest of NSW will increase by a cumulative total of 24,976 additional employee years between 2022 and 2032 (or an annual average of 2,271 FTE jobs a year)

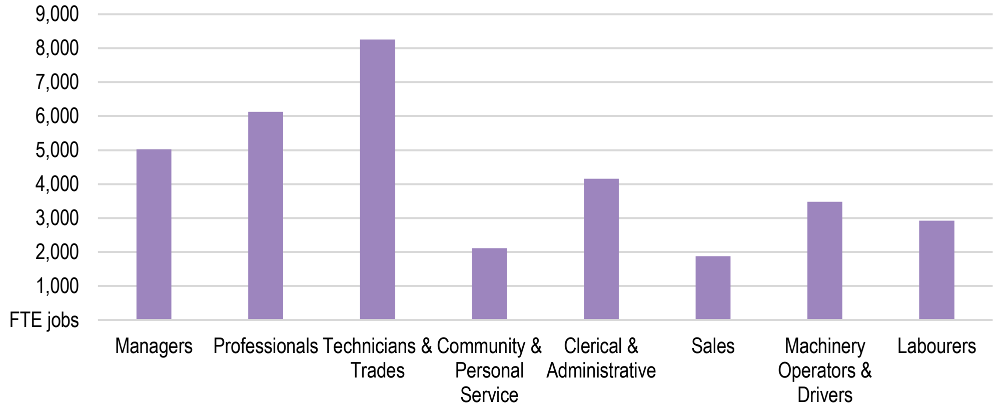
Figure ES 5 Employment impacts relative to a Reference Case, 2022–2032



Source: ACIL Allen modelling based on BZE data and assumptions

Employment by key occupations in 2032 is summarised in **Figure ES 6**. It is estimated that there will be a demand for both skilled and unskilled occupations in the Hunter region.

Figure ES 6 Impact on occupations in Hunter Valley in 2032



Source: ACIL Allen modelling based on BZE data and assumptions

Introduction 1

1.1 Background

Beyond Zero Emissions (BZE) is an internationally recognised think tank that provide approaches prosper in a zero-emissions economy. To accelerate policy change, BZE publishes research on technological solutions that unlock huge economic potential for industries, regions and communities.

BZE and WWF released a joint paper in 2020 on "*Renewable Energy Industrial Precincts (REIP)*", highlighting the opportunities and identifying a number of potential REIPs.

REIPs will be located in regional Australia where there is an existing manufacturing base with supporting infrastructure such as transport connections (port, rail and road) brownfield land and technically skilled workforce. Key identified REIPs are provided in **Table 1.1**.

The precincts will be designed for energy intensive businesses such as aluminium smelting, steel and other metal processing, hydrogen production, chemical production, recycling and data centres. The precincts could provide security to existing high energy intensive manufacturers and attract new businesses. They could also provide a base for companies making clean low emission technologies such as wind turbines, batteries, electric vehicle chargers, electric buses and mining equipment.

Table 1.1 Potential REIPs

REIP name	Location
Bell Bay	Tasmania
Collie	Western Australia
Fitzroy and Wide Bay	Queensland
Gladstone (Central Queensland)	Queensland
Kwinana	Western Australia
Latrobe Valley	Victoria
Hunter Valley	New South Wales
Port Kembla	New South Wales
Portland	Victoria
Townsville	Queensland
Whyalla	South Australia

Source: BZE-WWF (2020), Renewable Energy Industrial Precincts, Briefing Paper, September 2020 and update

1.2 Hunter Valley REIP

This report's focus is on the Hunter Valley REIP. The Hunter region of New South Wales has been a powerhouse of Australian mining and energy exports. The region is also well known for manufacturing, and energy-intensive industries such as aluminium and steel. It is currently diversifying its energy sources to use more renewables — wind and solar sources — from the region.

The Hunter Valley could offer several advantages as a REIP:

- excellent air, rail and transmission infrastructure as well as a deep-water port
- a skilled and large workforce
- proximity to Renewable Energy Zones
- strong existing trade relationships with Asia, especially Japan and Korea
- has been selected as a Hydrogen Technology Cluster
- hosts the NSW Energy and Resources Knowledge Hub
- has powerful research capability with strong ties to industry
- the NSW government is actively seeking new industry opportunities.

1.2.1 Renewable energy supply

The NSW Government's Electricity Infrastructure Roadmap has identified the Hunter as a Renewable Energy Zone (REZ). The Hunter REZ has an excellent existing transmission infrastructure that can enable access to local renewable generation.

New transmission infrastructure is planned to connect to both the Central West Orana REZ (3GW) and New England REZ (8GW).

By 2030, the Hunter region will have access to in excess of 11GW of renewable energy.

1.2.2 Existing manufacturing base

Some key manufacturers currently operating in the Hunter currently include:

- Tomago Aluminium
- Orica
- Molycop
- Infrabuild.

However, to remain competitive these businesses need access to cheaper energy.

Figure 1.1 presents an overview of one possible configuration of a REIP in the Hunter Valley. It is a vision of a low-cost energy hub that makes existing heavy industry internationally competitive and supports the growth of new industry. The system is based around Aluminium, which consumes 12 per cent of NSW's electricity as noted by BZE. Its key features are:

- Renewable Energy
  - Renewable Energy Zone with >2 GW solar and wind, supplying electricity at a competitive price.
  - Guaranteed (firm) supply to Aluminium smelter of 800-900 MW.
- Demand side participation – market mechanisms and smart grid technologies to allow manufacturers to load shift where sensible providing flexibility and valuable grid services as an additional source of revenue.

— Renewable hydrogen
  — Excess electricity used to power an electrolyser to make hydrogen (for ammonia).
  — Other local manufacturers use additional excess electricity and waste heat from smelter.

The technical and economic details of this system would need to be assessed in a feasibility study. But in principle, this plan could be largely funded by the private sector.

The Hunter's existing expertise in developing and manufacturing defence and mining equipment provides a good platform for expanding in other advanced manufacturing industries. For example, local company Ampcontrol was built on providing electronic solutions for the mining sector and is now applying their advanced manufacturing capability to innovations such as standalone power systems, remote water filtration, hybrid electric boats, electric vehicles and even emergency ventilators to support NSW Health during the COVID crisis. [3]

Local company 3ME Technology develops and manufactures batteries for mining vehicles. They collaborated with a local mining equipment specialist called BME to retrofit the Tritev, a diesel-powered 20-tonne Integrated Tool Carrier. This vehicle provides superior performance in the underground mine environment and there is an influx of demand from the industry. This battery retrofit template could be applied to other transport including zero-emissions buses, waste trucks and even ferries.

In addition, the Hunter has a strong capability in the aluminium, steel recycling, and medical technology industries.

Across the Hunter, community and industry groups, businesses, researchers and state and local government agencies are working to secure new manufacturing, new markets, and new ways to export energy. This includes renewable hydrogen, green steel, green aluminium, green minerals processing and products manufactured with 100 per cent Australian renewable energy.

1.2.3 New potential activities

BZE identified the following potential new activities in the REIP which could benefit from the low-cost renewable energy sources in addition to supporting the existing manufacturing base. They include:

— **Resource Recovery:** Circular economy, recycling, turning waste into products
— **Battery Manufacturing:** Manufacture of batteries, primarily Li-ion
— **Hydrogen:** Production of hydrogen through electrolysis, powered by renewables
— **Green Steel:** Production of green steel via renewable hydrogen and electricity
— **Downstream green steel:** Value added green steel via coatings/painting/metal forming etc.
— **Low carbon building materials:** Building materials made from fly-ash, low carbon processes and other new technologies

The economic and employment impacts of the above new activities and sustainment of the existing manufacturing base in the region are assessed in this report.

[3] https://bze.org.au/repowering-australian-manufacturing/the-hunter/

Potential new activities in the REIP 2

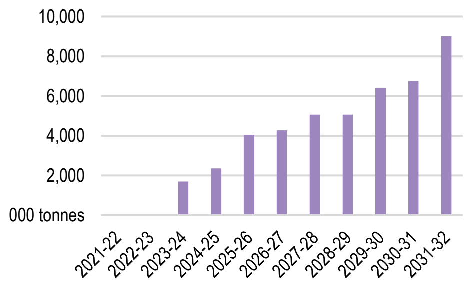
The estimated production and revenue of new activities are summarised in this chapter.

2.1 Renewable steel

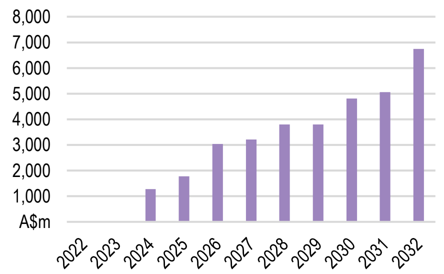
It is estimated that the potential production volumes of renewable steel produced from renewable sources will be around 9 million tonnes in 2032. An indicative profile of the estimated production and revenue is provided in **Figure 2.1**. It is estimated that the revenue from the renewable steel production will be around $6,750 million in 2032.

Figure 2.1 Estimated renewable steel production and revenue

Production



Revenue



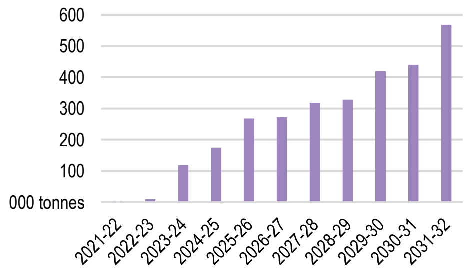
Source: ACIL Allen estimates based on BZE data and assumptions

2.2 Renewable hydrogen

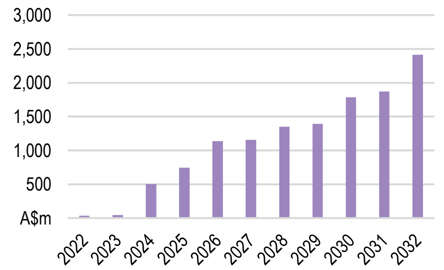
It is estimated that around 570,000 tonnes of hydrogen could be produced in the REIP in 2032. An indicative profile of the estimated production and revenue is provided in **Figure 2.2**. It is estimated that the revenue from this renewable hydrogen will be $2,416 million in 2032.

Figure 2.2 Estimated renewable hydrogen production and revenue

Production



Revenue

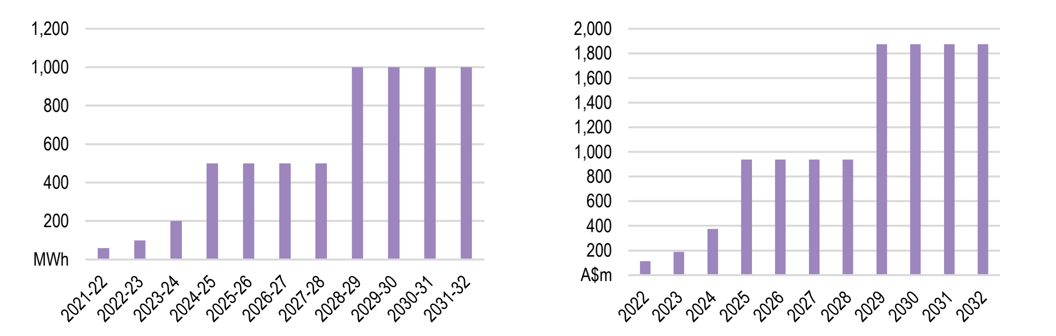


Source: ACIL Allen estimates based on BZE data and assumptions

2.3 Battery manufacturing

It is estimated that the battery storage production capacity of 1,000MWh in 2032 in the region. An indicative profile of the estimated production and revenue is provided in **Figure 2.3**. It is estimated that the revenue from the battery manufacturing will be $1,876 million in 2032.

Figure 2.3 Estimated battery manufacturing and revenue

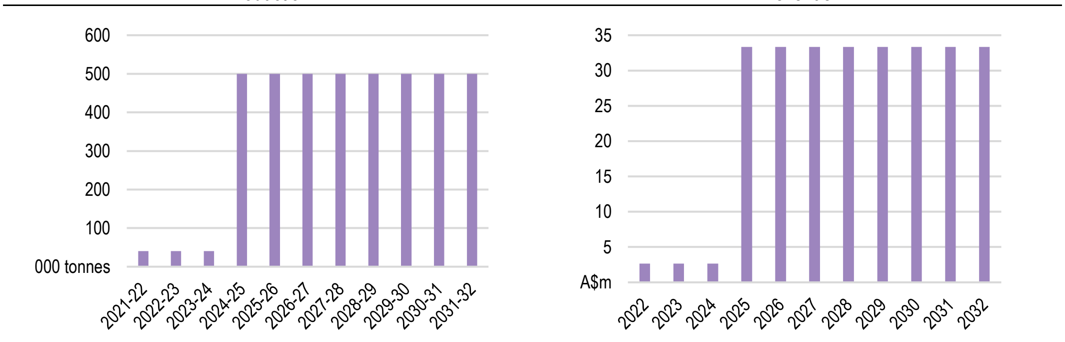


Source: ACIL Allen estimates based on BZE data and assumptions

2.4 Low carbon building material

An indicative profile of the estimated production and revenue from low carbon building material is provided in **Figure 2.4**. It is estimated that the revenue from the fly ash will be around $33 million in 2032.

Figure 2.4 Estimated low carbon building material production and revenue

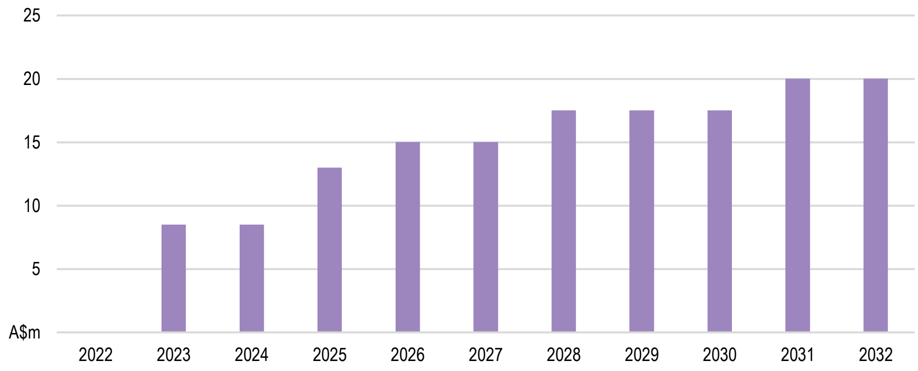


Source: ACIL Allen estimates based on BZE data and assumptions

2.5 Resource recovery projects

Currently, two resource recovery projects have identified in the region. An indicative profile of the estimated revenue from these two projects are provided in **Figure 2.5**. It is estimated that the revenue from the resource recovery projects will be around $20 million in 2032.

Figure 2.5 Estimated resource recovery projects revenue

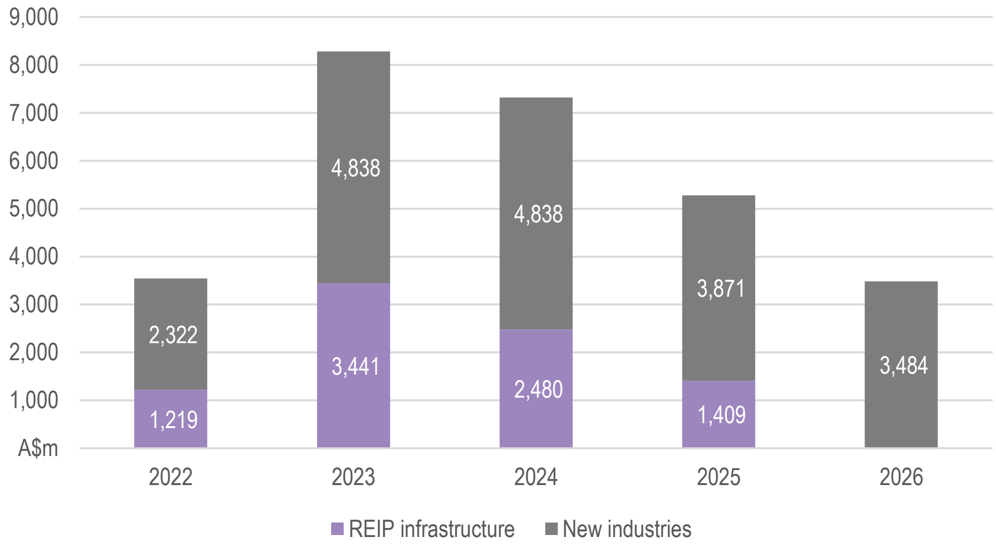


Source: ACIL Allen estimates based on BZE data and assumptions

2.6 Investment

Substantial investment will be required to produce the above new products. It is estimated that the investment required to undertake the above new activities including the supporting REIP infrastructure (but not the upstream renewable electricity generation) will be around $20 billion. An indicative investment profile is provided in **Figure 2.6**.

Figure 2.6 An indicative investment profile



Note: Asset life of 45 years with 5 per cent return is assumed to generate profit to meet the capital commitments.
Source: ACIL Allen estimates based on BZE data and assumptions

Economic impact assessment of REIP

3

3.1 Economic impact model

ACIL Allen's *Tasman Global* regional CGE model, has been used to estimate the economic impacts of the scenario on the economies of each local region, state and on the Australian economy. This ensure that broader factors (productivity of labour, profitability, taxation payments, etc.) are also taken into consideration when assessing the impact of REIPs. See **Appendix A** for more details.

Tasman Global is a model that estimates relationships between variables at different points in time. This contrasts with comparative static models, which compare two equilibriums (one before a policy change and one following).

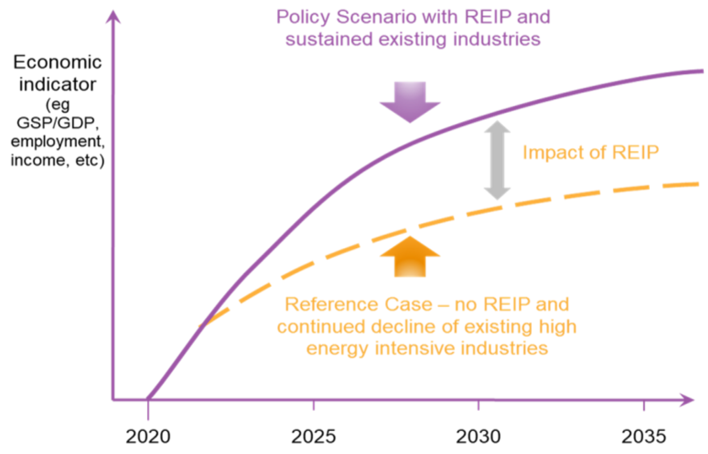
A dynamic model such as *Tasman Global* is beneficial when analysing issues where both the timing of impacts and the adjustment path that economies follow are relevant in the analysis. In applications of the *Tasman Global* model, a Reference Case simulation provides a 'business-as-usual' scenario against which to compare the results of various REIP simulations.

The Reference Case provides projections of growth in the absence of the REIP. It therefore provides the base line projections of GDP/GSP, population, labour supply, industry output, and other relevant measures, and provides projections of endogenous variables such as productivity changes and consumer preferences.

The Policy Scenario assumes all productivity improvements, tax rates and consumer preferences change as per the Reference Case projections but also includes the construction and operation of the REIP.

The two scenarios result in two different projections of the economy, and the net impacts of the REIP can be calculated as the differences, for each relevant measure, between the Policy scenario and the Reference Case. This is illustrated schematically in **Figure 3.1**.

Figure 3.1 Illustrative analysis of assessing the impact of REIP



Source: ACIL Allen

3.2 REIP in the model

To accurately assess the economic impacts or economic contribution of a major project such as the proposed REIP in Hunter Valley region, it is necessary to represent it faithfully in the model's database. An accurate representation can be achieved by establishing the projects within each REIP as its own 'activity' in the database. Using this approach for evaluations such as this is the most accurate way to capture the detailed economic linkages between the REIP and the other industries in the region and the rest of the economy. This approach also helps to understand the importance of input sources from the region, rest of the state, rest of Australia and internationally. This approach has been developed by ACIL Allen because each asset or activity is unique relative to the more aggregated ANZSIC industries in the CGE model database.

Consequently, in addition to the industries identified in **Appendix A**, the database will also identify the projects within each REIP as a separate industry with its own input cost structure, sales, employment, tax revenues and greenhouse gas emissions based on detailed information assembled for this study.

With respect to the 'with REIP Scenario', another important aspect of the CGE modelling approach will be used for this analysis is to have separate identification of the fixed capital stock embodied in the REIP businesses and isolating it from the rest of the economy, thereby preventing the economy gaining false benefits from redeploying the capital into other economic uses.

The model can also explicitly account for the repatriation of profits (for example through foreign ownership of capital or through the use of fly-in, fly-out workers) for each industry in each region. As with any asset, the share of domestic versus foreign ownership is not guaranteed to remain the same in the future, but in the absence of other information will be assumed to remain constant over the life of the projection period.

3.3 Key assumptions

General equilibrium models like *Tasman Global* has a number of behavioural responses calibrated based on the historical relationships in factor, product and external markets. Key assumptions related to this study are summarised in **Table 3.1**.

Table 3.1 Some key assumptions

Item	Data source	Assumption
Average FTE employee wages	Calculation	$86,683
Input sourcing assumptions — construction expenditure	ACIL Allen based on each new industry cost structure	Hunter 29% Rest of NSW 26% Rest of Australia 18% Outside Australia 27%
Input sourcing assumptions — operational expenditure	ACIL Allen based on each new industry cost structure	Hunter 46% Rest of NSW 21% Rest of Australia 22% Outside Australia 12%
Operational labour intensity	ACIL Allen based on each new industry cost structure	Total wages are 21 per cent of total revenue
Duration of the analysis	BZE	10 years
Real discount rate	Office of the Best Practice Regulation (OBPR)	7% for central estimate and 3% for sensitivity
Real values	ACIL Allen	All values are in $2020

Source: ACIL Allen

3.4 Estimated economic impacts

Figure 3.2 shows the impacts of the planning, construction, and operation of the REIP on real economic output for the Hunter Valley region, rest of NSW and rest of Australia. This is measured as the change between the Policy Scenario (without REIP and declining existing manufacturing base) compared to the Reference Case (with REIP and sustaining existing manufacturing base).

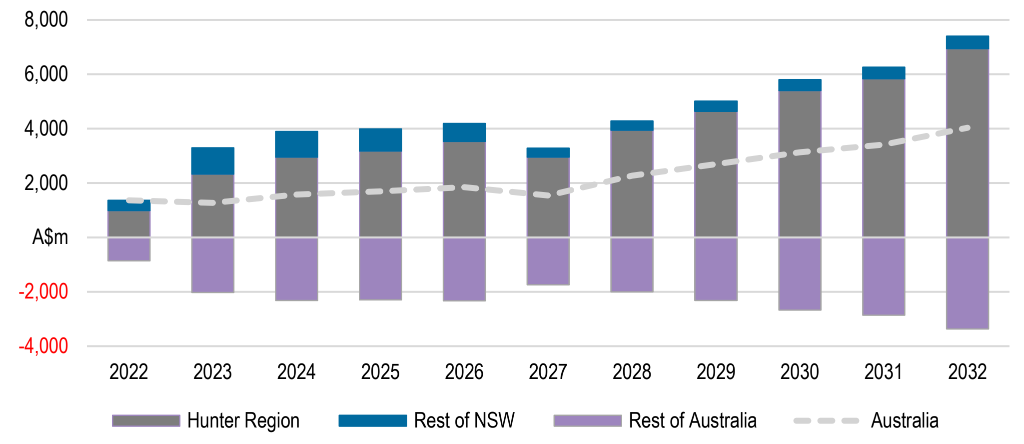
The estimated real income impact to the region is higher than the economic output. This is mainly due to regional income spend on regional goods and services.

The largest changes in real economic output occur broadly in line with the projected value of revenue. This is not surprising as the production phase is where the key benefits of the REIP will be realised. In contrast, the construction phase largely increases demand for scarce factors of production and so has a smaller effect on economic output compared to the size of the investment. However, the additional construction activity associated with the REIP has some effect on the real income of residents in NSW as there will be increased demand for labour and goods and services and this will boost local incomes relative to the Reference Case.

3.4.1 Real economic output impacts

The expenditure associated with the construction and operation of REIP will generate a stimulus to the Gross Product of Hunter Valley region and rest of NSW in the form of the direct expenditure and the indirect stimulus to expenditure in the wider economy that this creates as shown in **Figure 3.2**.

Figure 3.2 Real economic output impacts relative to a Reference Case, 2022–2032



Note: All dollars are in 2020 prices.
Source: ACIL Allen modelling based on BZE data and assumptions

This has been estimated using ACIL Allen's CGE model incorporating the data obtained by ACIL Allen from the BZE. Over the period 2022 to 2032 (see **Table 3.2**), the Hunter Valley REIP is projected to increase the real economic output of:

— Hunter Valley *region* (i.e. real GRP) by a cumulative total of $42,726 million relative to the Reference Case (with a net present value of $28,523 million, using a 7 per cent real discount rate)[4]

— *Rest of NSW (*i.e. real GSP) by a cumulative total of $6,078 million relative to the Reference Case (with a net present value of $4,659 million, using a 7 per cent real discount rate)

— Rest of Australia would benefit to the extent that there is no crowding out effects related to the REIP.

To place these projected changes in economic output estimates in perspective, the discounted present values (using a 7 per cent discount rate) are equivalent to an annual additional increase of 0.45 per cent of Hunter Valley region's GRP, and nearly 0.08 per cent of rest of NSW's GSP for next 10 years.[5]

Table 3.2 Real economic output impacts relative to a Reference Case, 2022–2032

Regions	Units	Annual average	Total (2022-2032)	Impact at 2032	NPV at 3%	NPV at 7%
Hunter Valley	$2020, $m	3,884	42,726	6,947	35,629	28,523
Rest of NSW	$2020, $m	553	6,078	453	5,384	4,659
Rest of Australia	$2020, $m	-2,254	-24,796	-3,366	-21,057	-17,274
Australia (GDP)	$2020, $m	2,183	24,008	4,035	19,956	15,908

Note: All dollars are in 2020 prices.
Source: ACIL Allen modelling based on BZE data and assumptions

Existing and new industries

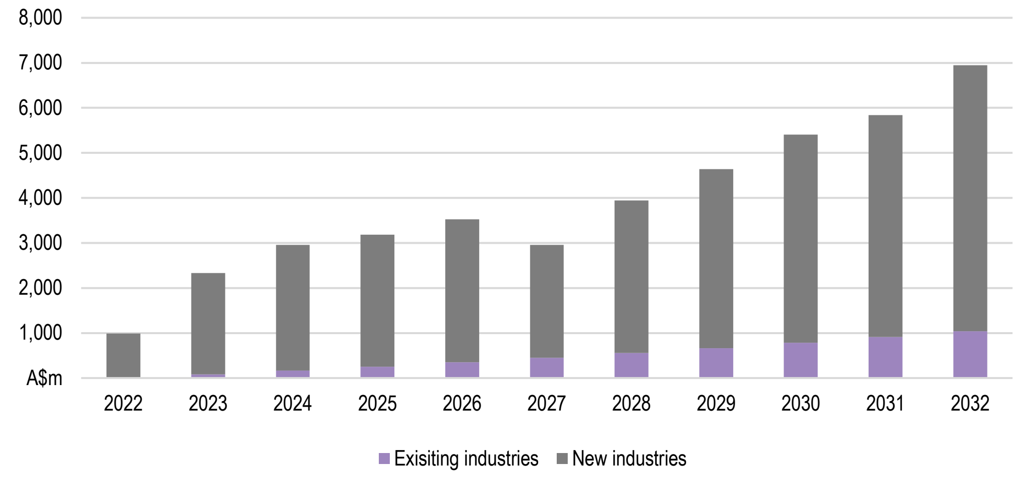
Additional economic output reported above includes the economic activity from the new activities and also sustain the existing energy intensive industries in the region. The real economic output

[4] A 7 per cent real discount rate is based on the OBPR Guidelines on evaluation of projects.

[5] Based on the estimated Hunter Valley GRP of $53,908 million and the rest of the NSW's GSP of $579,002 million in 2019-20.

impacts for existing energy intensive industries transitioning, and new industries planning to use to use renewable energy sources are summarised in **Figure 3.3**. Over the next 10 years, nearly 20 per cent of the projected benefit in the Hunter region is related to existing industries.

Figure 3.3 Real economic output impacts in the Hunter Valley region by industries, 2022–2032



Note: All dollars are in 2020 prices.
Source: ACIL Allen modelling based on BZE data and assumptions

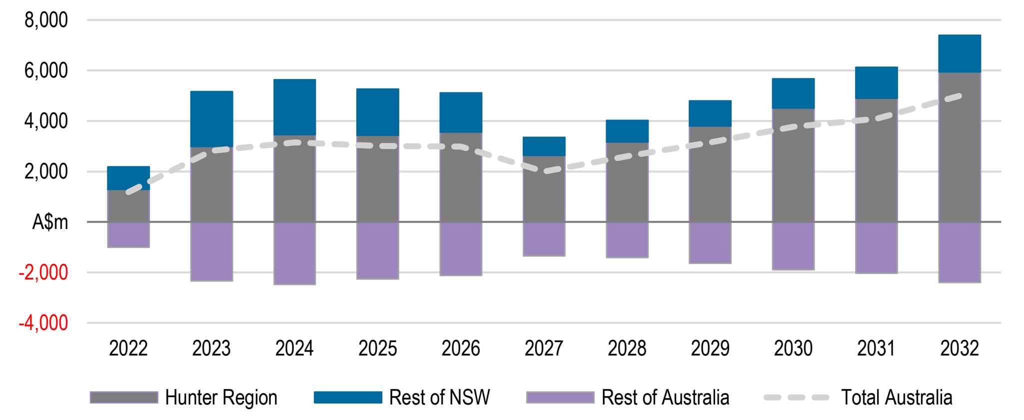
3.4.2 Real income impacts

Real income is a measure of the ability of residents 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 arising from a REIP is a measure of the change in welfare of the residents of an economy. The extent to which the local residents will benefit from the additional economic output depends on the level of ownership of the capital (including the REIP assets) utilised in the business as well as any wealth transfers undertaken by governments as a result of the taxation revenues generated by the REIP. Given the assumed high proportion of the potential employees for the REIP that will live in Hunter Valley region, a significant amount of the additional personal incomes that are generated by the REIP are projected to stay in NSW.

Real income impacts are shown in **Figure 3.4**.

Figure 3.4 Real income impacts relative to a Reference Case, 2022–2032



Note: All dollars are in 2020 prices.

Source: ACIL Allen modelling based on BZE data and assumptions

Over the period 2022 to 2032, the REIP is projected to increase the real income of:

— Hunter Valley *region residents* by a cumulative total of $39,627 million relative to the Reference Case (with a net present value of $27,247 million, using a 7 per cent real discount rate)

— *Rest of NSW residents* by a cumulative total of $15,104 million relative to the Reference Case (with a net present value of $11,341 million, using a 7 per cent real discount rate)

— *Total Australian residents* by a cumulative total of 33,731 million relative to the Reference Case (with a net present value of $23,368 million, using a 7 per cent real discount rate)

To place these projected changes in income in perspective, the discounted present values (using a 7 per cent real discount rate) are equivalent to a one-off increase in the *average* annual real income of all residents of Hunter Valley region by approximately $4,133 per person. This is a noticeable increase in real income of the residents.[6]

Table 3.3 Real income impacts relative to a Reference Case, 2022–2032

Regions	Units	Annual average	Total (2022-2032)	Impact at 2032	NPV at 3%	NPV at 7%
Hunter Valley region	$2020, $m	3,602	39,627	5,941	33,459	27,247
Rest of NSW	$2020, $m	1,373	15,104	1,458	13,254	11,341
Rest of Australia	$2020, $m	-1,909	-21,001	-2,403	-18,143	-15,220
Australia	$2020, $m	3,066	33,731	4,996	28,570	23,368

Note: All dollars are in 2020 prices.
Source: ACIL Allen modelling based on BZE data and assumptions

3.5 Estimated employment impacts

The construction and operation of the REIP will create direct and indirect employment. Direct employment is the number of workers directly employed by the REIP. Indirect employment is the number of workers employed as a result of the additional expenditure induced by the REIP in the economy which generates enough demand to create additional jobs. Job creation is expressed in full time equivalent employee years which is the number of full-time staff employed in one year.

3.5.1 Mechanisms of employment generation

A key issue when estimating the impact of a project is determining how the labour market will respond to the construction and the operation of the REIP.[7] An increase in the demand for labour in the Hunter Valley region can be met by three mechanisms:

— Increasing migration from the rest of NSW/Australia

— Increasing participation rates and/or average hours worked

— By reducing the unemployment rate

[6] According to ABS, estimated residential population of Hunter region (Hunter Valley including Newcastle and Lake Macquarie) in 2019 was 659,271.

[7] As with other CGE models, the standard assumption within *Tasman Global* is that all markets clear (ie. 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.

In the model framework, the first two mechanisms are driven by changes in the real wages paid to workers in Hunter Valley 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 accounts 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 REIP.

3.5.2 Total employment

As a result of the REIP and related activities, it is projected that full time equivalent employment within the:

- Hunter Valley Region will increase by a cumulative total of 257,568 additional employee years between 2022 and 2032 (or an annual average of 23,415 FTE jobs)
- Rest of NSW will increase by a cumulative total of 24,976 additional employee years between 2022 and 2032 (or an annual average of 2,271 FTE jobs a year)
- Australia will increase by a cumulative total of 176,717 additional employee years between 2022 and 2032 (or an annual average of 16,065 FTE jobs a year).

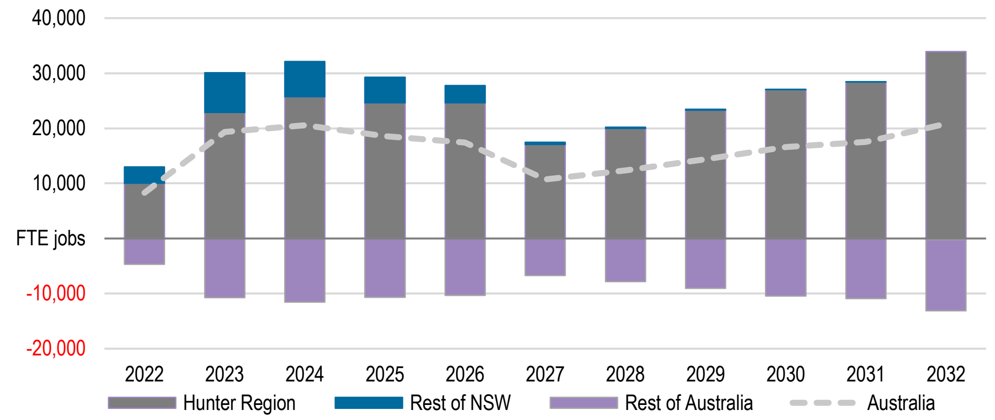
Table 3.4 Employment impacts relative to a Reference Case, 2022–2032

Regions	Annual average	Employment in 2032	Total (2022–2032)
	FTE jobs	FTE jobs	Employee years
Hunter Valley region	23,415	33,958	257,568
Rest of NSW	2,271	-231	24,976
Rest of Australia	-9,621	-12,904	-105,827
Australia	16,065	20,822	176,717

Source: ACIL Allen modelling based on BZE data and assumptions

As illustrated in **Figure 3.5**, the total additional employment is projected to be greatest during the initial construction phase and then broadly increases with the production profile throughout the projection period.

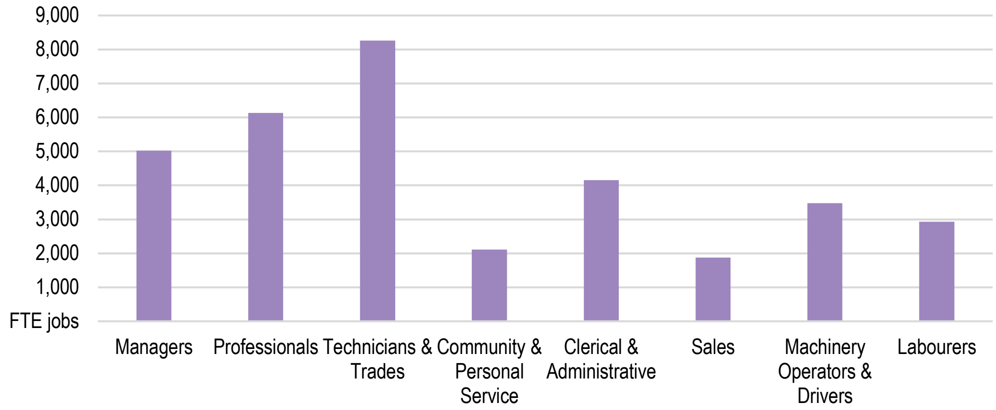
Figure 3.5 Employment impacts relative to a Reference Case, 2022–2032



Source: ACIL Allen modelling based on BZE data and assumptions

Employment by key occupations in 2032 is summarised in **Figure 3.6**. It is estimated that there will be a demand for both skilled and unskilled occupations in Hunter Valley region.

Figure 3.6 Impact on occupations in Hunter Valley in 2032



Source: ACIL Allen modelling based on BZE data and assumptions

Appendices

ACIL Allen's CGE model

A

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.

Thus, 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 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 explicitly represent multiple regions within states and territories of Australia.

Nominally, version 9.1 of the *Tasman Global* database divides the world economy into 150 regions (142 international regions – including Timor-Leste – 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.

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.

Table A.1 Standard sectors in Tasman Global CGE 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, silkworm 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

Source: ACIL Allen

- ‘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'[8] 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.
  - 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

[8] 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).

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 between all international regions. Domestic savers in each region purchase 'bonds' in the global financial market through local 'brokers' while investors in each international region sell bonds to the global financial market to raise investible funds. A flexible global interest rate clears the global financial market. Once the aggregate investment has been determined for each international region, for any country with disaggregated regions, the investment and debt allocations are determined by a country-wide investor based on rates of return and debt burdens within each disaggregated region.

— 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 give 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 is 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.5 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.

A.5.1 Labour supply in *Tasman Global* is presented as a three-stage process:

1. labour makes itself available to the workforce based on movements in the real wage and the unemployment rate;
2. labour chooses between occupations in a state based on relative real wages within the state; and
3. 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).

A.5.2 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+) and 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). 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.

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.[9] 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:

[9] For example, at the start and end of each year 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.

- 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.[10]

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 (i.e., it actively participates with a certain average hour 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.

[10] 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 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.

Table A.2 Occupations in the Tasman Global CGE model

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 Panelbeaters, 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: ACIL Allen

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. Thus, 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[11], while the fuel-factor and technology bundle elasticities are the same as those specified in GTEM.[12] 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[13]. 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 (i.e., the lower the unemployment rate the lower the elasticity and the higher the unemployment rate the higher the elasticity).

A.6 References

Australian Government (2008), *Australia's Low Pollution Future: the economics of climate change mitigation*, Australian Government, Canberra.

Dixon, Parmenter, Sutton, & Vincent (1997), ORANI: A Multisectoral Model of the Australian Economy.

Dixon, P.B. and Rimmer, M.T. (2002), *Dynamic general equilibrium modelling for forecasting and policy*. Contributions to Economic Analysis 256, North Holland, Amsterdam

Hertel, T. (1997), *Global Trade Analysis: modelling and applications*, Cambridge University Press, Cambridge.

Jakeman, G., Heyhoe, E., Pant, H., Woffenden, K. and Fisher, B.S. (2001), The Kyoto Protocol: economic impacts under the terms of the Bonn agreement. ABARE paper presented to the International Petroleum Industry Environmental Conservation Association conference, 'Long Term Carbon and Energy Management - Issues and Approaches', Cambridge, Massachusetts, 15-16 October.

Narayanan, G., Badri, Angel Aguiar and Robert McDougall, Eds. (2012). *Global Trade, Assistance, and Production: The GTAP 8 Data Base*, Center for Global Trade Analysis, Purdue University.

Pant, H.M. (2007), *GTEM: Global Trade and Environment Model*, ABARE Technical Report, Canberra, June

[11] Narayanan et al. (2012).

[12] Pant (2007).

[13] 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).

Melbourne
Level 9, 60 Collins Street
Melbourne VIC 3000 Australia
+61 3 8650 6000

Sydney
Level 9, 50 Pitt Street
Sydney NSW 2000 Australia
+61 2 8272 5100

Brisbane
Level 15, 127 Creek Street
Brisbane QLD 4000 Australia
+61 7 3009 8700

Canberra
Level 6, 54 Marcus Clarke Street
Canberra ACT 2601 Australia
+61 2 6103 8200

Perth
Level 12, 28 The Esplanade
Perth WA 6000 Australia
+61 8 9449 9600

Adelaide
167 Flinders Street
Adelaide SA 5000 Australia
+61 8 8122 4965

ACIL Allen Pty Ltd
ABN 68 102 652 148

acilallen.com.au