ACIL ALLEN CONSULTING

REPORT TO
CUSTRING PTY LTD
14 DECEMBER 2020

COPPERSTRING ECONOMIC TECHNICAL REPORT

ASSESSMENT OF ELECTRICITY MARKET AND ECONOMIC IMPACTS

FINAL REPORT

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1 INTRODUCTION

ACIL Allen was engaged by CuString Pty Ltd (CuString) to undertake an economic impact analysis for the CopperString 2.0 transmission development project (CopperString 2.0). CopperString 2.0 will connect the North West Power System (NWPS) to Powerlink's transmission network allowing participation in the National Electricity Market (NEM). The NWPS, the main electricity distribution network for the North West Minerals Province (NWMP) of Queensland, is a remote islanded network currently supplied from gas fired generation at Mount Isa, that does not participate in the NEM.

This report is being provided as an input to the Environmental Impact Statement process.

The purpose of this report is to establish the economic context and description of the economic environment CopperString 2.0 is located in and to assess CopperString 2.0's economic contribution and impact. Specifically, the report provides an in-depth analysis of CopperString 2.0 in terms of its impacts on the supply of electricity to Mount Isa and the NWMP (in terms of investment and cost), the Queensland region of the NEM, and the economy. The report includes a high-level analysis of the gas market, a detailed analysis of future prospects in the NWMP, projections of the NEM and a broader economic impact analysis of CopperString 2.0.

This report summarises ACIL Allen analysis in the following chapters:

Chapter 2 provides a profile of the regions which CopperString 2.0 is located in and potentially will impact.

Chapter 3 provides a summary of the gas market in the Mount Isa region and Queensland.

Chapter 4 summarises our analysis of future prospects in the NWMP and what this means for electricity demand.

Chapter 5 summarises our analysis of the Queensland region of the NEM as well as the power system in the Mount Isa region, and the projected market outcomes if CopperString 2.0 was to be developed.

Chapter 6 takes the above analyses as inputs and uses our computable general equilibrium (CGE) model to provide a summary of our analysis of the economic impacts of CopperString 2.0.

Chapter 7 presents our results of the economic Cost Benefit Analysis (CBA) conducted for the CopperString 2.0 project.

Chapter 8 discusses how CopperString 2.0 will achieve various Queensland Government policies.

Chapter 9 discusses the potential impacts and mitigation measures on property holders impacted by the construction and operation of the line.

It is worth noting that the analysis and modelling included in the report have not taken into account the impacts and possible long-term effects of the COVID-19 pandemic as the analysis was largely completed prior to the declaration of COVID-19 as a pandemic by the Word Health Organisation

(WHO). Revised modelling would be required in order to understand how the economic impacts of CopperString 2.0 and their magnitude may have changed as a consequence of the pandemic.

2 REGIONAL PROFILE

2.1 Regional economic profile

The regions potentially impacted by CopperString 2.0 are located in Queensland along a corridor which runs inland from the Burdekin Local Government Area (LGA) through to the Mount Isa LGA. They comprise the LGAs of Burdekin, Charters Towers, Cloncurry, Flinders, McKinlay, Mount Isa, and Richmond[1].

The location in which CopperString 2.0 will be constructed is characterised by regions which have significant mining and agriculture industries. The population of these regions is of similar age to the State average, noting there is variability across the individual LGAs. The median income of workers living in CopperString 2.0 regions is marginally higher than the average for the State at $58,736 per annum compared to $50,901 per annum in Queensland. However, this varies greatly between LGAs.

Unemployment is consistently high in regions such as Charters Towers and Mount Isa with current unemployment rates in excess of 8.5 per cent compared to 6.1 per cent in Queensland. The unemployment rates for Indigenous people is particularly high at 22 per cent compared to a State rate of 20 per cent. The construction and operation of the transmission line will therefore bring important economic and social opportunities to the region. This will include employment opportunities for local job seekers and business opportunities for local businesses.

2.2 Regional economic context

The economy of the aggregate CopperString 2.0 region has a strong mining and minerals processing sector and the agricultural sector also has a significant footprint in the region.

Mount Isa, which is the largest population centre in North West Queensland, was developed as a result of the region's extensive mineral resources (copper, lead, silver and zinc) which are now mined and processed in and around the city. The city is approximately 904 kilometres (km) from Townsville on the east coast of Queensland.

Cloncurry is around 121 km east of Mount Isa and around 783 km from Townsville. The township was originally established to service the Great Australia Copper Mine after ore was discovered in the area in 1867. Cloncurry now serves as a dormitory town for mines, such as Glencore's Ernest Henry mine. Cattle grazing is also a significant industry in the region and Cloncurry has a large saleyard to service this industry.

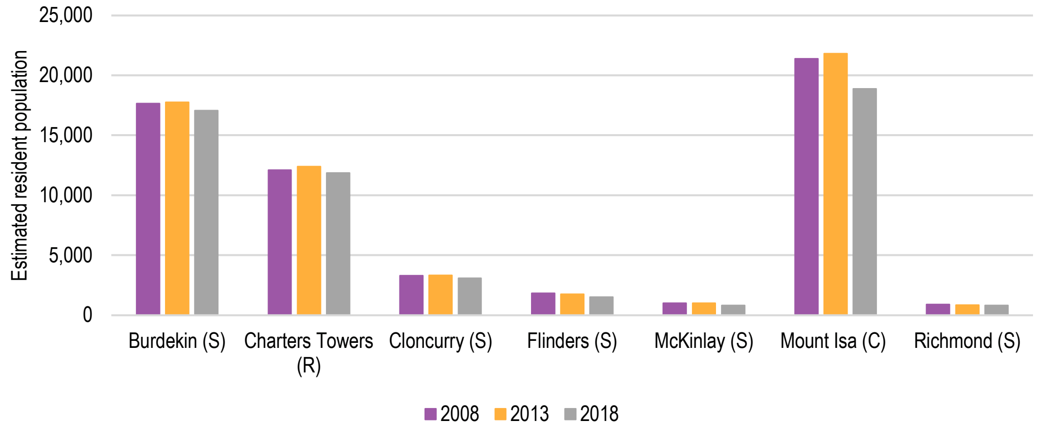
[1] Or, running from West to East when looking at a map, comprise the LGAs of Mount Isa, Cloncurry, McKinlay, Richmond, Flinders, Charters Towers, and Burdekin.

2.3 Population characteristics

As of June 2018, the combined population of the CopperString 2.0 region was 54,015 or 1.1 per cent of the population of Queensland.

The largest regions potentially impacted by CopperString 2.0 include Mount Isa which has a population of 18,878 or 35 per cent of the potentially impacted regions and Burdekin which has a population of 17,077 or 32 per cent of the potentially impacted regions. This is illustrated in Figure 2.1 which shows population over the past decade.

FIGURE 2.1 ESTIMATED RESIDENT POPULATION OF POTENTIALLY IMPACTED REGIONS



NOTE: ABS REGIONS – S STANDS FOR SHIRE, R STANDS FOR REGIONAL COUNCIL, AND C STANDS FOR CITY
SOURCE: *ABS 3218.0,* REGIONAL POPULATION GROWTH, AUSTRALIA, *VARIOUS EDITIONS*

Table 2.1 shows annual average population growth of the potentially impacted regions. There has been a decline in population in the aggregate CopperString 2.0 region over the past five and ten years. This trend is opposite to the observed population growth in Queensland.

In terms of the individual LGAs, there has been a decline in population over the past five years and past decade for all regions. The largest fall in population over the past decade has been in the McKinlay and Flinders LGAs, which have each seen an average annual population decline over that period of 2.0 per cent.

TABLE 2.1 ESTIMATED RESIDENT POPULATION GROWTH OF POTENTIALLY IMPACTED AREAS

Region	Estimated resident population (people)			Average annual growth (%)	
	2008	2013	2018	2008-2018	2013-2018
CopperString region	58,164	58,879	54,015	-0.7	-1.7
– *Burdekin (S)*	*17,653*	*17,754*	*17,077*	*-0.3*	*-0.8*
– *Charters Towers (R)*	*12,096*	*12,391*	*11,850*	*-0.2*	*-0.9*
– *Cloncurry (S)*	*3,308*	*3,327*	*3,091*	*-0.7*	*-1.5*
– *Flinders (S)*	*1,837*	*1,754*	*1,499*	*-2.0*	*-3.1*
– *McKinlay (S)*	*994*	*992*	*814*	*-2.0*	*-3.9*
– *Mount Isa (C)*	*21,381*	*21,822*	*18,878*	*-1.2*	*-2.9*
– *Richmond (S)*	*895*	*839*	*806*	*-1.0*	*-0.8*
Queensland	**4,219,505**	**4,652,824**	**5,011,216**	**1.7**	**1.5**

SOURCE: *ABS 3218.0,* REGIONAL POPULATION GROWTH, AUSTRALIA, *VARIOUS EDITIONS*

2.3.1 Demographic profile

The age profile of the population in the CopperString 2.0 region closely resembles that of Queensland. There is a slightly higher proportion of persons aged 1-14 and 45-64 in the CopperString 2.0 regions compared with Queensland. Similarly, there are slightly fewer persons aged 15-64 and 24-44 in the CopperString 2.0 regions compared with Queensland (as shown in Table 2.2).

Table 2.2 also shows a smaller share of the population in the 65 and over age groups for the Cloncurry and Mount Isa LGAs, and a higher proportion for the Burdekin and Flinders LGAs. There is a higher proportion of people aged 24 to 44 in the Cloncurry, McKinlay and Mount Isa LGAs.

The median age for Queensland is 37.3, and the regions with a higher median age are Burdekin at 45.0, Flinders at 42.9; and the LGAs with a lower median age include Mount Isa at 31.4 and Cloncurry at 35.4.

TABLE 2.2 ESTIMATED RESIDENT POPULATION BY AGE AND LGA, 2018

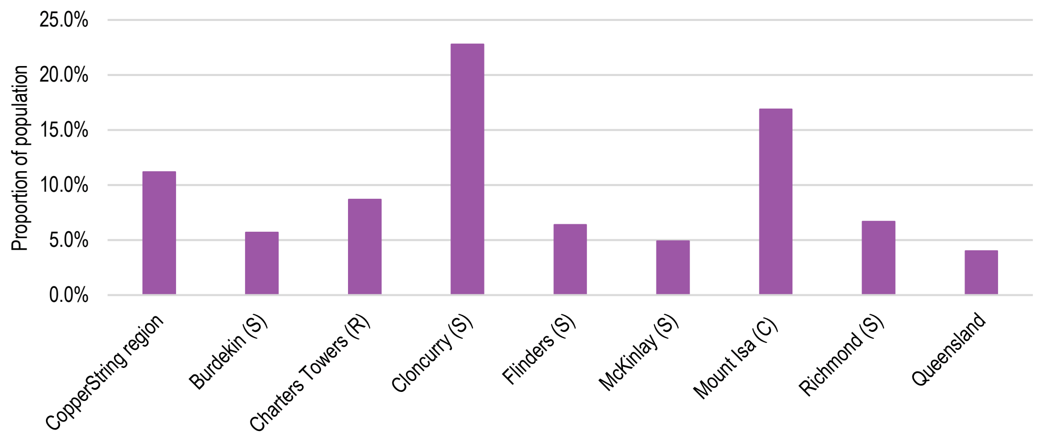
Region	Proportion of population by age bracket					Median age
	1–14	15-24	24-44	45-64	65+	
CopperString region	20.9	12.0	26.3	25.4	15.4	37.3
– Burdekin (S)	*17.2*	*11.7*	*21.1*	*27.8*	*22.3*	*45.0*
– Charters Towers (R)	*20.8*	*12.8*	*21.7*	*25.6*	*19*	*40.5*
– Cloncurry (S)	*20.6*	*10.8*	*32.5*	*26.6*	*9.4*	*35.4*
– Flinders (S)	*18.9*	*9.0*	*24.9*	*27.1*	*20.1*	*42.9*
– McKinlay (S)	*21.1*	*6.1*	*34.3*	*26.7*	*11.8*	*38.2*
– Mount Isa (C)	*24.5*	*12.7*	*32.6*	*22.7*	*7.5*	*31.4*
– Richmond (S)	*23*	*7.1*	*27.9*	*26.7*	*15.4*	*36.6*
Queensland	**19.6**	**13.1**	**27.3**	**24.7**	**15.4**	**37.3**

SOURCE: *ABS 3235. 0,* POPULATION BY AGE AND SEX, REGIONS OF AUSTRALIA

2.4 Indigenous residents

Aboriginal and Torres Strait Islander (Indigenous) people make up 4.0 per cent of the population of Queensland. In the CopperString 2.0 region, Indigenous people comprised 11.2 per cent (n = 6,039) of the population at the 2016 Census. There are higher proportion of Indigenous people in the Cloncurry LGA and the Mount Isa LGA which comprise 22.8 per cent (n = 3,149) and 16.9 per cent (n = 692) of the population respectively as illustrated in Figure 2.2 which shows the proportion of the population which are Indigenous.

FIGURE 2.2 INDIGENOUS STATUS BY LGA, 2016

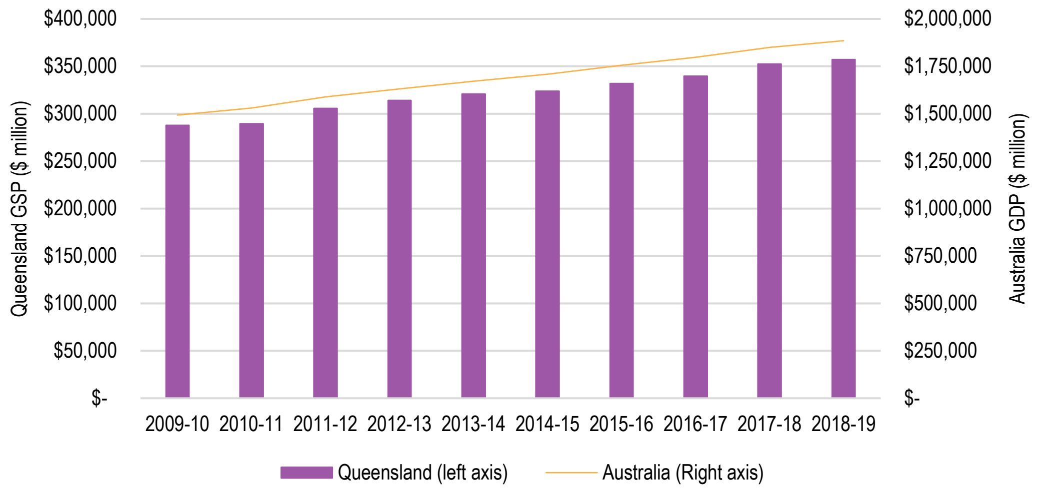


SOURCE: ABS, CENSUS OF POPULATION AND HOUSING, 2016, ABORIGINAL AND TORRES STRAIT ISLANDER PEOPLES PROFILE - I02

2.5 Gross Regional Product

In 2018-19, the Gross Domestic Product (GDP) of Australia was $1.88 trillion. The Queensland economy generated over $357 billion or 19 per cent of this value. Figure 2.3 shows the year on year growth in the GDP of Australia and the Gross State Product (GSP) of Queensland. In the five years to 2018-19, the average annual growth of Queensland's GSP was 2.4 per cent a year. GSP is expected to continue to grow with forecast growth of 3.0 per cent in 2019-20.[2].

FIGURE 2.3 GROSS STATE PRODUCT: AUSTRALIA AND QUEENSLAND ($ MILLION)

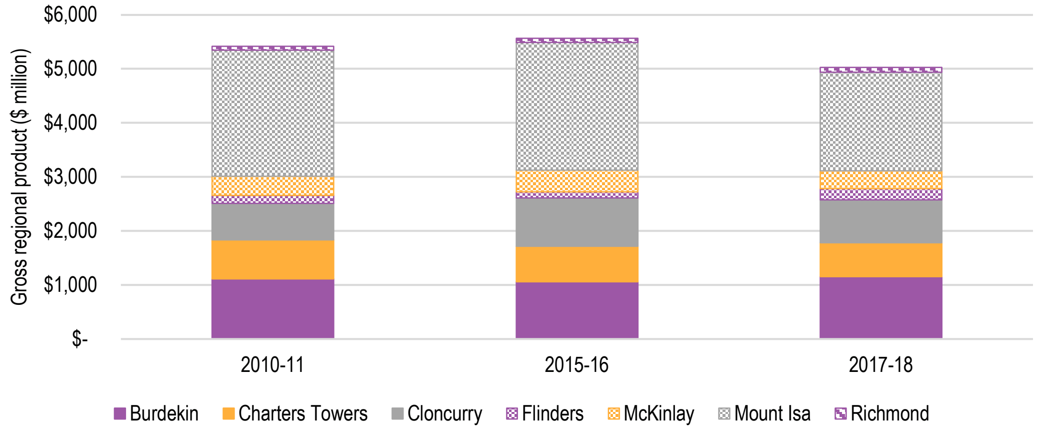


SOURCE: AUSTRALIAN BUREAU OF STATISTICS CATALOGUE 5220.0

In 2017-18, the CopperString 2.0 regions contributed $5.0 billion to the Queensland economy which is equivalent to around 1.7 per cent of the State's GDP. Economic growth in the CopperString 2.0 regions have varied as illustrated in Figure 2.4. There has been an average annual decline in Gross Regional Product (GRP) over the past two years of 4.8 per cent, the bulk of this decline has been a result of a fall in GRP in the Mount Isa LGA. [3]

[2] Queensland Government, 2019, https://www.treasury.qld.gov.au/queenslands-economy/about-the-queensland-economy/). https://economic-indicators.id.com.au/?StateId=3[3]

FIGURE 2.4 GROSS REGIONAL PRODUCT: COPPERSTRING REGIONS ($ MILLION)



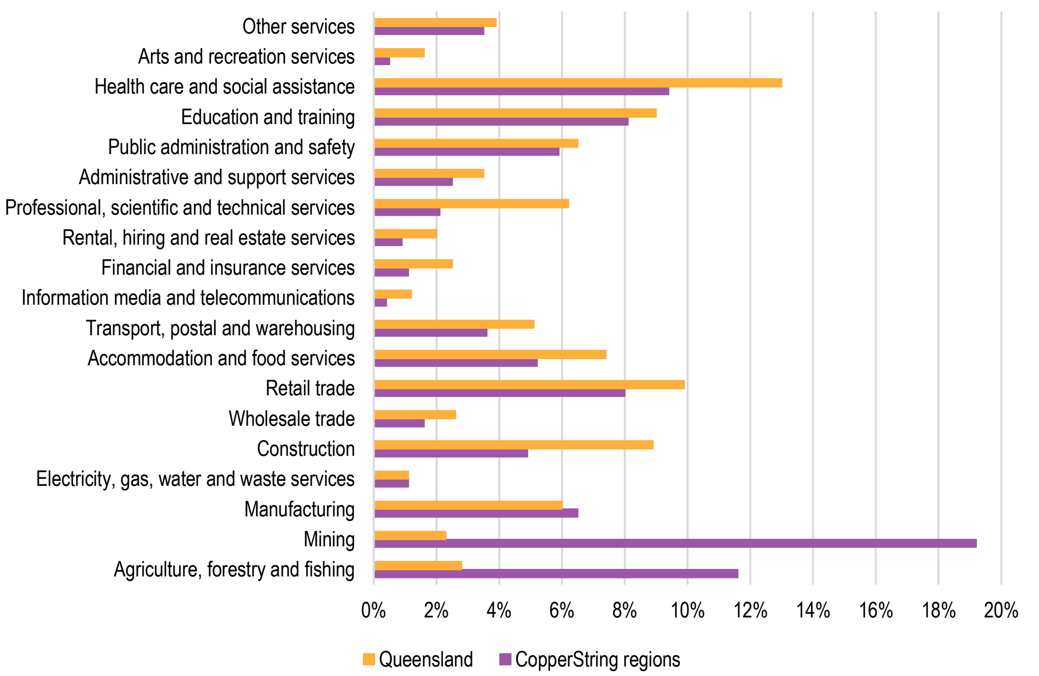
SOURCE: NATIONAL INSTITUTE OF ECONOMIC AND INDUSTRY RESEARCH

The major industries in these regions in terms of economic value and employment are the agriculture industry, in particular the production of beef cattle, and the mining industry, including copper, silver and gold mining.

2.6 Key regional industries

The key regional industries of the CopperString 2.0 region include mining and agriculture, forestry and fishing. Figure 2.5 shows the industry employment for the employed residents of the CopperString 2.0 region compared to Queensland. It shows that the employment profile of residents is different to that of Queensland and is more reliant on mining and agriculture, forestry and fishing industries for employment. Together these two industries employ 31 per cent of the working population.

FIGURE 2.5 INDUSTRY OF EMPLOYMENT: QUEENSLAND, COPPERSTRING REGIONS (%), 2016

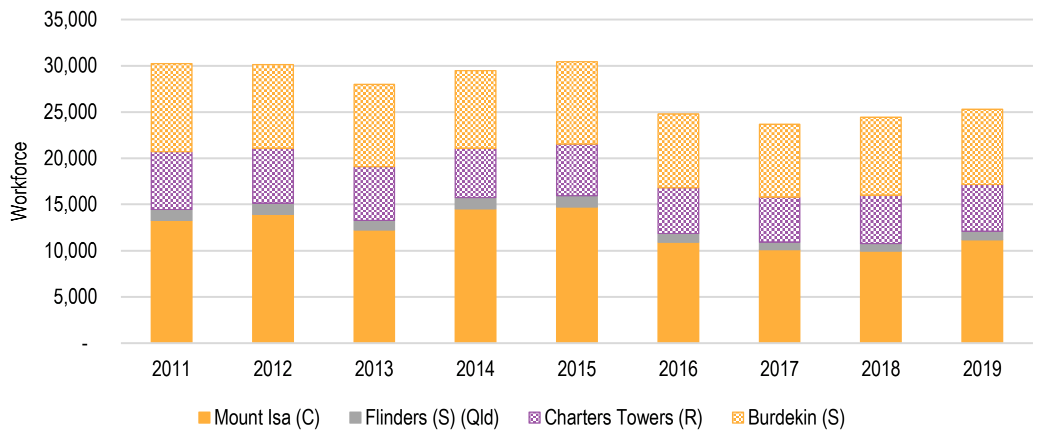


SOURCE: ABS, CENSUS OF POPULATION AND HOUSING, 2016, WORKING POPULATION PROFILE - W09 (PLACE OF WORK)

2.7 Labour force information

There are 2.4 million people in the Queensland workforce which comprises of just over 2.1 million people in employment and 175,000 people seeking work. This is around 20 per cent of the Australian workforce. The workforce of the CopperString 2.0 region is small, comprising 26,656 people or 1.3 per cent of the workforce of Queensland (Figure 2.6). The Mount Isa LGA has a workforce of over 11,000 people which is equivalent to approximately 44 per cent of the workforce of the CopperString 2.0 region.

FIGURE 2.6 WORKFORCE OF SELECTED COPPERSTRING REGIONS (NUMBER OF PERSONS)



Note: Labour force data not reported for Richmond, McKinlay and Cloncurry.
SOURCE: AUSTRALIAN GOVERNMENT DEPARTMENT OF JOBS AND SMALL BUSINESS, SMALL AREA LABOUR MARKETS AUSTRALIA

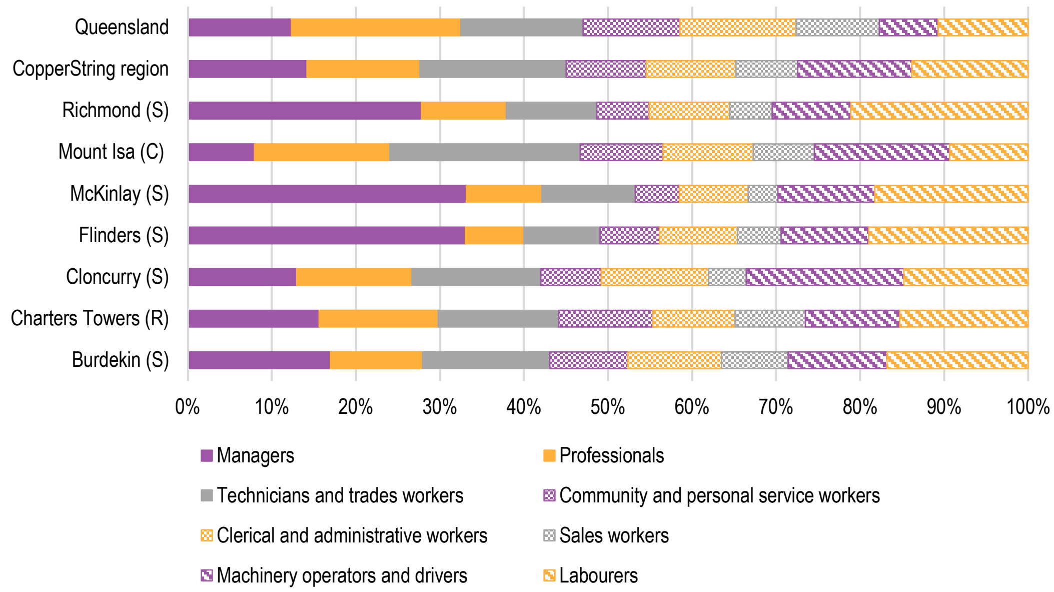
2.7.1 Occupation

Figure 2.7 shows the occupation of employed persons in the CopperString 2.0 regions compared with Queensland. There is a much higher share of Machinery operators and drivers; and Labourers in CopperString 2.0 regions compared to Queensland.

Just under 27.4 per cent of employed people are employed in these occupations in CopperString 2.0 regions, compared with 17.4 per cent of employed people of Queensland.

There is a relatively high number of Managers in Richmond, McKinlay and Flinders LGAs. Generally, the CopperString 2.0 regions have a higher proportion of Machinery operators and drivers, and Labourers. In particular, Mount Isa and Cloncurry LGAs have a high proportion of Machinery operators and drivers, and Richmond, McKinlay and Flinders LGAs have a high proportion of labourers.

FIGURE 2.7 EMPLOYMENT BY OCCUPATION: QUEENSLAND AND COPPERSTRING REGIONS (%), 2016



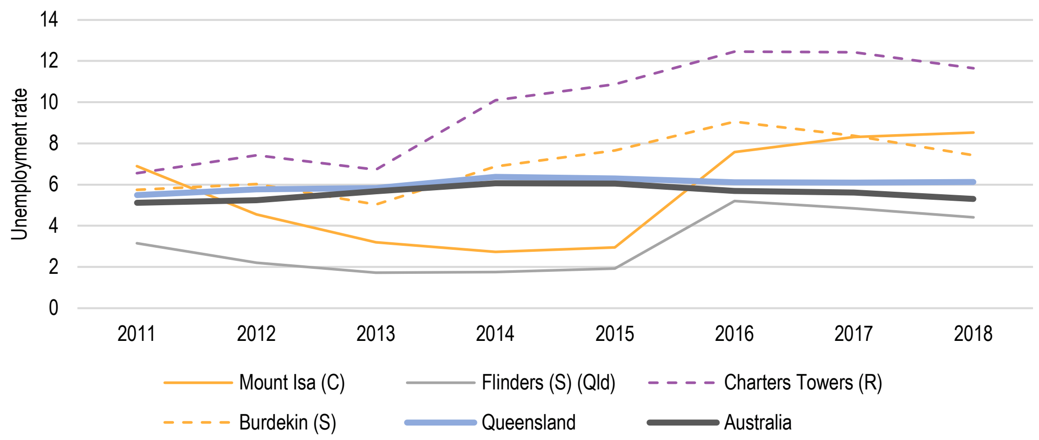
SOURCE: ABS, CENSUS OF POPULATION AND HOUSING, 2016, GENERAL COMMUNITY PROFILE - G57

2.7.2 Unemployment

The unemployment rate within the CopperString 2.0 regions vary with some LGAs having an unemployment rate comparable to the Queensland average, and others having a significantly higher unemployment rate as illustrated in Figure 2.8, which shows the rate of unemployment since 2011. In 2018, the rate of unemployment in the Flinders LGA (4.4 per cent) was lower than the Queensland average of 6.1 per cent. Unemployment in the Burdekin and Mount Isa LGAs was higher at 7.4 per cent and 8.5 per cent, respectively. The Charters Towers LGA had a significantly higher unemployment rate in 2018 at 11.7 per cent.

Unemployment in the CopperString 2.0 regions have generally followed a similar trend with declining or stable unemployment between 2011 to 2014, followed by an increase until 2017.

FIGURE 2.8 UNEMPLOYMENT RATE: AUSTRALIA, QUEENSLAND, COPPERSTRING REGIONS (%)



Note: Labour force data not reported for Richmond, McKinlay and Cloncurry.

SOURCE: AUSTRALIAN GOVERNMENT DEPARTMENT OF JOBS AND SMALL BUSINESS, SMALL AREA LABOUR MARKETS AUSTRALIA, 6202.0 - LABOUR FORCE, AUSTRALIA, NOV 2019

2.7.4 Indigenous workforce

According to the 2016 Census, Indigenous people comprised 2,067 people or 8.3 per cent of the workforce in the CopperString 2.0 region. Unemployment amongst Indigenous people is very high with an unemployment rate of 22 per cent, significantly higher than the total rate of unemployment for the region and higher than the State average for Indigenous people of 20 per cent as illustrated in Table 2.3. There are 461 unemployed Indigenous people in the CopperString 2.0 region comprising 29 per cent of all job seekers in the region.

The largest Indigenous workforce is located in the Mount Isa LGA (1,122), which together account for 54 per cent of the Indigenous workforce across the CopperString 2.0 region.

While the number of Indigenous job seekers in certain LGAs is smaller, the unemployment rates are typically high. The indigenous unemployment rates are particularly high in Charters Towers (30 per cent), Burdekin (27 per cent), Mount Isa (21 per cent) and Richmond (21 per cent) LGAs.

TABLE 2.3 INDIGENOUS WORKFORCE: QUEENSLAND, COPPERSTRING REGIONS

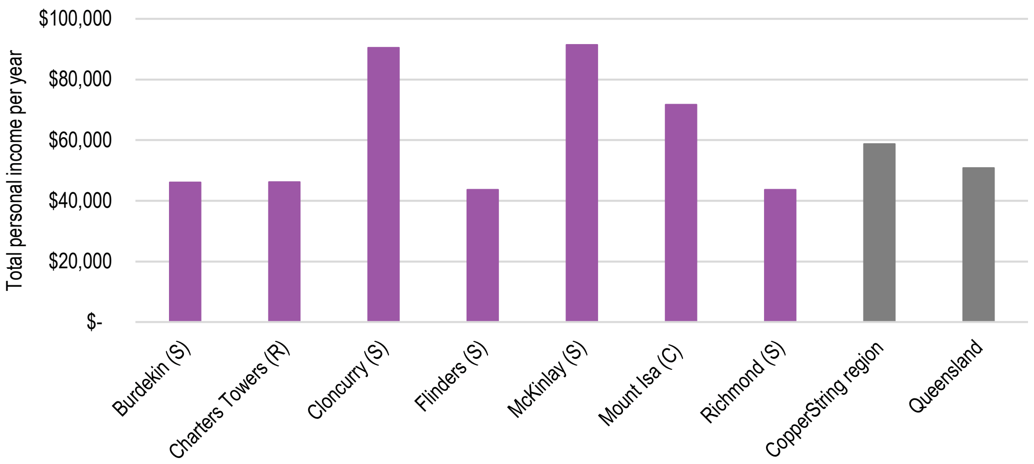
	Labour force	Number of unemployed	Unemployment rate	Indigenous Share of total labour force	Indigenous Share of total number of unemployed
Queensland	64,965	13,178	20%	2.9%	7.7%
CopperString region	2,067	461	22%	8.3%	29%
Burdekin (S)	317	85	27%	4%	18%
Charters Towers (R)	296	90	30%	6%	21%
Cloncurry (S)	254	42	17%	17%	61%
Flinders (S)	41	4	10%	6%	15%
McKinlay (S)	18	0	0%	4%	0%
Mount Isa (C)	1,122	236	21%	12%	41%
Richmond (S)	19	4	21%	5%	44%

SOURCE: ABS, CENSUS OF POPULATION AND HOUSING, 2016

2.7.5 Wages and salaries / Income

The median individual income of people living in the CopperString 2.0 regions is marginally higher than the average for Queensland. The median income of people aged 15 years and over is $58,736 per year in the CopperString 2.0 regions compared to $50,901 per annum in Queensland. The median income varies significantly in the local government areas which comprise the CopperString 2.0 region. The highest incomes are in the Cloncurry ($90,581) and McKinlay ($91,504) LGAs. The LGAs with the lowest income are Flinders ($43,736) and Richmond ($43,643).

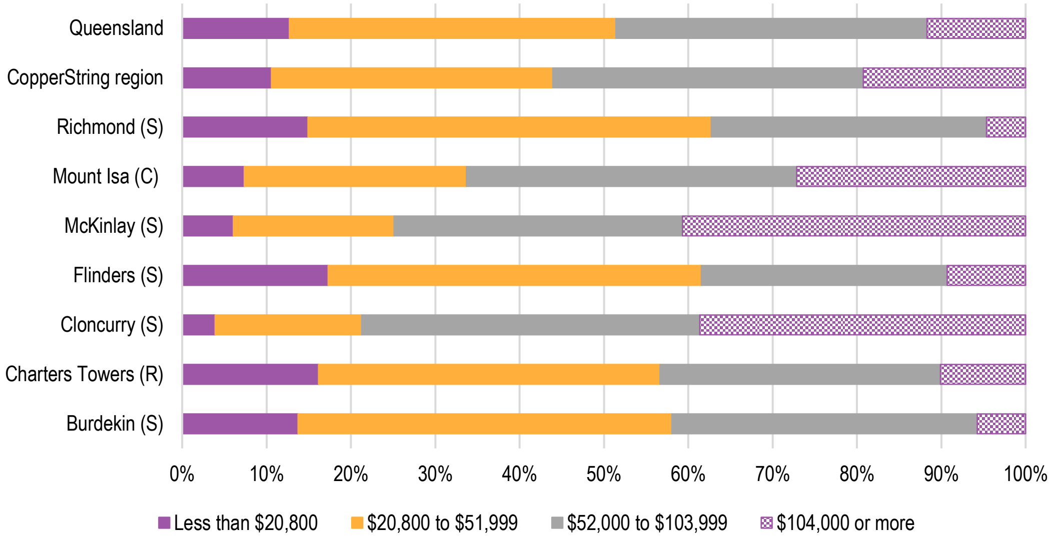
FIGURE 2.9 TOTAL PERSONAL INCOME FOR QUEENSLAND AND COPPERSTRING REGIONS, 2016



SOURCE: ABS, CENSUS OF POPULATION AND HOUSING, 2016, WORKING POPULATION PROFILE - W06 (PLACE OF WORK) AND QUEENSLAND GOVERNMENT STATISTICIAN'S OFFICE, QUEENSLAND TREASURY, QUEENSLAND REGIONAL PROFILES: WORKFORCE PROFILE FOR TOWNSVILLE AND NW QLD REGION

Figure 2.10 shows a more detailed breakdown of personal incomes. The graph shows that there is a much higher share of the population which earn less than $52,000 annually living in Richmond (63 per cent), Flinders (62 per cent), Charters Towers (57 per cent), and Burdekin (58 per cent) LGAs compared to Queensland (51 per cent). However, across all CopperString 2.0 regions the proportion is lower than the Queensland average due to the high incomes of the population in the Mount Isa, McKinlay and Cloncurry LGAs.

FIGURE 2.10 TOTAL PERSONAL INCOME BY QUEENSLAND AND COPPERSTRING REGIONS (%), 2016

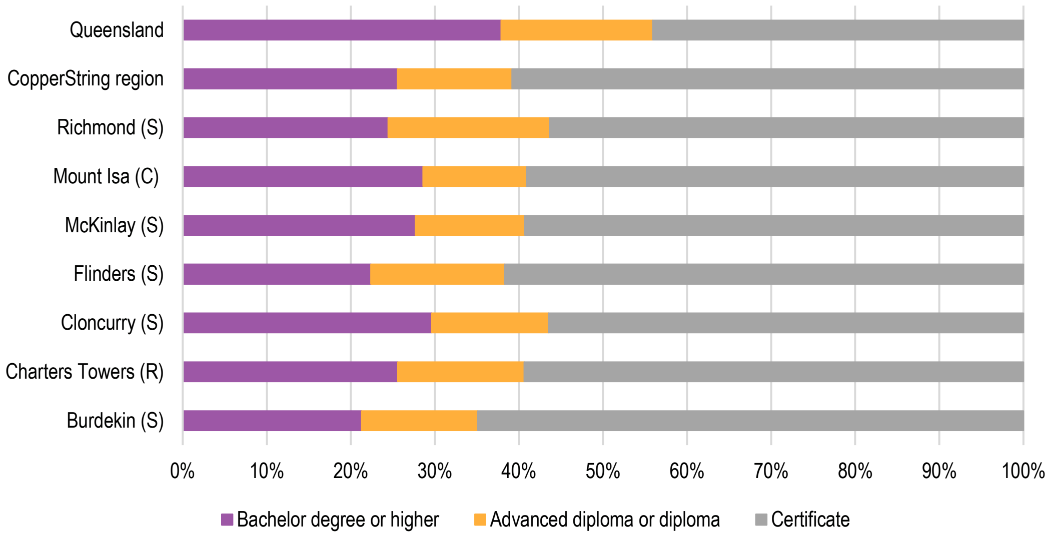


SOURCE: ABS, CENSUS OF POPULATION AND HOUSING, 2016, WORKING POPULATION PROFILE - W06 (PLACE OF WORK)

2.7.6 Skills

Figure 2.11 shows the distribution of the population with non-school qualifications for each of the CopperString 2.0 regions. The graph shows that there is a much higher share of Certificate level qualifications in the CopperString 2.0 regions compared with the State average. While 61 per cent of the qualifications in the CopperString 2.0 regions are at a Certificate level, only 44 per cent of the qualifications held in Queensland are Certificate level. The share of Certificate level qualifications in the CopperString 2.0 region is reflective of the job opportunities in the area.

FIGURE 2.11 NON SCHOOL QUALIFICATION FOR QUEENSLAND AND COPPERSTRING REGIONS (%), 2016



SOURCE: ABS, CENSUS OF POPULATION AND HOUSING, 2016, GENERAL COMMUNITY PROFILE - G40 AND G46

2.8 Housing and land market

2.8.1 Housing market

Table 2.4 shows 2019 housing building approvals data for the CopperString 2.0 regions. What stands out is that many of the regions have a very small number of residential building approvals with four of the regions reporting three or less residential building approvals and one or less new houses. The Burdekin LGA had the highest number of building approvals with 30. Across the CopperString 2.0 regions, the average value of residential building approvals was $350,148 for new houses and $237,276 for new other residential building, but this value varies greatly between regions.

TABLE 2.4 HOUSING BUILDING APPROVALS AND AVERAGE HOUSE VALUES IN COPPERSTRING REGIONS, 2019

Heading	Burdekin	Charters Towers	Cloncurry	Flinders	McKinlay	Mount Isa	Richmond	CopperString region
Residential building approvals (number)								
New houses	19	8	1	0	0	3	0	31
New other residential building	10	2	0	0	0	5	0	17
Total dwelling approvals	30	10	1	0	0	8	0	49
Average value of residential building approvals ($)								
New houses	$417,084	$250,313	$143,500	N/A	N/A	$261,333	N/A	$350,148
New other residential building	$200,000	$172,750	N/A	N/A	N/A	$337,640	N/A	$237,276
Total dwelling approvals	$330,820	$234,800	$143,500	N/A	N/A	$309,025	N/A	$303,843

SOURCE: ABS 8731.0, BUILDING APPROVALS, AUSTRALIA

2.8.2 Rental market

Table 2.5 shows the weekly housing rents for each of the CopperString 2.0 regions. The median rent varies across regions, but is typically lower than the Queensland median. In 2019 the median rent for a three-bedroom lodgement varied from $200 per week in Richmond to $370 in Mount Isa, and $360 across Queensland.

TABLE 2.5 LODGEMENTS AND MEDIAN RENT FOR QUEENSLAND AND COPPERSTRING REGIONS, 2019

Heading	Lodgements	Median rent ($ per week)			
		1 bedroom	2 bedroom	3 bedroom	4 bedroom
Burdekin (S)	436	$180	$210	$255	$315
Charters Towers (R)	282	N/A	$205	$255	$330
Cloncurry (S)	147	$185	$250	$300	$365
Flinders (S)	35	N/A	N/A	$200	N/A
McKinlay (S)	5	N/A	N/A	N/A	N/A
Mount Isa (C)	903	$180	$220	$370	$450
Richmond (S)	21	N/A	N/A	$200	N/A
Queensland	**178,289**	**$320**	**$370**	**$360**	**$430**

SOURCE: QLD REGIONAL RESIDENT PROFILE 2019

2.8.3 Land market

Due to the low turnover of rural properties in the CopperString 2.0 regions and the wide variety of terrain potentially affected by CopperString 2.0, it is difficult to obtain an accurate estimate of the current land prices in the region. However, based on rural property sales over 500ha reported by the Department of Natural Resources, Mines and Energy (DNRME) much of the grazing land in the Flinders, Richmond, McKinlay and Cloncurry LGAs seems to be valued between $220 and $450 per hectare. More specifically, property values for the McKinlay LGA were between $220 and $370 per hectare, Richmond LGA between $220 and $430 per hectare and Flinders LGA between $280 and $470 per hectare.[4]

An alternative source of reported land values by municipality is Rural Bank which reported an average price per hectare for the McKinlay LGA of $289, and $310 for the Flinders LGA in 2018.

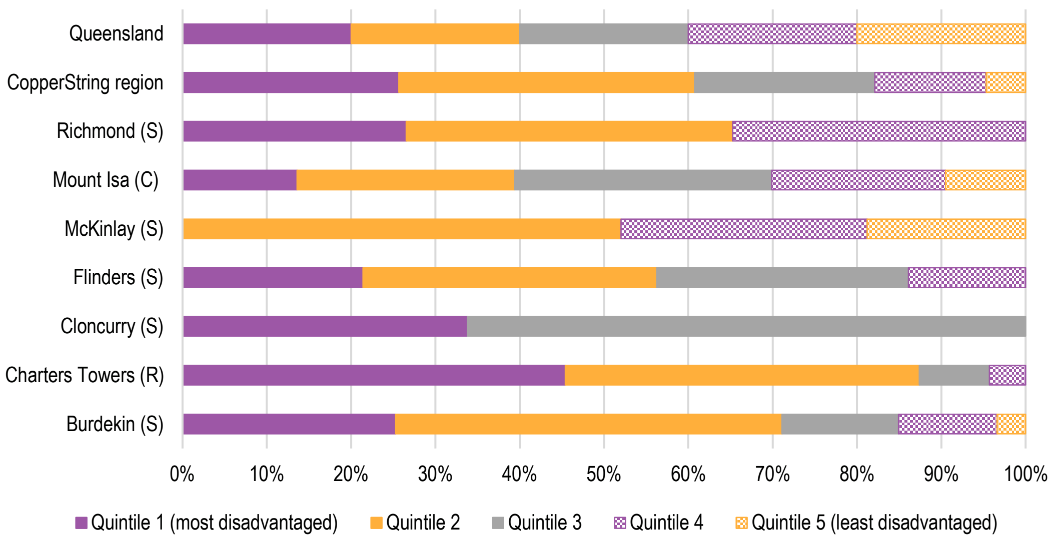
The precise value will of course depend on the specific characteristics of the property (including water supply and capital improvements).

2.9 Regional disadvantage and opportunity

The social and economic indicators for the CopperString 2.0 regions are poor when compared to other LGAs in Queensland. The proportion of the population in the lowest two quintiles of the index of relative socio-economic disadvantage (IRSD) for the CopperString 2.0 regions is 60.8 per cent compared with 40 per cent for Queensland.

Figure 2.12 shows the share of the population by the index of relative socio-economic disadvantage quintiles. The disadvantage of the regions is varied. The McKinlay LGA for example has a noticeably lower disadvantage than other regions and Queensland on average. Whereas the Charters Towers LGA has substantially more disadvantage with 100 per cent of the population falling in the most disadvantaged three quintiles, compared to 60 per cent for Queensland.

FIGURE 2.12 POPULATION BY INDEX OF RELATIVE SOCIO-ECONOMIC DISADVANTAGE QUINTILES FOR QUEENSLAND AND COPPERSTRING REGIONS, 2016



SOURCE: ABS 2033.0.55.001 CENSUS OF POPULATION AND HOUSING: SOCIO-ECONOMIC INDEXES FOR AREAS (SEIFA), AUSTRALIA, 2016

[4] Department of Natural Resources, Mines and Energy (2019), Online map of rural property sales. http://qgsp.maps.arcgis.com/apps/webappviewer/index.html?id=dcdd187168d244c78856077487b81390

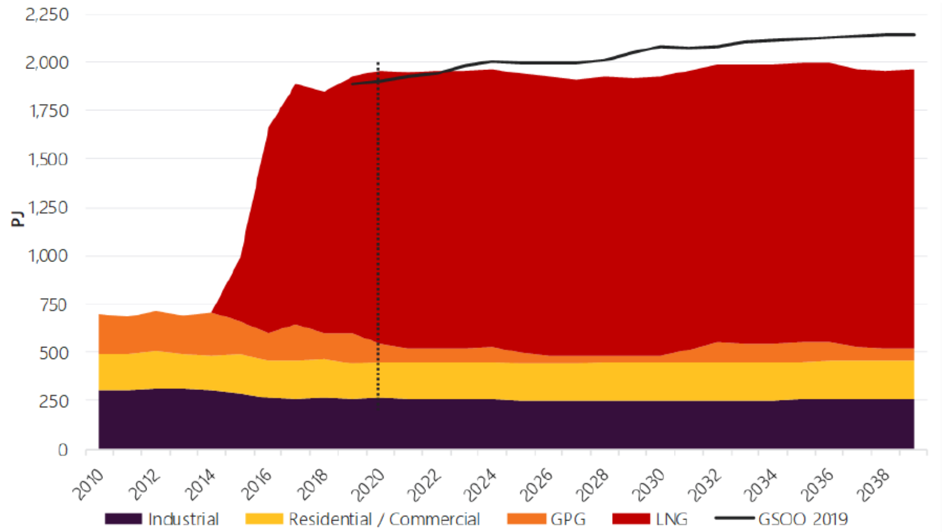
3 GAS MARKET ANALYSIS

This chapter provides a brief review of developments in the eastern Australian gas market and the impacts for gas users in the NWMP. Gas-fired power generation is the primary source of energy for most mining projects and other industries in the NWMP.

3.1 Eastern Australia: tightening gas supply with little relief

Over the past decade there has been an unprecedented transformation of the Eastern Australian gas market, driven by large-scale export liquefied natural gas (LNG) developments and associated upstream coal seam gas (CSG) field production facilities in Queensland. Three separate LNG export projects, with a combined production capacity of more than 25 million tonnes per year of LNG, were commissioned between late 2014 and late 2016. These facilities have a combined gross gas requirement of around 1,500 PJ/a—almost triple the amount of gas currently used in the entire eastern Australian domestic gas market (see Figure 3.1).

FIGURE 3.1 EAST COAST GAS DEMAND



Note: GPG stands for gas powered generation

SOURCE: AEMO, GAS STATEMENT OF OPPORTUNITIES (GSOO) 2020 REPORT

The impact that these LNG projects have had on the Eastern Australian domestic gas market would be difficult to overstate.: They have affected the availability of gas to supply power generation, industrial, commercial and residential customers; they have pushed up the price of domestic gas and changed the ways in which gas prices are determined; and they have affected levels of domestic gas consumption, particularly in the power generation sector.

Although the situation has arguably improved over the last couple of years, there remains significant uncertainty regarding gas supply adequacy in Eastern Australia over the medium to long term. These factors we expect will continue to influence the supply-demand outlook and wholesale gas prices.

The Australian Competition and Consumer Commission (ACCC) and the Australian Energy Market Operator (AEMO) note in their latest reports[5] that the supply outlook in Eastern Australia remains tight, particularly due to lower forecast levels of future production, particularly from the Bass Strait. AEMO note in their 2020 Gas Statement of Opportunities Report that the eastern Australian market could face a supply shortfall by 2024.

Other long term factors contributing to uncertainty about future gas supply adequacy include:

— the volume of gas being exported by Queensland LNG projects
— low oil prices, which can impact significantly on gas exploration and development for both domestic producers and LNG projects. This has been exacerbated by the collapse in oil prices as a result of reduced global oil demand in the wake of the COVID-19 pandemic.
— Government policy and regulatory restrictions (including moratoria on gas exploration activities), which can affect long term gas supply.

Global gas demand

The demand for gas globally is only expected to increase over the next two decades which will have important ramifications for Australia’s domestic gas market, mainly via the demand for LNG exports and gas prices. Gas will continue to be an important fuel for the global economy in reducing emissions with various countries utilising gas to help meet their emission targets. Additionally, most of the increase in demand will come from Asia, led by China and India where gas benefits from strong policy support[6]. In both countries, the industrial sector is the main source of demand growth as these economies continue to industrialise and experience increasing rates of urbanisation and energy use.

Even despite a sharp decline in short term gas demand and consumption from the COVID-19 pandemic, the International Energy Agency (IEA) predicts global gas consumption to return to growth within the next two years, and global gas demand to grow at a rate of around 1.5 per cent over the medium term[7]. Long term growth projections by BP and Shell predict gas demand to grow closer to 2 per cent per annum to 2035-40[8]. LNG demand is expected to be a key driver of overall gas demand, growing by a projected 4 per cent over the same period[9].

This growth in LNG demand will also primarily come from Asia, with Shell predicting three quarters of future consumption of LNG to be accounted for by the region. Long term demand for Australian LNG exports are then expected to be underpinned by this demand from Asia. A key implication for the eastern Australian domestic market will be that the Queensland LNG export projects are expected to draw consistently on large volumes of gas to meet this long term demand. Therefore, not only will this trend remain a pivotal one for the Eastern Australian supply/demand balance, but prices are likely to be largely influenced by movements in international gas and LNG markets.

3.2 Future gas supply in Eastern Australia

Analysis undertaken by the ACCC in its review of the East Coast gas market and AEMO’s annual Gas Statement of Opportunities report suggests that in the medium term (to around 2023) sufficient gas will be produced in the east coast gas market to meet domestic demand as well as the current export contract commitments of the three Gladstone LNG plants. This position is, however, reliant on a large quantity of currently undeveloped supply sources for both the LNG projects and other producers being brought into production[10].

[5] ACCC – January 2020 Gas Inquiry report; AEMO – 2020 Gas Statement of Opportunities Report
[6] IEA – 2020 Annual Gas Outlook Report, June 2020; IEA 2019 World Energy Outlook
[7] IEA – 2020 Annual Gas Outlook Report, June 2020
[8] BP – World Energy Outlook 2020; Shell – LNG Outlook 2020
[9] Shell – LNG Outlook 2020
[10] ACCC, East Coast Gas Inquiry Report 2015, April 2016

3.2.1 Northern Territory supply

Gas production in the Northern Territory is becoming relevant to the Eastern Australian market demand situation with the Northern Gas Pipeline now in operation. Current domestic gas supply sources in the NT gas market are:

— Offshore – Blacktip field in the Bonaparte Basin. Blacktip gas will provide the initial supply into Queensland via the Northern Gas Pipeline.

— Onshore – the Mereenie, Palm Valley and Dingo fields in the Amadeus Basin.

The Bayu-Undan field in the Bonaparte Basin has been supplying gas into the Darwin LNG project since 2006. It is not expected to supply any gas into the domestic market, with all reserves and production currently committed to LNG exports.

Gas and condensate from the Ichthys field, located in Western Australian waters in the Browse Basin some 890 km west of Darwin, will be transported to the Inpex LNG plant at Darwin which is now nearing completion. There is currently no expectation that the Ichthys project will provide any gas to the domestic market in the Northern Territory or Eastern Australia.

The Beetaloo Sub-basin (part of the Macarthur River Basin) in the Northern Territory is regarded as highly prospective for shale gas. Several exploration companies are actively working on Beetaloo Basin prospects. However, the timing and scale of any commercial gas production from the Beetaloo Basin, and the level of supply into the Eastern Australian states, remains uncertain. Meaningful supply for the eastern Australian gas market is not projected till the 2030s, late 2020s at the earliest.

3.2.2 Northern Gas Pipeline

As mentioned above, Jemena has finished the construction of the Northern Gas Pipeline between Tennant Creek and Mount Isa and the pipeline was commissioned in late 2018. This pipeline is capable of supplying up to 90 TJ/d of gas from the Northern Territory into the Eastern Australian market at Mount Isa. Initially the pipeline will transport gas supplied by Power and Water Corporation (PWC; Northern Territory Government) from its Blacktip (offshore Bonaparte Basin) contract entitlements and Santos will supply gas to mining customers in Mount Isa. In the longer term, the Northern Gas Pipeline could carry gas from the Beetaloo Basin or other unconventional prospects in the onshore regions of the Northern Territory.

In order to deliver large quantities of gas from the Northern Territory (potentially from the Beetaloo basin) to the main Eastern Australian demand centres, there would be a need for further investment in infrastructure to expand the Northern Gas Pipeline and to provide additional transport capacity downstream of Mount Isa. It should, to a large extent, be possible to stage such investment to meet emerging market opportunities, without the need for large infrastructure investments ahead of demand. Jemena has openly supported increasing the capacity of the Northern Gas Pipeline if shale development is successful in the Northern Territory, with capacity potentially being increased to as much as 900 TJ/day.

3.3 Implications for the NWMP

There are two key implications for the NWMP from recent developments in the gas market – the increase in gas prices and impacts on reliability of future long-term supply.

3.3.1 Gas prices

The typical price for large industrial consumers in Mount Isa has risen from around $5/GJ to $10-12/GJ[11]. The wholesale price of gas accounts for approximately 80 per cent of the price with a small transport component on top.

These higher gas prices have resulted in higher power prices for mining projects in the NWMP. Power is a key input costs for mines and typically represents around 15-20 per cent of a mine's operational costs. Mines that are primarily open-cut operations will have even higher portion of costs attributed to

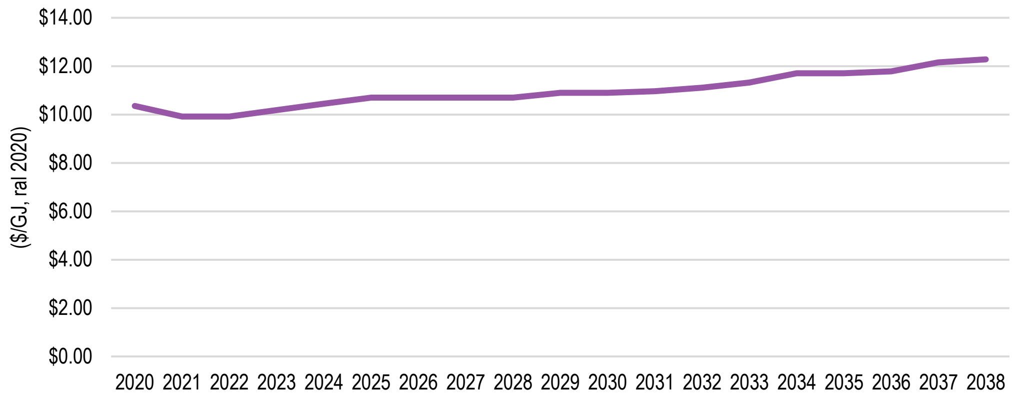
[11] Oakley Greenwood, Gas Price Trends Review 2017, March 2018

power supply. Additionally, ACIL Allen expects this to only get larger as mines into the future will be developing deposits which are deeper and contain lower mineralisation grades. This will require more energy, and therefore more power for mines to develop these types of deposits.

ACIL Allen's projection for long term contract gas prices in the Mount Isa region is shown in Figure 3.2. Contract gas prices are expected to hover around $10/GJ for the next few years before beginning a climb towards $12/GJ from the early 2030s. In this forecast, supply for Mount Isa is initially sourced mainly from the Surat/Bowen and Cooper basins via the Carpentaria pipeline. This then switches to supply mainly from contracted gas in the Northern Territory via the Northern Gas Pipeline. Around 2030, early supply from the Beetaloo basin begins from unconventional gas plays. The forecast below also assumes the Northern Gas Pipeline capacity of 90 TJ/day is not increased. The tariff applied to gas moving through the Northern Gas Pipeline is set at the current rate of $2.20/GJ (including a $0.70/GJ nitrogen removal cost in addition to the regular $1.50/GJ tariff).

Without any significant developments along the east coast that can ease supply pressure, gas prices are expected to increase over time. Even if more development was successful and extraction costs of gas developed from basins such as the Beetaloo were to be low, the cost of gas for consumers in Mount Isa will also be largely influenced by movements in international LNG prices and the flow on effect to the domestic market. Long term contract prices are only likely to potentially fall significantly if a new large source of supply came online which substantially eased the pressure on domestic and LNG gas supply. At present, there is no foreseeable source that could radically address the fundamental problem of tight supply.

FIGURE 3.2 FORECAST LONG TERM CONTRACT MOUNT ISA GAS PRICE ($/GJ, REAL 2020)



SOURCE: ACIL ALLEN GASMARK MODELLING

3.3.2 Long term supply contracts

Another key consideration from recent developments in the east coast gas market is long term supply for customers in the NWMP. As discussed in the previous section, gas prices have been the main impact from the tightening of the east coast gas market and the evolution of the market to include LNG exports. However, another key impact has been on the reliability of supply. As conditions have tightened, the reliability of supply and the ability to negotiate long term supply contracts has diminished, notably. Recent gas supply contracts for large industrial consumers have shortened in length and uncertainty on the ability to contract supply beyond 2-3 years has increased. This concern is more focused on those existing and future mines which are isolated loads, and not serviced through power stations such as the Diamantina power station.

Previously, consumers have been able to negotiate long term gas supply contracts, some well in excess of 10 years. This has provided certainty for consumers and has allowed mining companies to match supply inputs with long term investments for power generation and plans for mining operations. However, in the past couple of years there have been many examples of consumers rolling off long-term gas supply contracts and failing to secure a further long-term contract. Many consumers have only been able to secure 12-month contracts or 2-year contracts. The January 2020 ACCC Gas Inquiry report confirmed that these issues are prominent concerns for consumers at present[12].

As energy requirements become more vital for future mines, particularly with deeper deposits and lower grades, mining companies will have affordability and supply certainty front of mind. CopperString 2.0 will become an even stronger option for power supply in the NWMP if it can provide consumers with certainty regarding supply as well as offering lower prices.

[12] ACCC, Gas Inquiry 2018, Interim Report, January 2020

4 NORTH WEST MINERALS PROVINCE ANALYSIS

ACIL Allen has undertaken a review of recent mining related developments in the NWMP and how this is expected to further evolve over the coming years. Despite the NWMP facing some economic challenges in recent years, including a number of older, larger operations closing and exploration activity declining, the pipeline of future investments is still relatively healthy.

This section of the report will review how things have changed over the past 10 years in the NWMP and highlight the key developments that have taken place. Following this, the chapter will then summarise the analysis undertaken in estimating long term power demand in the NWMP.

4.1 The NWMP

4.1.1 Resources endowment

The NWMP is internationally renowned for being one of the largest, most prospective regions for metals mining. After several decades of significant mining activity, the NWMP still holds about 75 per cent of Queensland's base metal mineral endowment including copper, lead and zinc as well as major silver and phosphate deposits[13]. The NWMP is also becoming increasingly popular in the exploration for rare earths as global demand grows for the use of these materials in advanced and renewables-based technologies.

The region also has significant energy resource potential including geothermal and non-traditional (tight shale) resources[14].

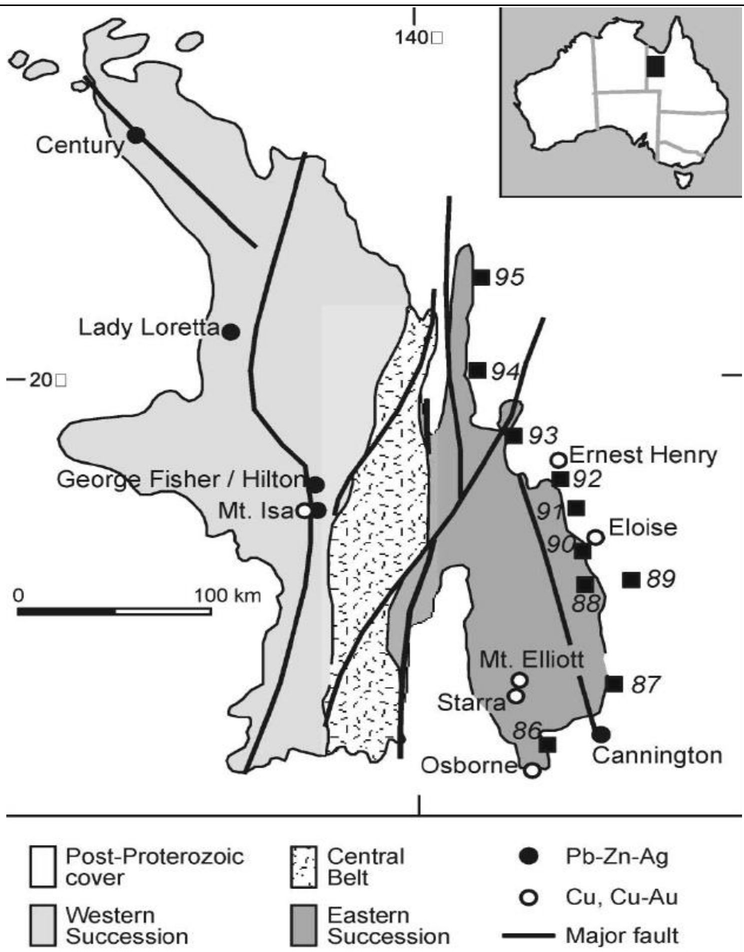
The NWMP is also rich in a diverse range of other commodities with recent discoveries of the world's largest molybdenum-rhenium deposit and a high-grade graphite resource.

In addition to the NWMP's well-developed areas, the Queensland Government and industry is currently undertaking further mineral geophysics and geochemistry studies to better understand the highly prospective area east of Mount Isa known as the Eastern Succession (see Figure 4.1). Initial studies have uncovered deposits with promising potential for significant iron-oxide-copper-gold development.

[13] Department of State Development, Manufacturing, Infrastructure and Planning, A Strategic Blueprint for Queensland's North West Minerals Province, https://www.statedevelopment.qld.gov.au/a-strategic-blueprint-for-queensland-s-north-west-minerals-NWMP-nwmp/regional-development/nwmp.html

[14] DNRM, 2014, Queensland Geology Volume 14, An Assessment of the Geothermal Energy Potential of Northern and Eastern Queensland

FIGURE 4.1 MAP OF THE EASTERN SUCCESSION, NORTH-WEST MINERALS NWMP



SOURCE: W.L. GRIFFIN ET AL (2006) ARCHAEAN AND PROTEROZOIC CRUSTAL EVOLUTION IN THE EASTERN SUCCESSION OF THE MOUNT ISA DISTRICT, AUSTRALIA: U–PB AND HF-ISOTOPE STUDIES OF DETRITAL ZIRCONS

The mineral endowment of the NWMP is likely to continue to be demanded by global manufacturing and construction industries for a range of intermediate uses, including as key inputs into innovative and more traditional applications such as renewable energy, transport infrastructure and other industrial machinery and equipment. However, key challenges will need to be overcome for these resources to be developed in the future as the location of these resources get deeper underground and mineral grades get weaker.

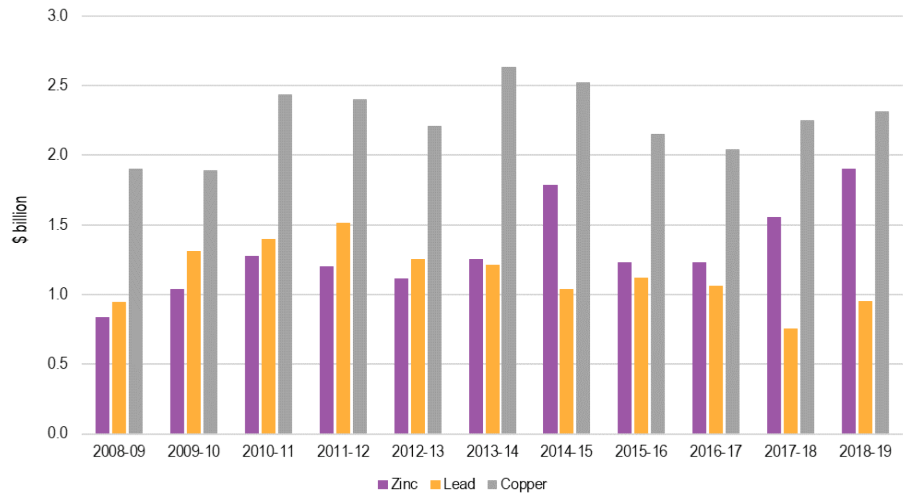
4.1.2 Export history

On average over the past couple of decades, more than 80 per cent of Queensland's base metals exports have come from mines within the NWMP. This has been led by three large mines: Glencore's Mount Isa copper/zinc/lead mine complex; MMG's former Century zinc/lead mine; and South32's (formerly BHP Billiton) zinc/lead Cannington mine.

Exports have been supported by a significant number of smaller to medium sized mines that have targeted common base metals and precious metals including gold and silver.

Figure 4.2 below shows the value of Queensland's base metal exports over the past decade (2008-09 to 2018-19). Export values did experience marked declines from 2014-15 due to reduced production volumes from mines closing (particularly the Century zinc mine) and weaker commodity prices. However, export values have recovered in the past couple of years, particularly for copper and zinc as a result of stronger production and improving commodity prices. Copper remains the largest metals revenue earner for Queensland.

FIGURE 4.2 QUEENSLAND EXPORTS OF BASE METALS: VALUE ($ BILLIONS)



SOURCE: QUEENSLAND GOVERNMENT STATISTICIAN'S OFFICE, FEBRUARY 2020

4.2 Recent developments in the NWMP

The NWMP has experienced some recent developments which ACIL Allen believe are important with respect to the future prospects of the NWMP. These include developments in relation to recent and future mine closures, new mine investments, rising input costs, exploration activity, government policy and market demand. This section will analyse these developments in more detail to assist in the understanding of recent mining activity in the NWMP and what the future may hold.

4.2.1 Market demand

A fundamental positive for mining investment in the region is the growing demand for metals. Increasing levels of industrialisation in emerging and developing economies, as well as a push towards renewable technology and advanced communication and information technologies, is driving long term demand for metals mined in the NWMP.

The following descriptions on the outlook for various commodities has been sourced from the latest versions of the Resources and Energy Quarterly Report published by the Office of the Chief Economist within the Commonwealth Department of Industry, Innovation and Science[15].

Copper

Industrial production remains the primary driver of growth in copper consumption. The largest source of growth in power and infrastructure investment is still China, although other countries in Asia are also increasing their copper use. Among other countries, copper demand is being supported by growing uptake of wireless communication technology and batteries.

Further through this decade, electric vehicles are likely to take over as the primary source of growing copper demand.

Zinc and lead

Zinc's primary use is galvanizing steel, so consumption is expected to move with steel use and, in turn, vehicle production and infrastructure development. China accounts for around half of all zinc consumption. Demand for zinc from China is expected to moderate, however, as environmental policies limit new and expanded zinc smelting capacity. However, this moderation is expected to be partially offset by growth in steel consumption in India and other emerging economies.

[15] Department of Industry, Innovation and Science, Resources and Energy Quarterly, December 2019 and March 2020 reports.

Gold

Global gold consumption is forecast to rise over the short term. Ongoing effects from the COVID-19 pandemic, a global economic slowdown, low interest rates and other uncertainties are all expected to dampen consumer and business confidence and boost safe haven demand for gold.

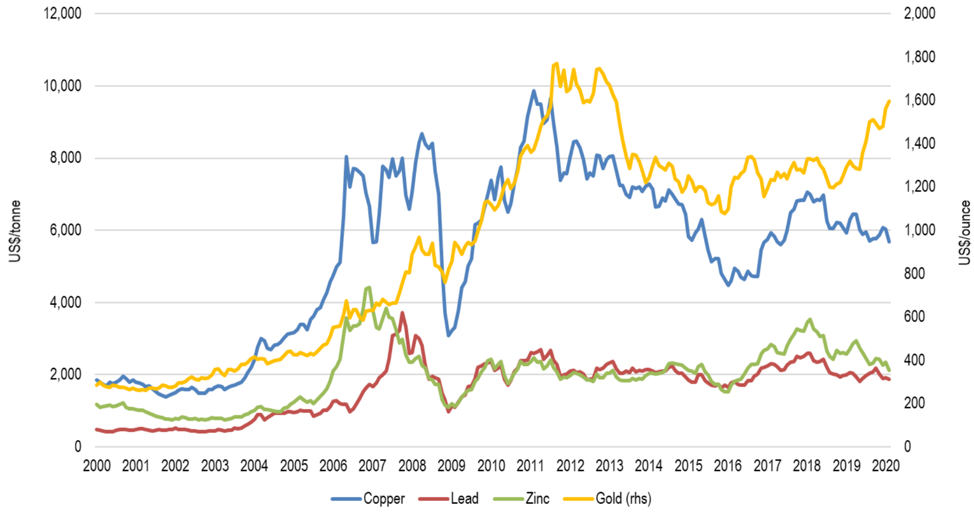
World gold consumption is projected to rise from 2021, driven by increasing central bank purchases and industrial/commercial demand.

Rare earths

Rare earth elements have unique catalytic, metallurgical, nuclear, electrical, magnetic and luminescent properties. Their strategic importance is indicated by their use in emerging and diverse technologies that are becoming increasingly more significant in today's society. Applications range from routine (e.g., lighter flints, glass polishing mediums, car alternators) to high-technology (lasers, magnets, batteries, fibre-optic telecommunication cables) and those with futuristic purposes (high-temperature superconductivity, safe storage and transport of hydrogen for a post-hydrocarbon economy, environmental global warming and energy efficiency issues)[16].

Rising metals prices over the past two decades has been as a result of this increasing demand and the increased cost of higher production from declining mine ore grades. Figure 4.3 shows how commodity prices for certain metals have increased over the years as new sources of demand evolve.

FIGURE 4.3 SELECTED GLOBAL METALS PRICES



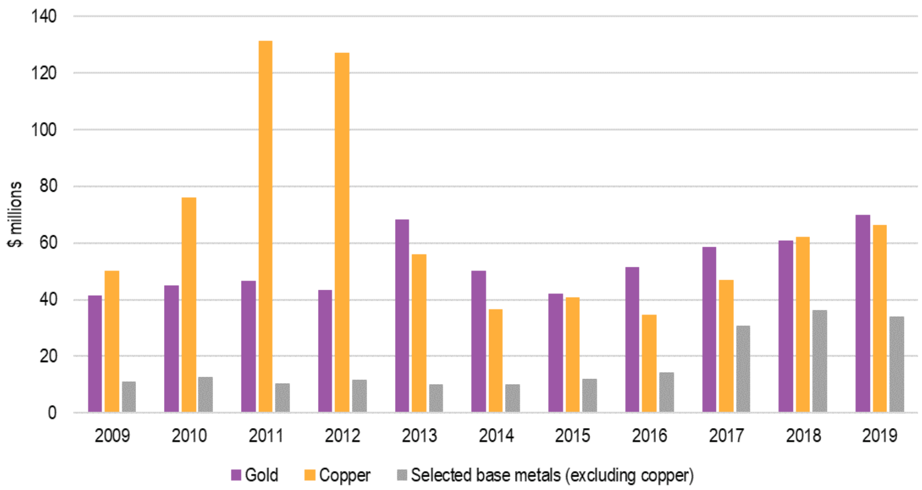
SOURCE: THE WORLD BANK, 2019

4.2.2 Exploration

Exploration activity in the NWMP has recently lifted after experiencing a period of lacklustre exploration in response to weaker commodity prices. Base metals in particular are relatively sensitive to changes in commodity prices while gold exploration has experienced less volatility. Figure 4.4 shows minerals exploration in Queensland for a variety of minerals over the past decade.

[16] Geoscience Australia, Rare Earth Elements, https://www.ga.gov.au/scientific-topics/minerals/mineral-resources-and-advice/australian-resource-reviews/rare-earth-elements

FIGURE 4.4 EXPLORATION EXPENDITURE FOR SELECTED METALS



SOURCE: THE AUSTRALIAN BUREAU OF STATISTICS, DECEMBER 2019

Copper exploration expenditure has been the hardest hit with expenditure falling from a peak of $130 million in 2011 to half this total in 2019 at $65 million. A noticeable lift has occurred since 2017 for other base metals which includes zinc, lead, cobalt and nickel.

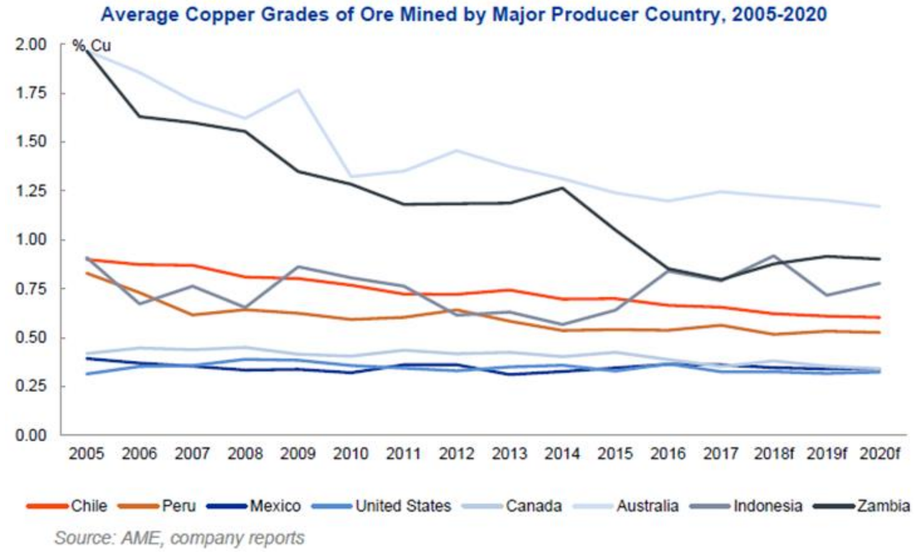
The relationship between exploration expenditure and commodity prices has always been a close relationship in the minerals sector. As the majority of exploration is still carried out by junior miners, this fluctuation in expenditure occurs as a result of junior miners being heavily reliant on equity funding. As commodity prices are beginning to rise and explorers become more attractive to equity markets, exploration budgets are increasing due to fresh waves of equity funding.

Due to the high prospectivity of the region, close access to markets and available infrastructure, the region will always be attractive for explorers. This is despite exploration becoming more difficult as explorers drill deeper to find the next significant mineralisation deposits. Additionally, these future deposits are more frequently lower grade deposits which will require higher levels of processing to extract the contained metal. Figure 4.5 shows how copper grades have fallen noticeably over the past few years in several copper producing regions[17].

This trend of lower grades is leading to less significant deposits than in previous decades and new mines that are smaller in size and in mine life. Pressure on mining costs will also increase for future mines as processing requirements increase and the benefits of scale are not as significant. Therefore, new mines in Queensland will have to find ways to remain competitive against their global competitors (who are also experiencing similar issues) as their productivity and cost advantages are eroded over time.

[17] AME Group, Declining copper ore grades, February 2018, http://aus.amegroup.com/Website/FeatureArticleDetail.aspx?faId=437

FIGURE 4.5 COPPER METAL GRADES



SOURCE: AME GROUP, 2019

4.2.3 Regulatory environment and Government policy

A positive for development in the NWMP is the continued support of the Queensland Government to encourage investment and mining in the region. Mount Isa is a key city for regional growth and employment. Government policy has been increasingly supportive in recent years as the NWMP faces some challenging times with regards to future mining investment.

The Queensland Government supported the establishment of a North West Minerals Province Taskforce in 2015 to investigate the issues and opportunities impacting the NWMP and advise on a way forward for the region's future. Building on the work of the Taskforce, a strategic blueprint was developed in 2017 that set out a platform through which the Queensland Government would collaborate with other levels of government, business and industry, and communities to support a smooth transition to a stronger and more diversified economy in the longer term[18].

The Queensland Government announced the following measures to incentivise major resources-related projects in the NWMP:

— Resources development (royalties) policy
— Improve pre-competitive geoscientific data
— Establish a Minerals Collaborative Exploration Program
— Develop new geological databases
— Promote the investment potential of the NWMP
— Clarify and streamline approvals processes for explorers
— Investigate opportunities to re-process waste materials from tailings
— Leverage common user infrastructure opportunities

This strategic blueprint included almost $30.9 million over four years in additional budget measures to support the resources sector. These measures outlined below were intended to provide tangible support to promote prosperity of the NWMP for many years to come.

The latest initiative from the Queensland Government announced in November 2019 is targeting greater investment in 'new economy minerals' in Queensland, needed for advanced electronics and renewable technologies for the future. New economy minerals, including minerals such as cobalt,

[18] Department of State Development, Manufacturing, Infrastructure and Planning, A Strategic Blueprint for Queensland's North West Minerals Province, https://www.statedevelopment.qld.gov.au/a-strategic-blueprint-for-queensland-s-north-west-minerals-NWMP-nwmp/regional-development/nwmp.html

graphite, rhenium, vanadium, rare earth elements and also traditional base metals, that are mostly concentrated in the state's North West and North East mineral provinces. To develop a sustainable pipeline of 'new economy minerals' projects into the future, the Queensland Government is investing in exploration activities to improve scientific understanding and supply the valuable geoscience data needed by industry to help locate and define deposits for future production.[19]

The key items of the recently announced $13.8 million package are:

— $4.8 million to re-examine old mine tailings and core samples for new age minerals
— $9 million to unearth more and better geological information to help industry identify new projects, including $3.5 million in industry grants over five years for new and innovative exploration activities.

The Queensland Government expects the initiative will encourage new exploration, re-investigate old mines and probe the effectiveness of geological information the Government holds already.

4.2.4 Mine closures and openings

A significant challenge the NWMP has faced over the past few years has been the closure of a number of large producing mines. This is expected to continue over the next 10-15 years as a number of further significant mines are forecast to cease mining. This has been a key development which has encouraged further support by Government to ensure mining is sustainable in the NWMP over the long term.

The largest of these closures has been the Century zinc mine operated by MMG. Century at its peak produced over a third of Queensland's zinc and lead production. The mine was operational for two decades but ceased due to the exhaustion of primary ore reserves at the site. This had significant consequences for zinc and lead production in the state with Queensland exports falling noticeably in 2016 and 2017.

The next looming concern for the NWMP is the future of two further large mines – Glencore's Mount Isa Copper mining complex and South32's Cannington zinc/lead mine. These two operations, particularly Glencore's copper operations in Mount Isa, have supported the NWMP for several decades. They produce the overwhelming amount of base metal production in Queensland and support a significant number of businesses and jobs in the region. These two mines have been anticipated to close within the next 10-15 years but in some scenarios (e.g. development of tailings) could keep operating for a longer period. The investment coming online and into the future is not predicted to be at levels which will entirely compensate for the closure of these two mines.

Nevertheless, there are a number of positive developments that could see continued strong development and mining activity in the NWMP if they come to fruition. The first is Glencore deciding to proceed with its 'Super Pit' development. This development would effectively see Glencore maintaining its mining activities in Mount Isa for the next two to three decades at production rates comparable to levels seen over the past decade. However, it would require a substantial investment by Glencore, which the company has ruled out at this stage. Other possible developments could include the processing of tailings deposits, which would also extend mine life significantly.

Other opportunities that have the potential to minimise the impacts of large existing mines ceasing production are new mines entering production and different types of mining occurring. In recent years the NWMP has seen a number of mines come online including MMG's Dugald River zinc mine, Capricorn Copper's copper mine and CuDeco's Rocklands copper mine (although this mine has currently suspended operations). These mines still demonstrate the on-going potential of the region, albeit at a smaller scale to the giant mines of previous decades. The region is also experiencing a wave of interest in commodities that have not traditionally been mined or explored in the area, including vanadium, graphite and cobalt. If industry can find avenues to mine these commodities commercially at a large scale, this could significantly boost exploration and mining development around Mount Isa.

[19] Department of Natural Resources, Mines and Energy, New Economy Minerals, https://www.dnrme.qld.gov.au/mining-resources/initiatives/new-economy-minerals

A promising X factor for the NWMP is certainly New Century Resources' project at the former Century zinc mine. Based on the proposed production profile, New Century Resources' estimated Century will again be one of the top 10 zinc operations in the world, with steady state production forecasted at 507,000 tonnes per annum of zinc concentrate from the tailings dam only[20]. Although the mine's production rates to date have not matched this projected number, significant production is still being achieved. This project represents a very positive development for the mining industry and if this reprocessing pathway can be replicated at various sites, the opportunity to 're-mine' older sites could unlock significant additional value for the NWMP and the state. The mining of tailings also has benefits for mine rehabilitation. Further analysis of future tailings developments is presented later in this chapter.

4.2.5 Rising power prices

Another key development in the past decade has been rising input costs. Costs for a number of inputs has accelerated. One particular cost has been power.

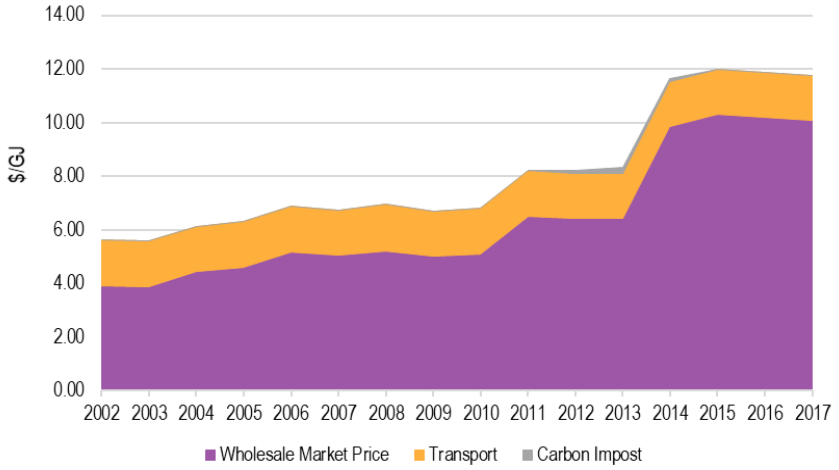
Existing energy supply in the NWMP is largely dependent on the supply of gas from Ballera over the Carpentaria gas pipeline, both for electricity generation and direct use in minerals processing plants. The Diamantina, Leichardt and Mica Creek power stations in Mount Isa have been the sources of power to the region over recent decades. Some mines operate isolated gas-fired or diesel fired generators. The Diamantina power station also supplies energy to meet Mount Isa's domestic and commercial requirements and those of Cloncurry and surrounding communities.

As described in chapter 2, the price of gas has increased significantly in recent years. This has driven wholesale prices up in North-West Queensland from levels around $6/GJ in 2013 to current prices now around $10GJ (see Figure 4.6). Prices for some customers has been even higher at levels around $11/GJ[21]. These higher gas prices are causing electricity prices to rise which is directly being passed on to customers, such as mining producers.

Some downward pressure on gas prices in the long term may result from the completion of the Northern Gas Pipeline built by pipeline company Jemena. This pipeline links Mount Isa with supply from the Northern Territory. Gas has commenced flowing through this pipeline into Mount Isa and has the potential in future years to provide the NWMP with larger volumes of gas.

Over the long term, mining activity in the NWMP will potentially be influenced by power prices. Options which help contain, and even reduce power prices, will increase the competitiveness of Queensland mines compared to their competitors in other jurisdictions.

FIGURE 4.6 NORTH-WEST QUEENSLAND LARGE INDUSTRIAL CUSTOMER GAS PRICES



SOURCE: OAKLEY GREENWOOD, GAS PRICE TRENDS REVIEW REPORT, JANUARY 2018

[20] New Century Resources, Restart Feasibility Study, https://www.newcenturyresources.com/century-mine-project/restart-feasibility-study/
[21] Oakley Greenwood, Gas Price Trends Review 2017, March 2018

4.3 Forecast of power requirements in the NWMP

The second section of this chapter summarises electricity loads in the NWMP over the next 30 years from existing and future mines. A comprehensive study to estimate the demand in the NWMP has been carried out by Soren Consulting in conjunction with Izmin Consulting.

A mine production and power demand forecast has been developed for mines according to different power supply scenarios.

The two power supply scenarios were:

1. A base case with the current gas fuelled power supply **(Business as Usual) (BAU)**
2. A base case with access to the NEM provided by CopperString 2.0 **(NEM connected)**

The difference in mining activity and development between the two scenarios is driven by the benefits of reduced energy input costs due to the NEM connection. These demand and production scenarios are then incorporated into the electricity modelling and economic modelling to understand the competitiveness of CopperString 2.0.

4.3.1 Methodology

As mentioned above, the demand analysis was carried out by Soren Consulting, in conjunction with the following consultant groups:

— Izmin Consulting – Geology, resource economics and evaluation expertise

— Neuchatel – Mining and mineral processing evaluation expertise

— JKTech – Mining technology and mineral processing expertise

— Wood Mackenzie – global market and commodity forecasting expertise

The methodology involved a number of key steps. The steps are summarised below:

— Developing a data base of known Mineral Reserves and Resources in the NWMP. The data base developed took into account projects/mines which had reported in the Australasian Joint Ore Reserves Committee (JORC) compliant Mineral Resources and Reserves. Consideration was also given to the potential for new mines to be discovered/developed in the 30 year review period based on the highly prospective resource potential and the historical rates of discovery over the past 100 years. In the BAU case, 3 additional New Mines were included in the database, each of average size based on the historical discoveries. In the NEM connected case, 6 were included.

— CuString engaged Wood McKenzie to prepare a market due diligence report to provide a global outlook for the main commodities produced in the NWMP and some of the major producers. Wood McKenzie indicated in their report that continued growth in the global economy (underpinned by growth in the developing economies of China and India) would continue with resultant growth in demand for commodities including copper, zinc and lead.

— A development assessment then followed the creation of the mines database with the aim of assessing the development potential of the region under the BAU scenario **– where CopperString was not developed**. This step determined which projects were forecast to occur in the NWMP under BAU case. Two outputs were produced from this step:

   3. A mine production schedule which was represented as a revenue curve, to homogenise the different commodities produced, demonstrating the production and earnings potential from the region over the forecast period; and
   4. A power demand curve which represents the power demand projected to deliver the production output.

— The next step then repeated this process under the NEM connected scenario **where CopperString was developed**. The key exercise involved in this step was estimating how much additional production could be achieved from lower operating costs as a result of a drop in power costs due to NEM connection. The lower operating cost impacts different projects in different ways including a reduction in cut-off grades at projected long-term commodity prices and allowing the use of fine grinding to improve the mineral recovery from lower grade resources. The impact of these reduced cut-off grades adds substantial marginal tonnes to be processed, increasing produced metal and mine lives for both existing and new mines.

— The outputs of this analysis - production and power demand are then used in ACIL Allen's modelling to project the impact of CopperString 2.0 on the electricity market (discussed in the following chapter).

Mines database

The mines database has been developed by Izmin Consulting in consultation with Soren Consulting. The database collected and categorised as much information as possible on the identified mines and projects. The database in its final iteration collected information on 112 projects in total. The database includes information for each project with respect to (but not exclusively):

— Mineral Reserves (various subcategories)
— Mineral Resources (various subcategories)
— Production statistics
— Power requirements
— Location
— Commodities mined/targeted
— Status of operation

Where information on Mineral Reserves and Mineral Resources was available from published material by mine owners, this has been used in the first instance. Projects assessed in the current analysis include 112 projects with quoted Mineral Resources of which 39 have Mineral Reserves as well. Mineral Resources and Reserves quoted are JORC compliant and determined by a Competent Person as defined by the 2012 JORC Code.

In the current power and production profiles presented as part of this study only 62 projects (out of 112 projects in the current database) have been used, with a large number of defined resource projects still considered to be at a stage too early to include in this review.

When projects do not have quoted Mineral Reserves, an assessment of the relationship for projects with both quoted Resources and Reserves has been examined and while there is significant variability, the average conversion rate is 50 per cent of Measured, Indicated & Inferred Resources to Proven & Probable Reserves. This relationship has therefore been used to estimate the quantity of resources that are likely to be developed for individual projects. This approach is also considered to be conservative because it assumes no extension to Mineral Reserves over the life of CopperString 2.0.

Similar to the treatment of a mines Mineral Reserves and Resources, production rates have been based on published information by project owners where possible. For those projects that do not have published production rates, an estimated mining rate has been estimated based upon the mines inventory. This has also been used to estimate the life of mine for each project which has been determined by dividing the mine inventory by the estimated production rate (per annum). This data forms the basis for the remainder of the demand analysis.

Resources assessment

The aim of the resources assessment was to forecast the level of development that would occur in both scenarios – the **BAU case** and the **NEM connected case.** The assessment for both would produce two outputs on the level of production expected to occur over the forecast period and the likely demand for power based on this forecast level of production.

As mentioned earlier in the chapter, the mineral industry in the NWMP is mature, with existing world class mines, strong processing and logistical infrastructure and geology that remains prospective on a global scale. These strong fundamentals mean the region is still forecast to be a prominent mineral production region well into the future. However, despite the relatively good infrastructure and promising geology, the cost of doing business in the region is relatively expensive, primarily due to the high cost of bulk product transport to port, and the very high cost and inflexibility of how mines currently procure their energy supply.

The difference between the two cases is the various benefits CopperString 2.0 is likely to have on current and future mining projects. NEM access would provide industries within the NWMP a reliable, flexible and globally competitive electricity market. This assessment includes the likely impact that lower electricity costs would have on resource development and life of mine extensions if NEM access was available. The benefits from reduced power costs could lead to several benefits for mining operations including:

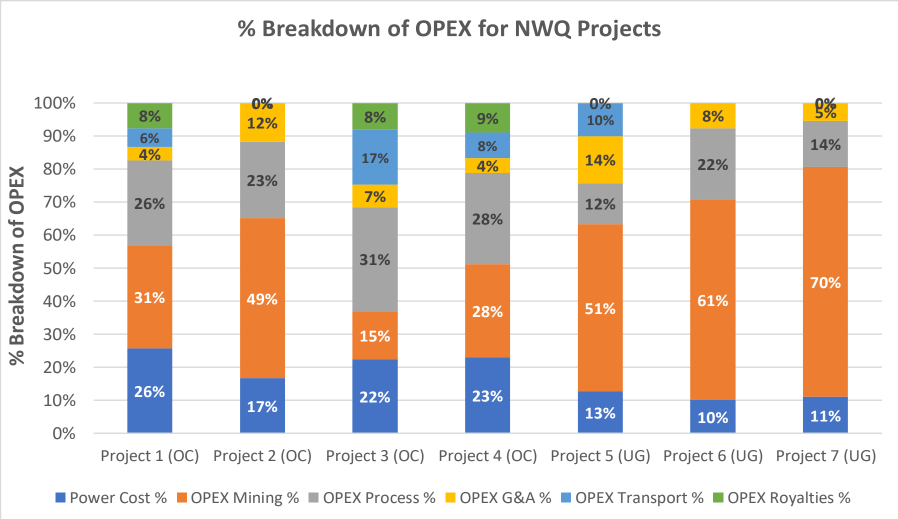
— Reduction in operating costs and cut-off grades
— Enables milling of lower grade, bulk tonnage deposits
— Application of fine grinding to refractory ores and tailings
— Development of deeper deposits
— Development of new deposits (e.g. cobalt, rare-earth elements, phosphate)

Power comprises a significant component of the overall operating cost base of mines. Figure 4.7 illustrates this finding.

The consulting team reviewed a range of mining projects and estimated that power costs as a proportion of total operating costs generally range between 17 and 26 per cent for open cut mines and between 10 and 13 per cent for underground mines.

As Figure 4.7 illustrates, the introduction of CopperString 2.0 is likely to have a significant impact on overall operating costs considering the contribution to total costs from power. The next phase of the demand analysis was then to understand how a reduction in power costs would impact mining activity.

FIGURE 4.7 BREAKDOWN OF OPERATING COST STRUCTURES FOR NWMP MINES



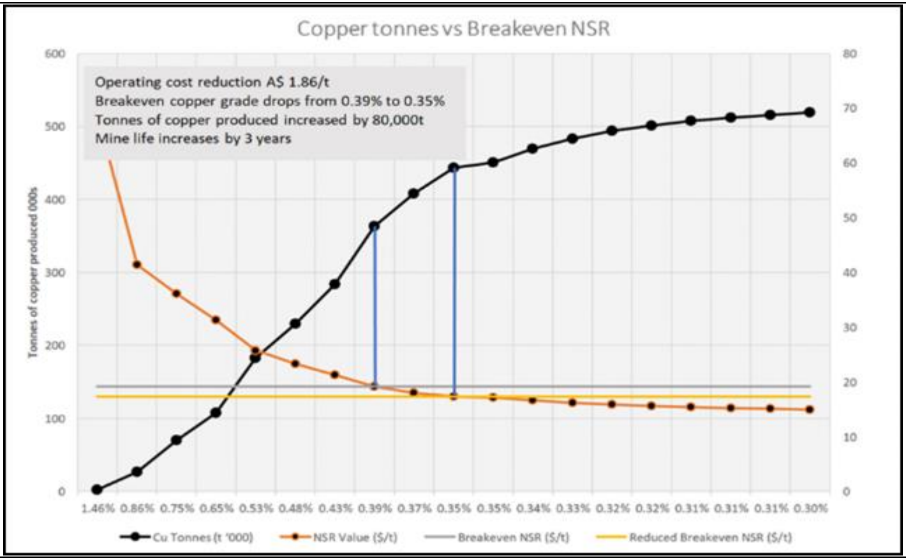
SOURCE: IZMIN CONSULTING

One of the significant benefits from lower power costs is the ability of mines to reduce cut-off grades and mine more material. Cut-off grade is the grade that is used to distinguish between ore and waste within a given orebody. It typically represents the minimum grade required in order for a mineral to be economically mined. Material found to be above this grade is considered to be ore (economic), while material below this grade is considered to be uneconomic and therefore categorised waste. By reducing the cut-off grade, more ore can be extracted from a given mine increasing the life of mine mineral production or potentially supporting a higher mining rate.

Assuming CopperString 2.0 can reduce power costs by 40 per cent, Izmin Consulting estimated that this equates to a reduction in operating costs ranging between $1.30 per tonne and $6.00 per tonne. This cost reduction results in a small but significant reduction in cut-off grade at projected long-term commodity prices.

An example is provided below (Figure 4.8) of how a reduced cut-off grade due to lower operating cost can impact projected production. The data used to develop this example was taken from the 2018 Little Eva feasibility study published by Copper Mountain Mining Pty Ltd.

FIGURE 4.8 EXAMPLE OF EFFECT OF REDUCED CUT-OFF GRADES ON PRODUCTION



SOURCE: NEUCHATEL PARTNERS

As the Figure demonstrates, the impact of these reduced cut-off grades (movement of the blue line right in the chart above) will add substantial marginal tonnes that can be economically mined and processed (movement up and along the black line above), increasing how much can be produced from the mine and resulting in an increase in mine life.

In addition to the impact on cut-off grades for mines, flexibility in energy procurement will also allow better management of operating cost through commodity cycles and to take advantage of market opportunities.

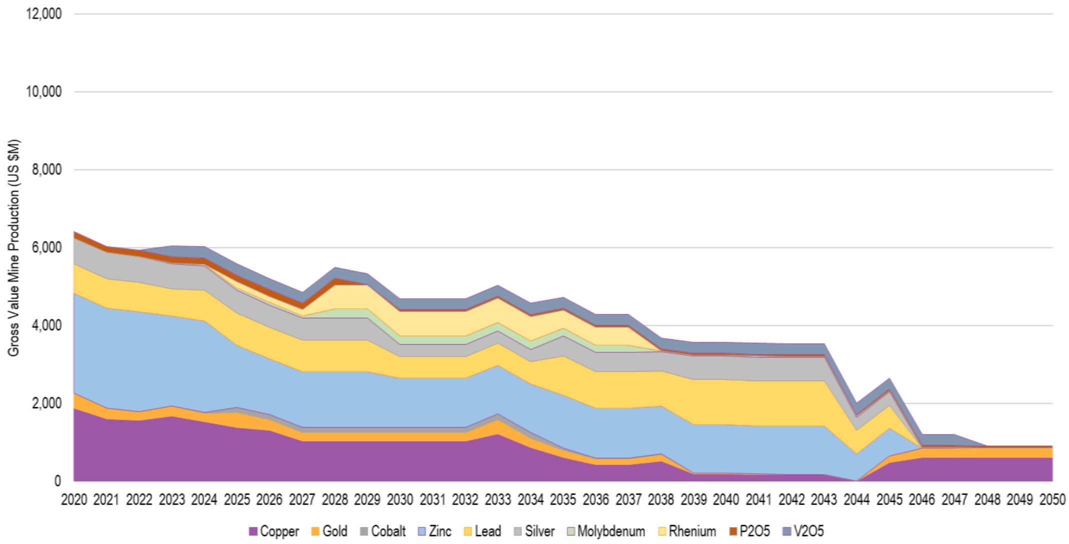
Base case without CopperString (BAU case)

The BAU Case assumes the ongoing operation of existing mines as described by their operators which is mainly based on power supply from gas-fired power stations. The BAU production profile shows production revenues steadily declining over the forecast period. The decline is largely brought about by large operations ceasing activity. These include:

— Glencore's Mount Isa Copper operations ceasing in 2025
— Glencore's Mount Isa Copper Smelter ceasing in 2022
— Glencore's Ernest Henry copper mine ceasing in 2025
— South32's Cannington zinc/lead mine ceasing in 2032
— New Century Mines' Century tailings deposit ceasing in 2025
— MMG's Dugald River zinc/lead mine ceasing in 2034
— Incitec Pivot's phosphate mine ceasing in 2028

As traditional base metal mining declines, the level of new investment in either base metal mining or the development of non-traditional metals is unable to reverse the decline or materially slow the decline in power demand. Some greenfield mine development projects in minerals such as Rhenium, Phosphate and Vanadium provide positive temporary uplifts for production revenues in the NWMP. However, the ceasing of activity for many of the large copper, zinc, lead and silver operations contribute to production revenues falling from levels around the US$6 billion/annum mark to levels below a third of that total by 2044.

FIGURE 4.9 PRODUCTION REVENUE: BAU CASE



SOURCE: IZMIN CONSULTING

Base case with CopperString (NEM connected case)

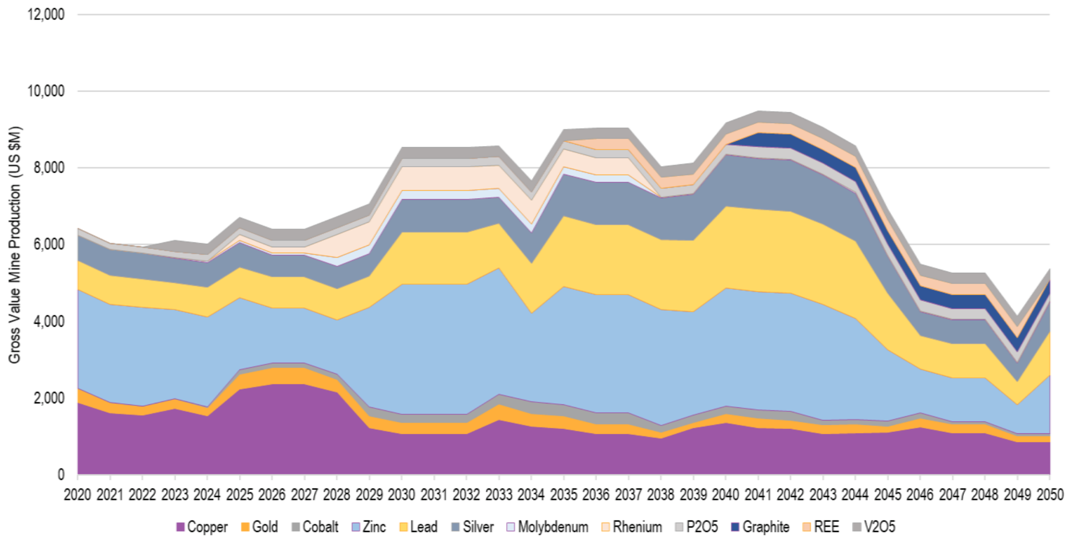
Figure 4.10 illustrates the NEM connected base case forecast production profile for the NWMP. As described earlier in the methodology, the impact of reduced power costs on the ability of mines to produce more output at lower cut-off grades is significant. Reduced power costs also bring about additional development from new projects and the development of tailings deposits left over from historic mining activity on existing mine sites.

The base case production profile with the inclusion of CopperString 2.0 shows production revenues steadily increasing over the forecast period before dropping significantly much later in the forecast period. This production profile which demonstrates sustained production revenues over the forecast period is largely brought about by mine life extensions of existing large operations and the development of new mines and tailings deposits.

In addition to the larger projects, other smaller to medium sized projects that are likely to be developed under the NEM connected case but are unlikely to be developed under the BAU case include:

- Development of phosphate projects including D-Tree
- Development of Roseby – Blackard
- Development of cobalt projects at Capricorn Copper and Mount Oxide
- Restart of the Rocklands and Lady Annie copper projects

FIGURE 4.10 PRODUCTION REVENUE: NEM CONNECTED CASE



SOURCE: IZMIN AND SOREN CONSULTING

As illustrated above, increases in mine revenue in the NEM connected case is mainly due to increases in the mine inventories for existing operations such as Mount Isa underground copper mine, George Fisher, Cannington, Dugald River and Phosphate Hill. These extensions to mine life are brought about due to expected reductions in cut-off grades due to reduced power costs.

The forecast for major operations is summarised in the table below.

TABLE 4.1 FORECAST FOR MAJOR EXISTING MINES UNDER NEM CONNECTED CASE

Mine/Operation	BAU case mine life	NEM connected case mine life	Comment
Glencore's current Mount Isa Copper operations	2025	2028	Completion of the Mount Isa copper underground operation extended to 2028. Tailings development to occur later in forecast period.
Glencore's Mount Isa Zinc operations	2045	2050	George Fisher will be operated in parallel with Lady Loretta until 2022 followed by Black Star underground operation, maintaining steady state 6Mtpa operation until 2045. Tailings development takes activity beyond 2050 (includes copper deposits).
Glencore's Ernest Henry copper mine	2025	2037	Completion of Ernest Henry underground in 2027 with 2-year extension to underground operation prior to mining E1 and Monakoff (1 year) and then re-treating Ernest Henry tailings from 2029 TO 2037.
South32's Cannington zinc/lead mine	2032	2056	Current mine operating until 2032 followed by Tailings development until beyond 2050.
New Century Mines' Century tailings deposit	2025	2025	Current mine operating until 2025.

Mine/Operation	BAU case mine life	NEM connected case mine life	Comment
MMG's Dugald River zinc/lead mine	2034	2043	Current mine operating until 2043, extended 9 years due to lower operating costs allowing mining of marginal ore
Incitec Pivot's phosphate mine	2028	2050+	Mine connects to CopperString following the current mine operating at completion of current gas contract in 2028 and operates until after 2050. Local acid production from pyrite roasting associated tailings treatment will assist this extension

Tailings deposits are a significant reason for many of these operations above continuing further into the forecast period. Izmin Consulting identified that tailings deposits are reported to have an in-situ value of around an estimated $54 billion. The tailings deposits are significant at existing mine sites which have operated for decades. These sites are also likely to be significant contributors to power demand in the future as these tailings deposits generally require even finer grinding rates to recover metal from the deposits, requiring greater power input.

For example, the levels of metal identified in the Mount Isa Mines tailings deposits are substantial, and could bring about multi-decade operations to simply re-process material in these deposits. The development assessment determined that a tailings operation at the Mount Isa Mines complex could last close to 30 years.

Large tailings operations could also be undertaken at the Cannington mine once conventional mining has ceased, Ernest Henry, Osborne and also the former Mary Kathleen mine. As technology is advanced over time, it is considered that more tailings deposits will be re-evaluated and mined considering the forecast demand for new economy minerals is increasing over the medium- long term.

Table 4.2 presents these currently identified tailings deposits.

TABLE 4.2 TAILINGS RESOURCES IN NWMP

Company	Project	Main Commodity	Resource	In Situ Value ($US millions)
Glencore	Mount Isa Tailings	Copper (Cu), Lead (Pb), Zinc (Zn), Silver (Ag)	325Mt @ 0.10% Cu, 1.67% Zn, 1.17% Pb @ 34.2g/t Ag	30,454
Glencore	Lead Smelter Slag	Zinc	60.0Mt @ 9.50% Zn	11,890
New Century	Century Tailings	Zinc, Lead, Silver	78.9Mt @ 3.00% Zn, 0.50% Pb, 12.00g/t Ag	6,268
Glencore	Ernest Henry Tailings	Copper, Gold (Au)	110.0Mt @ 0.10% Cu, 0.20g/t Au	3,609
South 32	Cannington Tailings	Silver, Lead, Zinc	12.5Mt @ 0.65% Zn, 1.00% Pb, 75.0g/t Ag	972
Chinova Resources	Osborne Tailings	Copper	21.9Mt @ 0.11% Cu	889
Chinova Resources	Selwyn Tailings	Copper, Gold	10.0Mt @ 0.19% Cu, 0.49g/t Au	368

SOURCE: IZMIN AND SOREN CONSULTING

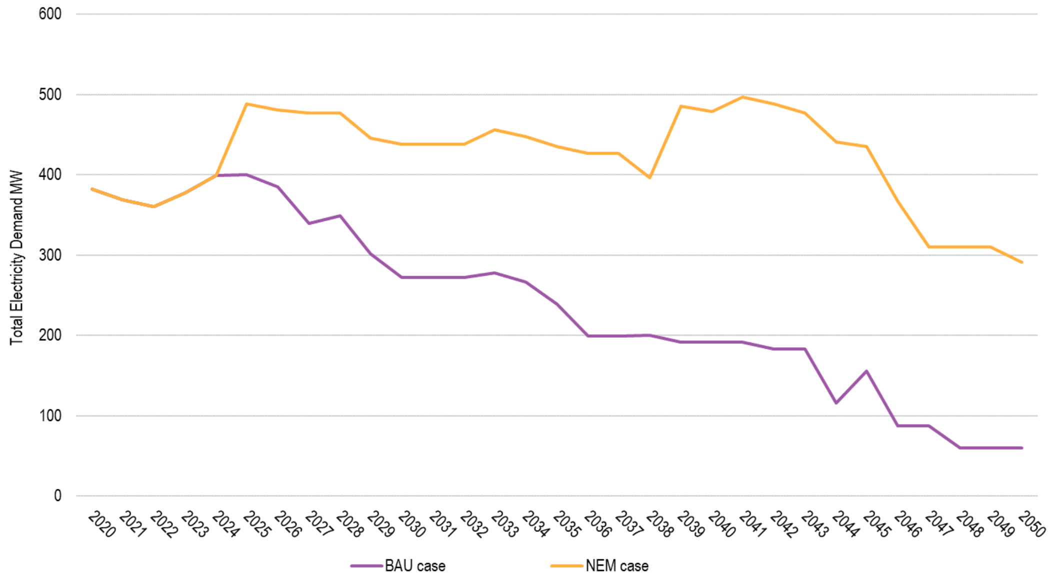
Reprocessing material at tailings deposits also has an environmental advantage when it comes to rehabilitating sites. Once mines cease, mines sites are required to rehabilitate the areas where mining activity has impacted the land and return it as close to its pre-mining state as possible. A critical stage for the rehabilitation process is managing tailings deposits. As tailings deposits are generally regarded as waste, which is required to be cleaned up, the reprocessing of minerals from these deposits can provide revenue stream to accelerate the rehabilitation of these tailings deposits and effectively manage this problem. With frameworks for rehabilitation across Australia strengthening and particularly in Queensland in recent years, the reprocessing of tailing deposits would be a favourable activity from a rehabilitation perspective alone.

Power demand

The impact on power demand from the two demand scenarios is presented below in Figure 4.11. What is immediately evident is the difference in demand between the two demand scenarios with the NEM connected case sustaining strong power demand for much longer. This is principally the case as even a relatively small reduction in total operating costs brought about by a significant reduction in power costs can generate considerable additional production. Decreasing cut-off grades marginally as demonstrated in this analysis can lead to far greater quantities of material being classified as economic and commercially viable to produce. More power is also required for operations such as tailings developments in the future which require very fine grinding rates.

In the BAU case, power demand is expected to trend down and mirror the production profile for this scenario. Without a significant drop in operating costs, mining activity is expected to generally follow current production schedules and mine lives as forecast by mine owners and operators. With several large mines expected to wind-down over the forecast period, power demand will fall as forecast below with much lower new investment over the review period to sustain mining activity and power demand in the NWMP. The BAU and NEM power demand curves are then used for the next piece of the evaluation – the electricity market analysis which is presented in the next chapter of this report.

FIGURE 4.11 POWER DEMAND: BAU AND NEM CONNECTED CASES



SOURCE: IZMIN AND SOREN CONSULTING

5 ELECTRICITY MARKET ANALYSIS

5.1 Introduction

This chapter summarises the findings of our analysis of the impact CopperString 2.0 is projected to have on the supply of electricity to Mount Isa and the NWMP, as well as the Queensland region of the NEM.

We start with a summary of our understanding of the current electricity supply and demand situation in Mount Isa and the NWMP, and then consider how this may evolve over time if CopperString 2.0 is not developed.

We then provide a brief summary of our projection of the Queensland region of the NEM if CopperString 2.0 was not developed. We then provide a summary of the implications of the development of CopperString 2.0 on electricity supply to Mount Isa and the NWMP, as well as Queensland more broadly.

For the avoidance of doubt, the following geographic terms are used in this chapter:

— *Mount Isa*, or the *Mount Isa region*, refers to the area covering Mount Isa and the portions of the NWMP that are or are projected to be electrically connected to the isolated NWPS or connected to the gas transmission network passing through the region.

— *Queensland*, or the *rest of Queensland*, refers to the current Queensland region in the NEM (and excludes the Mount Isa region)

— *Whole of Queensland* refers to the aggregate of the Mount Isa region and the Queensland region[22].

Since the previous study of CopperString[23], the key changes in the electricity market relate to emissions abatement and renewable energy policy. 10 years ago, there was little prospect for renewable energy investment in the Queensland region of the NEM – with most projections at the time suggesting renewable energy targets would be met by investment in wind farms in southern states. The rapid decline in solar photo voltaic (PV) capital costs, continued decline in wind farm capital costs and improvements in wind turbine efficiency, and continued exploration and discovery of commercially viable wind resources in Queensland, coupled with larger renewable energy targets (both national and state) and increasing coal and gas costs have changed this outlook. By 2021 there will be about 2,800 MW of large-scale renewable projects operating in the Queensland region of the NEM (these are either operating now or have reached financial close). Between 2021 and 2030, the Queensland Renewable Energy Target (QRET) policy will require an additional 2,300 MW of large-scale renewable investment, which we project will require some form of subsidy since wholesale electricity prices are projected to be below new investment levels during this period.

22 Despite the terminology, the *whole of Queensland* excludes other isolated networks in Queensland.
23 Noting that ACIL Allen was not engaged in 2009 to undertake electricity market analysis of CopperString.

These changes will result in a decline in wholesale electricity prices in the Queensland region of the NEM out to about 2028, after which projected closures in older coal fired power stations in Queensland will result in an increase in wholesale prices back to levels to incentivise new investment in additional generation.

5.2 Modelling process

The inclusion of CopperString 2.0 will change the dynamics of the Queensland region of the NEM by connecting additional demand and sources of supply – not just in Mount Isa per se – but along the corridor of CopperString 2.0.

ACIL Allen has used its internal February 2020 Reference case projection of the NEM, together with assumptions regarding the QRET policy, and the Base case from the NWMP study to develop two central projections of the electricity market using its inhouse power market simulation model, PowerMark:

— A Business as Usual (BAU) case in which CopperString 2.0 is not developed. In this case, since the Mount Isa region remains separate to the NEM, we used a least cost approach to projecting what the efficient supply of wholesale electricity will cost (assuming no barriers to entry of new supply).
— A NEM connected case in which the Mount Isa region has access to the NEM via CopperString 2.0. This case also includes additional mining related demand (mainly existing and new mining load) that takes advantage of lower wholesale prices (due to access to the NEM).

The market modelling of these two scenarios provides insights into:

— the changes in the wholesale cost of electricity for Mount Isa and NWMP electricity consumers, and consumers in the Queensland region of the NEM (including the impacts on wholesale electricity prices and if applicable, changes in transmission costs – accounting for the cost of CopperString 2.0 (depending on how CopperString 2.0 is treated))
— the changes in fuel consumption, generation investment and retirements, and emissions levels
— utilisation of CopperString 2.0.

We have modelled every year out to 2035 and well as spot years in 5-year increments out to 2050.

5.3 Mount Isa and the NWMP – current supply situation

ACIL Allen has included in its analysis the NWPS and the isolated loads and supply of Cannington, Phosphate Hill and Mount Dore mines.

The current demand for electricity totals about 396 MW / 3,287 GWh. The time of day profile is quite flat as the vast majority (90 per cent) is mine load (about 375 MW) with the remainder made up of the Mount Isa and Cloncurry town (residential and commercial) loads (about 40 MW peak / 21 MW average).

Electricity supply is dominated by gas fired generation coupled with some minor solar and liquid fuel. The table below sets out the current supply in the region.

The majority of energy is supplied by the Diamantina Power Station (DPS) which commenced operations in 2014-15 and consists of the Diamantina closed cycle gas turbines (CCGT) and Leichardt open cycle gas turbines (OCGT). DPS is owned and operated by APA. DPS has contracts with Glencore and Ergon Retail. AGL supplies gas to DPS under a gas sales agreement which expires in 2023. We understand that DPS acts as the system operator for the NWPS.

Prior to the development of the DPS, the Mica Creek power station was the main source of supply. Stanwell operates Mica Creek and has been planning on decommissioning the station for past few years since the commissioning of DPS. In 2016 Mica Creek was placed into cold storage when its sole mining customer ceased operations, but Stanwell states that it was required to supply electricity again from mid-2017 to 2020 with the recommencement of operations at Dugald River mine and for the New Century Resources tailings operation at the former Century zinc mine. Stanwell announced in May 2020 that Mica Creek would again be put into cold storage at the end of 2020 as it had no contracted supply for 2021 and beyond.

TABLE 5.1 CURRENT SUPPLY OF NORTH WEST POWER SYSTEM AND ASSOCIATED ISOLATED LOADS

Sub region	Generator	DUID	Gen Type	Fuel	Installed capacity (MW)	Auxiliaries (%)	Efficiency (%, HHV sent-out)	Emission factor (tCO2-e/GJ)
North West Power System	X41 Recip	X41 Recip	Reciprocating Engine	Natural gas	42	1.0%	36.0%	0.0513
	Ernest Henry Recip	Ernest Henry Recip	Reciprocating Engine	Liquid Fuel	2	2.0%	33.0%	0.0697
	Diamantina CCGT	Diamantina CCGT	Gas turbine combined cycle	Natural gas	121	2.0%	48.0%	0.04923
	Diamantina CCGT	Diamantina CCGT2	Gas turbine combined cycle	Natural gas	121	2.0%	48.0%	0.04923
	Leichhardt OCGT	Leichhardt OCGT	Gas turbine	Natural gas	60	2.0%	32.0%	0.0513
	Mica Creek C CCGT	Mica Creek C CCGT	Gas turbine combined cycle	Natural gas	52	2.0%	43.0%	0.04923
	Mica Creek A GT	Mica Creek A GT	Gas turbine	Natural gas	132	3.0%	27.0%	0.0513
Isolated	Cannington Recip	Cannington Recip	Reciprocating Engine	Natural gas	35	2.0%	36.0%	0.0513
	Cannington Solar	Cannington Solar	Solar PV - SAT Oversized	Solar	3	1.0%	100.0%	0
	OsborneRecip	Orborne Recip	Reciprocating Engine	Natural gas	23	2.0%	36.0%	0.0513
	Phosphate Hill	Phosphate Hill	Gas turbine combined cycle/open cycle	Natural gas	42	2.0%	33.3%	0.0513

Note: HHV refer to High Heating Value.

SOURCE: ACIL ALLEN ANALYSIS OF VARIOUS SOURCES

5.3.1 The NWPS

The NWPS is operated as a coordinated power system. The ACCC's decision to grant conditional authorisation for participants in the NWPS to agree to rules relating to the coordination of electricity dispatch schedules at electricity generators in the NWPS was made in 2015 and was renewed in 2020, extended to 2025. The rules governing operations are set out in a dispatch protocol, apply to major suppliers, off takers (including retailer Ergon Energy Queensland), and the network owner (Ergon Network).

Those mining loads without their own generation have entered into Power Purchase Agreements (PPAs) with APA and Stanwell – expiring between 2023 and 2030 (with extension options):

— ACIL Allen understands that DPS supplies electricity to Glencore's Mount Isa mines and Ergon Retail to 2023 when the gas supply contract with AGL expires. Both PPAs continue to 2030 under a capacity tolling arrangement.

— New Century Resources' New Century mine and MMG's Dugald River mine were off takers of Mica Creek to end 2020.

— In 2017-18 New Century Resources entered into a gas supply agreement (GSA) with Santos which will be used by DPS or Mica Creek. According to New Century Resources' press release of March

2018, the GSA amounts to 9 PJ of gas over four years at a total cost of about $100 M (suggesting a delivered gas price of about $11/GJ).

ACIL Allen understands that the wholesale cost of electricity under these arrangements currently ranges around $150-$180/MWh (however, we have no evidence from public sources to support this value). Nonetheless, a gas price of $11/GJ coupled with a thermal efficiency of about 48 per cent implies a cost of gas of about $83/MWh (excluding the capacity toll and other O&M costs) for a CCGT, and about $123/MWh and $101/MWh for an OCGT/recip plant respectively (assuming a thermal efficiency around 30 and 39 per cent respectively). After accounting for O&M costs and amortised capital costs, ACIL Allen estimates the levelised cost of electricity (LCOE) of the current fleet is in the order of $160/MWh.

Residential and commercial retail customers in the Mount Isa and Cloncurry region are supplied by Ergon Retail, at a tariff rate set by the Queensland Competition Authority (QCA). Under the Queensland Government's Uniform Tariff Policy (UTP), Ergon Retail receives a subsidy (the Community Service Obligation or CSO) to ensure that consumers in regional and rural areas, such as Mount Isa and Cloncurry, pay the same regulated tariffs as consumers in south east Queensland.

5.4 BAU case – key assumptions

5.4.1 The NEM

This analysis utilises the assumptions, methodology and results for ACIL Allen's February 2020 Reference case projection of the NEM. The only change in assumptions to our Reference case for our work for CuString is the inclusion of the QRET policy. The electricity market modelling covers the calendar years 2020 to 2035, and spot years out to 2050 (at five-year intervals).

The modelling component of the analysis has been undertaken using ACIL Allen's in-house model PowerMark. Gas market projections and prices are derived from GasMark. All assumptions used in the modelling are taken from publicly available or in-house information and databases maintained by ACIL Allen. Prices are in 2020 real dollars unless otherwise stated[24].

This section outlines the principal assumptions used in our modelling of the NEM (including the Large-scale Renewable Energy Targe (LRET)). It includes assumptions for macro-economic variables, greenhouse gas emission policies, electricity demand, supply side assumptions around existing and new entrant electricity generators, fuel prices, interconnectors and the representation of bidding behaviour in the model. The key assumptions are highlighted in Table 5.2 below. The remainder of this chapter outlines the assumptions.

TABLE 5.2 OVERVIEW OF PRINCIPAL ASSUMPTIONS

Item	Summary of assumption	Rationale
Macro-economic variables	– Exchange rate of AUD to USD converging to 0.75 AUD/USD	– Long term average

[24] The cost inputs used the PowerMark NEM modelling framework are expressed in nominal terms assuming an annual inflation rate of 2.5 per cent. However, the results are deflated and presented in real 2020 terms, allowing the results to be used in subsequent analyses by our client's other advisers which may assume a slightly different inflation rate. Providing the inflation rate is between two and three per cent then rerunning PowerMark with a different inflation will have nil or negligible impact on the market modeling outcomes.

Item	Summary of assumption	Rationale
Federal greenhouse gas emission policies	– Between 26 and 28 per cent reduction in greenhouse gas (GHG) emissions below 2005 levels by 2030 – No emissions scheme required over the period 2021 to 2030. – Implementation of an Emissions Intensity Scheme (EIS) from 1 July 2030 to the end of the projection period in 2050. – Retention of the LRET in its current form	– Assuming an economy-wide pro-rata share of abatement across all sectors between 2021 and 2030 equates to an emissions budget for the NEM of around 1,260 Mt CO2-e, without the inclusion of carry-over credits or any abatement which will be delivered under the recently announced Climate Solutions Package. The inclusion of carry-over credits would expand the electricity sectors carbon budget to 1,350 Mt CO2-e over the period. – Projected emissions for the reference case over the budget period 2021-2030 are 1,136 Mt CO2-e. The NEM therefore overachieves on its abatement requirements, implying there is no need to legislate to reduce carbon emissions further. – To achieve net zero emissions by 2070 an emissions scheme is required post 2030.
State Based Schemes	– Inclusion of Queensland's "Renewables 400" reverse auction from 2022. – Deployment of an additional 600W by 2026 of CleanCo renewable capacity in Queensland included ("Renewables 400" assumed to be included as a part of the CleanCo portfolio, bringing the aggregate capacity for the portfolio to 1,000MW) – Inclusion of QRET policy out to 2030 – Inclusion of committed plant under the first stage of the Victorian Renewable Energy Target (VRET) auction, which enables Victoria to reach (and over-achieved) on its 25 per cent renewable energy target by 2020 – Inclusion of new entrant renewable plant such that Victoria meets its 40 per cent target by 2025 and 50 per cent by 2030	– Without a Federal emissions scheme implemented, it is assumed that state governments will try and drive emissions abatement on their own – Capacity will enter the market under market provisions similar to the recently conducted Victorian reverse auction scheme
Electricity demand	– AEMO August 2019 Electricity Statement of Opportunities (ESOO) forecasts with adjustments for smelter closures, ACIL Allen's projections for PV, storage uptake and electric vehicle uptake	– Aluminium smelters with long-term electricity supply agreements in place are re-evaluated on their contract termination. Smelters will either cease to operate or are extended based on their competitiveness.

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 final investment decision) – 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 are commercial are introduced – Committed or likely committed generator retirements included where the retirement has been announced by the participant (i.e. Liddell in 2022, Callide B 2028) – Retirements of other existing generators where the generator is projected to be unprofitable over an extended period of time – Snowy 2.0 pumped hydro storage of 2,000 MW included and assumed to be commissioned from 1 July 2026 – In the absence of CopperString or other transmission infrastructure investment, the North Queensland Renewable Energy Hub is assumed not to be developed and connected to the NEM	– 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 $7-$9/GJ to $10-$10.70/GJ by 2030 in real 2020 terms. By 2035 gas prices reach LNG netback, equating to about $11-$11.80/GJ in real 2020 terms.	– 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 to satisfy demand

Coal as a fuel for electricity generation	– The marginal price of coal for electricity generation is assessed in consideration of the specific circumstances for each generator considering:
	  – 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 (for example, Tarong, Tarong Nth, Kogan and Millmerran are unlikely to be affected by export prices and it has been assumed that they will offer marginal fuel costs into the market)
	  – Mining costs
	  – Existing contractual arrangements
	– International thermal coal prices are assumed to converge to real 2020 US$61.50/t in the long term
		– ACIL Allen has used its market intelligence and analysis to estimate the physical and contractual arrangements in place for each coal fired power station
		– International thermal coal prices are assumed to converge to their long-term average price

Item	Summary of assumption	Rationale

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

New entrant capital costs
(AUD$/kw, real 2020)
	– Wind
	  – $2,050/kW in 2020
	  – $1,730/kW in 2030
	– Solar (Single Axis Tracking)
	  – $1,420/kW in 2020
	  – $1,110/kW in 2030
	– Storage (with four hours)
	  – $1730/kW in 2020
	  – $980/kW in 2030
		– Near-term prices based on observations in the market from actual projects
		– Average capacity factors of new entrant wind farm approaching 40 per cent (with some zones achieving between 40 and 45 per cent)
		– Average capacity factors of new entrant solar farms approaching 30 per cent
		– Long-term projection based on an average of long-term projections by various forecasters for new technologies

Interconnectors	– Existing interconnection included
	– AEMO Integrated System Plan (ISP) Group One projects included:
	  – QNI minor (First stage of NSW to QLD upgrade)
	  – EnergyConnect (formerly SANI)
	  – Heywood Upgrade
	  – VNI Minor (VIC to NSW Upgrade)
	– VNI West (formerly part of SnowyLink)
		– Based on the high likelihood that the ISP projects will proceed

Intra-regional networks	– Marginal Loss Factors (MLFs) assumed in the Reference case are taken directly from the AEMO report – *List of Regional Boundaries and Marginal Loss Factors for the 2019-20 Financial Year* which are assumed to remain constant throughout CopperString 2.0. – Minor intra-regional upgrades to the existing transmission network are assumed to allow for timely investment of new renewable energy generation.	– The modelling assumes no further investment "rush events" as observed recently, and projects new investment is located in areas with relatively favourable MLFs. – PowerMark is a regional model. ACIL Allen has not been engaged to undertake detailed load flow and MLF modelling.

SOURCE: ACIL ALLEN

Federal policy to 2030 assumed in the market modelling

Australia remains broadly committed to the Paris Agreement which requires Australia to deliver emission reductions of at least 26 per cent below 2005 levels. Based on the current (2019) emissions projections, the additional cumulative abatement over the Paris commitment period (2020-21 to 2029-30) is 395 Mt CO_2-e. This is based on an emissions budget of 4,777 Mt CO_2-e and current projected emissions of 5,169 Mt CO_2-e (estimating an additional 3 Mt CO_2-e of voluntary abatement action[25]).

[25] According to the Department, voluntary action refers to emissions reductions achieved by individuals and companies additional to national targets.

However, the Australian Government has indicated its intention to carryover 411 Mt CO_2-e from the Kyoto commitment period to the Paris commitment period.[26] Therefore, Australia's remaining cumulative emissions reduction task under the Paris Agreement is -16 Mt CO_2-e, thereby meeting the 26 per cent target.

Table 5.3 shows the 2019 Projections baseline emission for each sector, each sectors' share of aggregate emissions, and each sectors' prorated budget to achieve the minimum 26 per cent target under the Paris Agreement (with Kyoto carryover).

TABLE 5.3 ASSUMED EMISSION BUDGETS BY SECTOR (MT CO2-E)

Sector	2019 Baseline emission projections (2020-21 to 2029-30)	Share of aggregate emissions	Emissions budget assuming pro-rata allocation of carry-over	Emissions change required
Electricity	1,482	28.7%	1,486	5
Direct combustion	1,047	20.2%	1,050	3
Transport	1,061	20.5%	1,064	3
Fugitive	548	10.6%	549	2
Agriculture	715	13.8%	717	2
Industrial processes	334	6.5%	335	1
Waste	110	2.1%	110	0
Land Use, Land Use Change and Forestry	-127	-2.5%	-127	0
Total	5,170		5,186	16

Note: For the period 2020-21 to 2029-30 assuming a target of 26 per cent reduction in 2005 level emissions by 2030 accounting for 411 Mt CO2-e carry-over credits.

SOURCE: ACIL ALLEN ANALYSIS; BASELINE EMISSION PROJECTIONS FROM THE DEPARTMENT OF THE ENVIRONMENT AND ENERGY

Policy to 2030 assumed in the BAU case

Given the Department of the Environment and Energy's 2019 emissions projections, there is no further requirement for the electricity sector, including the NEM, to deliver additional abatement in the period to 2030 to meets its share of the Paris Agreement abatement task. Beyond Australia's current 26 per cent reduction commitment, the current Australian Government appears unwilling to consider policies further restricting emissions in the wider economy or the NEM. Should government change at the next election (2022) or the one after (2025), it is uncertain whether Labor would seek to bring forward a certificate-based pricing policy in the near term. Therefore, ACIL Allen assumes no further policy action by the Australian Government for the NEM to 2030.

Beyond 2030, additional policies will be required to achieve zero emissions in the longer term. This is discussed in the next section.

Policy mechanism beyond 2030 assumed in BAU case

ACIL Allen assumes that an EIS is implemented in the BAU case from 2030 as a means of creating incentives to reduce emissions beyond 2030 to net zero emissions by 2070[27]. This assumption is considered the most likely based on the various policy options that have been considered to date.

The EIS modelled by ACIL Allen within the BAU case has the following characteristics:

— Scheme commencing on 1 July 2030

— Certificate based scheme with certificate creation, trade and surrender by generators

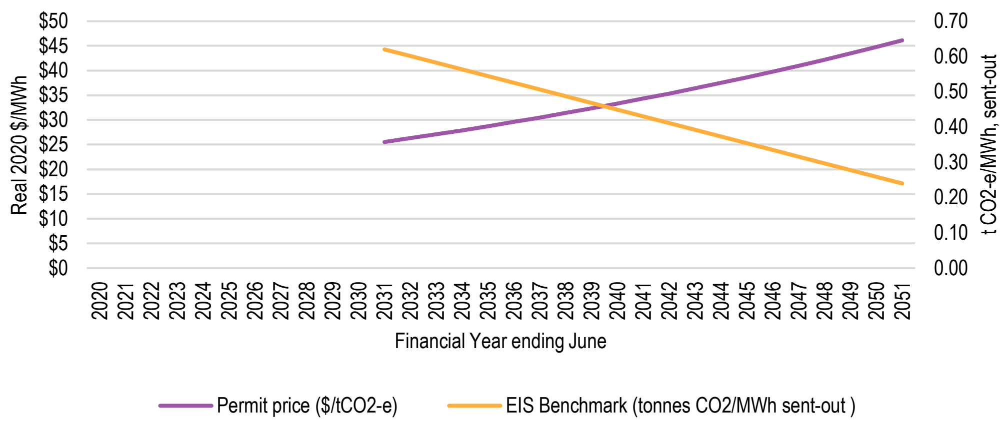
[26] The rules relating to the use of carry-over credits are yet to be determined under the Paris Agreement.

[27] The 2017 Finkel Review considered policies with a linear trajectory to zero emissions by 2070. More recently, the Labor party announced that if elected, it will seek to achieve net zero emissions economy-wide by 2050.

— All generators (existing and new) eligible to create EIS certificates regardless of age
— NEM to achieve emission reductions of around 80 per cent over 2005 levels by 2050 and net zero emissions by around 2070
— EIS with emissions threshold trajectory designed to meet the emissions budget given the assumed demand forecast. This is set at 0.62 tonnes CO_2-e/MWh sent-out in FY2031 (declining to 0.45 by FY2040 and 0.26 by FY2050), with certificate creation calculated based on a generator's emissions intensity relative to the benchmark.

The EIS certificate price was determined by the modelling which gave a price path starting at around $25/certificate in FY2031 (in real 2020 terms) and escalating at around 3 per cent in real terms per year thereafter, as shown in Figure 5.1.

FIGURE 5.1 ASSUMED EIS EMISSIONS BENCHMARK AND CERTIFICATE PRICE – BAU CASE



SOURCE: ACIL ALLEN ANALYSIS

QRET policy

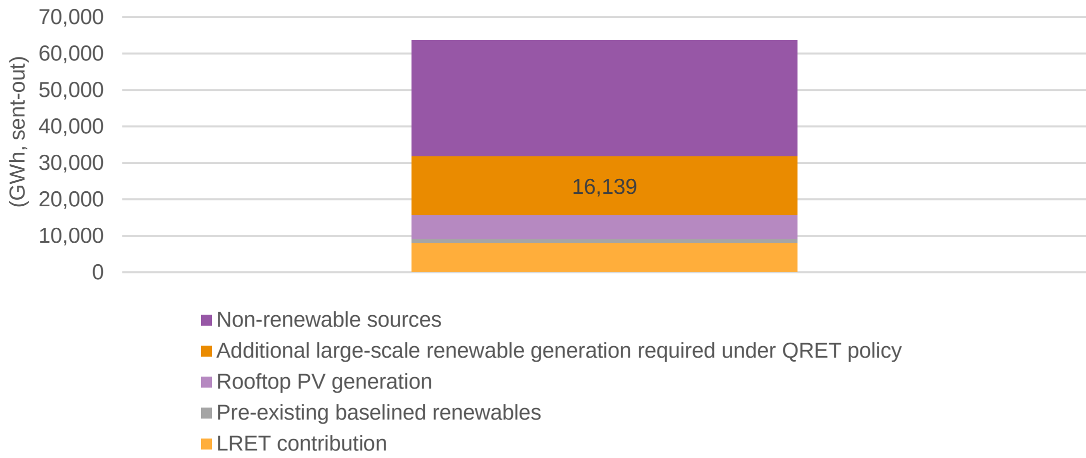
The QRET policy has been implemented in the modelling by calculating the target in 2030 and determining the amount of large-scale renewable energy required in that year. A straight line trajectory is then assumed between 2020 and 2030, and the modelling then identifies the least cost solution to achieve the target.

In determining the large-scale component of the target, the following have been taken into account:

— Queensland's total energy requirements in 2030 – including the Queensland region of the NEM, Mount Isa, other small grids, and embedded generation
— Queensland's contribution to the LRET
— Rooftop PV uptake
— Pre-existing large-scale renewable generators.

The target equates to requirement of about 2,400 MW of additional large-scale renewable energy capacity, beyond those projects already under construction or have reached financial close, by 2030.

FIGURE 5.2 BREAKDOWN OF QLD ELECTRICITY CONSUMPTION SUPPLIED FROM RENEWABLE SOURCES - 2030



SOURCE: ACIL ALLEN ANALYSIS

Supply

ACIL Allen incorporates changes to existing supply where companies have formally announced the changes – mothballing, closure and change in operating approach. Near-term named entrants are included where the plants are considered to be committed projects. Any additional supply requirements determined by the modelling are included as generic entrants.

Initial settings for existing plant

TABLE 5.4 CHANGES TO EXISTING SUPPLY

Project name	Generation technology	Capacity (MW)	Region	Nature and date of change
Gladstone	Black coal steam turbine	1,680	QLD	Five units in operation and one off-line
Torrens Island A	Natural gas steam turbine	480	SA	Gradual closure from Q4 2020 to Q4 2022
Liddell	Black coal steam turbine	2,000	NSW	Three units in operation and one off-line. Retires Q2 2023
Bayswater	Black coal steam turbine	2,740	NSW	25 MW upgrade to each of the 4 units, works beginning 2019 ending 2022
Mt Piper	Black coal steam turbine	1,400	NSW	30 MW upgrade to each of the 2 units, works beginning 2020 and ending 2021
Temporary Generation North and South	Liquid fuelled aero-derivative gas turbines	277	SA	Change of classification from market non-scheduled to market scheduled, to reflect 25- year leases secured by Infigen and Nexif. Assumed to transition to natural gas by 2021

Project name	Generation technology	Capacity (MW)	Region	Nature and date of change
Mackay GT	Liquid fuelled gas turbine	34	QLD	Closes in Q2 2021

SOURCE: ACIL ALLEN ANALYSIS

Near term entry

Table 5.5 provides near term entrants that ACIL Allen considers committed projects.

TABLE 5.5 NEAR TERM ADDITION TO SUPPLY

NEM Region	Name	Generation Technology	Capacity (MW)	Expected Entry
NSW1	Bango WF	Wind	244	Q1 2021
NSW1	Bomen Solar Farm	Solar	100	Q3 2021
NSW1	Collector WF	Wind	226.8	Q2 2021
NSW1	Darlington Point Solar Farm	Solar	275	Q1 2021
NSW1	Goonumbla Solar Farm	Solar	67	Q2 2021
NSW1	Limondale Solar Farm 1	Solar	220	Q3 2020
NSW1	Limondale Solar Farm 2	Solar	29	Q3 2020
NSW1	Nevertire Solar Farm	Solar	105	Q3 2020
NSW1	Sunraysia Solar Farm	Solar	200	Q3 2020
NSW1	Wyalong Solar Farm	Solar	70	Q1 2021
QLD1	Brigalow Solar Farm	Solar	34.5	Q1 2021
QLD1	Chinchilla Solar Farm	Solar	100	Q1 2021
QLD1	Kennedy Energy Park	Battery - Discharge	2	Q1 2021
QLD1	Kennedy Energy Park	Solar	15	Q1 2021
QLD1	Kennedy Energy Park	Wind	43	Q1 2021
QLD1	Quinbrook Aeroderivative GT	Natural gas	132	Q2 2022
QLD1	Teebar Solar Farm	Solar	52.5	Q1 2021
QLD1	Warwick Solar Farm	Solar	64	Q3 2020
QLD1	Yarranlea Solar Farm	Solar	102.5	Q3 2020
SA1	Hallett Aeroderivative GT	Natural gas	27.5	Q1 2020
SA1	Lincoln Gap WF Stage 2	Wind	86	Q4 2020
TAS1	Granville Harbour WF	Wind	112	Q2 2020
TAS1	Wild Cattle Hill WF	Wind	144	Q2 2020
VIC1	APA Dandenong Reciprocating Engine	Natural gas	176	Q4 2022
VIC1	Berrybank WF	Wind	180	Q1 2020
VIC1	Carwarp Solar Farm	Solar	99	Q2 2021
VIC1	Cherry Tree WF	Wind	57.6	Q2 2020
VIC1	Cohuna Solar Farm	Solar	27.27	Q2 2021
VIC1	Dundonnell WF	Wind	336	Q2 2020
VIC1	Elaine WF	Wind	86	Q3 2020

NEM Region	Name	Generation Technology	Capacity (MW)	Expected Entry
VIC1	Kiamal Solar Farm	Solar	200	Q4 2020
VIC1	Mortlake South WF	Wind	157.5	Q 2020
VIC1	Stockyard Hill WF	Wind	530	Q2 2020
VIC1	Winton Solar Farm	Solar	85	Q2 2021
VIC1	Yatpool Solar Farm	Solar	81	Q4 2020

Note: NEM region names are those used by AEMO. Renewable plant are assumed to come online progressively in stages, as are coal plant upgrades. The date of expected entry of a plant's capacity represents the entry of its first stage.

SOURCE: ACIL ALLEN ANALYSIS

Offer strategies

Generation portfolios enter into electricity derivative contracts to hedge wholesale revenues to reduce earnings risk and avoid insolvency. In entering into these contracts, generators are indifferent to spot price movements across the volume of these contracts except where the spot price falls below the short run marginal cost (SRMC). Therefore, a short-term optimal strategy is to offer all generation that is contracted at SRMC.

The generator supply curve tends to be based on SRMC for supply covered by contracts and then rise steeply beyond the level to which supply is covered by contracts. The overall contract volumes which determine the point of inflection are set by retailer demand (which is a function of the retailers' perspectives on risk) and by generator willingness to supply at various prices.

PowerMark provides two main options with regard to the offer strategy used by each portfolio. These offer strategies are:

— Maximising dispatch, so that each portfolio attempts to maximise its output in each period – typically for price takers

— Maximising net uncontracted revenue in which each portfolio is willing to trade off part of its uncontracted volume for higher prices – for price makers.

Net pool revenue is dispatch weighted pool revenue in each period less variable costs. Only uncontracted revenue is maximised as the portfolio is assumed to be indifferent in the short term to the price it receives from the pool for that volume of its dispatch, which is contracted. It will only attempt to maximise its revenue for that proportion of its output, which is not under contract.

The second strategy, that each portfolio will seek to maximise the returns from uncontracted revenue, is used for thermal power stations in the modelling. This reflects an objective of maximising the returns from contracted and uncontracted revenues over the long term.

An outcome of the second strategy is that large portfolios of generation capacity tend to play the role of price maker since they have sufficient market share to influence market outcomes during periods when the demand-supply balance is relatively tight, and smaller portfolios play the role of price taker – as is observed in the NEM and demonstrated by actual market outcomes.

Interconnector assumptions

Interconnectors can either be a source of lower priced electricity coming into a region, or a means to export surplus capacity. A summary of the interconnectors and interconnector expansion assumed in the scenarios is shown in the table below.

Interregional interconnection capacity assumed in the scenarios considers limitations of the transmission system. For this reason, the assumed interconnector capacities may well be less than the capacity of the physical interconnectors. For example, the total of the physical interconnector capacity between NSW and Queensland is about 1,000 MW – but the location of the interconnectors and the constraints of the NSW grid limits the flow of generation from the Hunter Valley region in NSW to Queensland such that the effective capacity of the NSW to Queensland interconnection is about 600 MW, reducing even further during peak and shoulder periods.

Basslink is set in *PowerMark* as an entrepreneurial interconnector linking Tasmania to Victoria. Basslink is operated by Hydro Tasmania, who is paying a form of toll charge. It is therefore bid in a way that attempts to maximise the net revenue of the Hydro Tasmania assets but at the same time accounting for the energy constrained capacity in Tasmania.

TABLE 5.6 ASSUMED INTERCONNECTION CAPACITY (MW)

From Year	Transfer from	Transfer to	Capacity (MW)
2020	NSW	VIC	590
September 2022	NSW (VNI Minor)	VIC (VNI Minor)	590
2020	VIC	NSW	900
September 2022	VIC (VNI Minor)	NSW (VNI Minor)	1070
2020	VIC (Heywood)	SA (Heywood)	460
July 2023	VIC (Heywood)	SA (Heywood)	560
2020	SA (Heywood)	VIC (Heywood)	500
July 2023	SA (Heywood)	VIC (Heywood)	600
2020	VIC (Murraylink)	SA (Murraylink)	220
2020	SA (Murraylink)	VIC (Murraylink)	180
2020	VIC (Basslink)	TAS (Basslink)	478
2020	TAS (Basslink)	VIC (Basslink)	594
2020	NSW	QLD	450
September 2022	NSW (QNI Minor)	QLD (QNI Minor)	600
2020	QLD	NSW	1100
September 2022	QLD (QNI Minor)	NSW (QNI Minor)	1290
2020	NSW (Terranora)	QLD (Terranora)	50
2020	QLD (Terranora)	NSW (Terranora)	150
July 2023	NSW (EnergyConnect)	SA (EnergyConnect)	800
July 2023	SA (EnergyConnect)	NSW (EnergyConnect)	800
July 2026	VIC (VNI West)	NSW (VNI West)	1930
July 2026	NSW (VNI West)	VIC (VNI West)	1800

Note: All included projects are part of the group 1, priority grid projects, as referred in the Integrated System Plan 2020. For the VNI West project, we have taken the midpoint of all VNI West options currently presented.

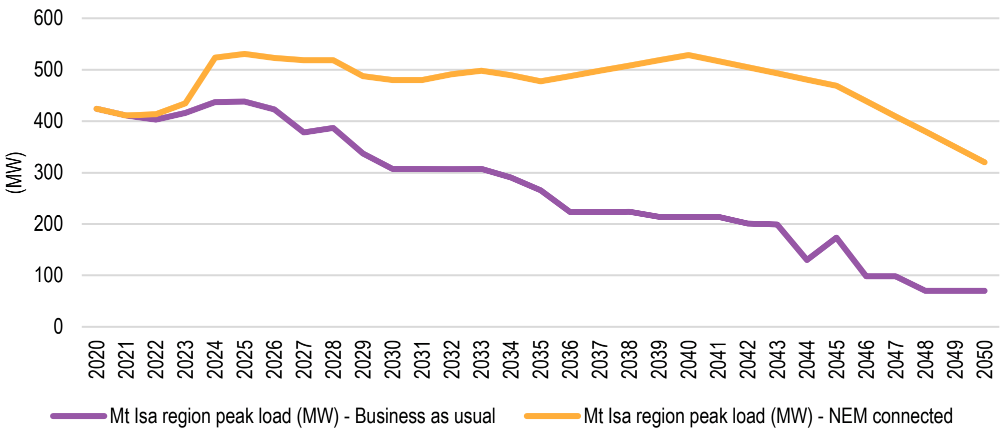
SOURCE: ACIL ALLEN ANALYSIS OF AEMO DATA

5.4.2 Mount Isa region

The electricity cost projection for the Mount Isa region assumes the BAU case demand forecasts from the mine load analysis summarised in Chapter 4 as shown in Figure 5.3.

In the BAU case, demand commences at about 400 MW and remains at the level until about 2026, from which point demand progressively declines to end CopperString 2.0 at about 70 MW. In the NEM connected case, demand increases to about 500 MW from 2024 and broadly remains at around this level until 2045, from which point it declines slightly to end CopperString 2.0 at about 300 MW.

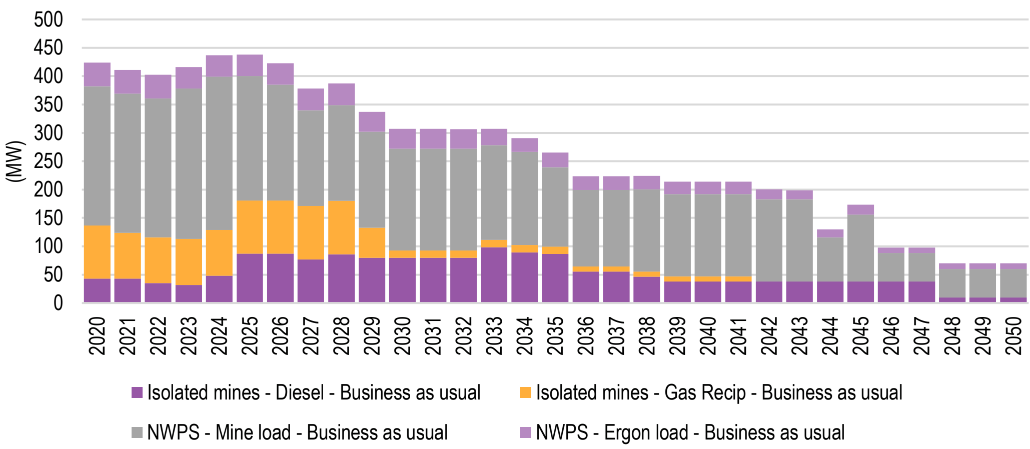
FIGURE 5.3 PROJECTED DEMAND FOR ELECTRICITY IN THE MOUNT ISA REGION



SOURCE: ACIL ALLEN ANALYSIS AND IZMIN AND SOREN

The declining demand profile of the BAU case is shown in more detail in Figure 5.4. About 130 MW of load is attributed to mining activity which is isolated from the current NWPS. Izmin and Soren advise that these loads will remain isolated in the BAU case. This means that demand in the NWPS is less than 200 MW from 2025, declining to about 150 MW in 2035.

FIGURE 5.4 DETAILS OF THE PROJECTED DEMAND FOR ELECTRICITY IN THE MOUNT ISA REGION - BAU CASE



SOURCE: ACIL ALLEN ANALYSIS AND IZMIN AND SOREN

With the expiry of PPAs in the Mount Isa region between 2023 and 2025, the modelling allows other sources of generation as candidates for new supply – this includes renewable energy and storage. A simplified brownfield least cost approach has been used to identify the efficient supply mix. Various assumptions and constraints have been taken into account such as:

— Components of the NWPS Dispatch Protocol (such as reliability requirements and spinning reserve).
— Mica Creek Power Station is assumed to close in 2021.
— The isolated loads remain isolated.
— Development of the renewable energy hub around Hughenden remains largely limited due to an assumed lack of a robust connection to the NEM and no connection to NWPS.
— The decline in demand post 2028.

— Gas prices for power generation in the Mount Isa region are held at $11/GJ in real terms until expiry of the gas supply contracts, from which point gas price decline to about $10.50/GJ, and are projected to rise to about $12.50/GJ by 2035 in real 2020 terms.

5.5 NEM connected case – key assumptions

The NEM connected case takes the BAU case as a starting point and includes CopperString 2.0. Except for the revised demand forecast (due to an assumed increase in mining activity) for the Mount Isa region, and ability of isolated mines to connect to the main grid, no other underlying assumptions change.

In *PowerMark*, CopperString 2.0 is set as a 500 MW interconnector between Mount Isa, the Hughenden region (specifically the Hughenden substation), and Woodstock substation south of Townsville (as shown in the map below).

The PowerMark modelling simplifies the specification of CopperString 2.0 by assuming CopperString 2.0 is commissioned on 1 January 2025. It is understood the current development schedule for will see commissioning some time in 2024.

Since CopperString 2.0 includes the connection of the remote loads at Phosphate Hill, Cannington and Mount Dore, as well as other isolated loads as advised by Izmin and Soren, these load centres are assumed to have the ability to exit (or carry) any existing power supply arrangements from 2025 onwards and take advantage of lower wholesale electricity prices should the modelling indicate.

FIGURE 5.5 COPPERSTRING 2.0 LOCALITY MAP

Note: Source: CopperString 2.0 website

5.5.1 Other assumptions

The results of the market modelling will provide important inputs into the economic impact analysis. It is important to note that the electricity market modelling does not take into consideration changes in transmission losses and marginal loss factors (MLF) –effectively these are assumed not to change between the two scenarios. At the time of the analysis, ACIL Allen was not engaged to undertake a MLF or load flow analysis).

Further, the analysis reports on wholesale electricity price impacts only, and not retail price impacts of CopperString 2.0. At the time of the analysis, ACIL Allen was not advised as to, or engaged to consider, how the cost of CopperString 2.0 is to be recovered from consumers.

5.6 BAU case – key results

This section of the report sets out the results of our modelling of the wholesale electricity market for the BAU case. Actual outcomes for 2000 to 2019 are included for reference in some graphs. All prices in this section are presented in real 2020 terms unless otherwise noted.

BOX 5.1 MEDIAN ANNUAL WHOLESALE ELECTRICITY PRICE PROJECTION

The electricity price projection presented in this section of the report has been normalised for stochastic weather and plant outage effects and represents broadly the median or central case rather than the mean of the distribution of possible annual pool price projections. The annual electricity price distribution exhibits positive skewness (long right-hand side tail). Lower annual pool price projections are associated with cooler summers/warmer winters/lower outage rates and higher annual pool price projections are associated with hotter summers/colder winters/higher outage rates. The lower annual price projections are less volatile and cluster close to the median projection as they are limited by the underlying marginal costs of the various plants operating in the market. The higher annual price projections are more volatile and spread over a longer tail above the median projection. This is because higher prices driven by higher demand and/or more plant outages are a result of less effective competition and are only limited by the market price cap. Hence the average or mean of the annual price projections is usually above the median annual price projection. Throughout this chapter reference will be made to average prices – these are averages of the hourly projected prices from the median or central reference case.

When generators and retailers contract they are more likely to price the contracts at prices in excess of the median price, typically at or above the mean. The extent that contracts are priced above the mean depends on the relative risk appetites of participants. Stand-alone retailers tend to be thinly capitalised and have lower risk appetites than generators. Therefore, when participants contract their output forward, it is reasonable to add a premium to the median prices in this report to reflect the premium that contracts would be sold for in the market. If requested by clients, ACIL Allen undertakes a stochastic analysis to estimate the distribution of annual prices due to weather and power station availability variations.

SOURCE: ACIL ALLEN

5.6.1 NEM

Wholesale electricity prices

Projections of the real time weighted annual average price for each region are shown in Figure 5.6.

Real annual average wholesale electricity spot market prices across the NEM are projected to decrease from current inflated levels of around $65-$75$/MWh to around $45-$55 in 2022.

The projected decline in prices between 2020 and 2022 is largely driven by the projected development of approximately 6,100 MW of renewable capacity in response to the LRET, other state government incentives and PPAs with corporate sponsors, coupled with little growth in energy requirements from the grid (and a decline in some regions such as Victoria).

Between 2023 and 2030, average annual spot prices are projected to fluctuate between $42 and $66/MWh driven by a wide array of factors that include:

— Significant NEM-wide interconnector expansion projects
— Government interventionist policies (VRET, 1,000 MW CleanCo renewable capacity, Snowy 2.0)
— Loss of loads from smelters ceasing operations
— Closures and mothballing of thermal plant.

In 2023, the interconnector projects (QNI upgrade, VNI Minor, EnergyConnect, Heywood upgrade) result in some convergence of the regional price trajectories. Prices increase in 2023 with the closure of Liddell in New South Wales and Torrens B in South Australia. They once again decline in the period 2024-2026 as additional renewable capacity enters via the 1,000 MW CleanCo portfolio, the VRET scheme and the ACT Next Generation Renewables auction.

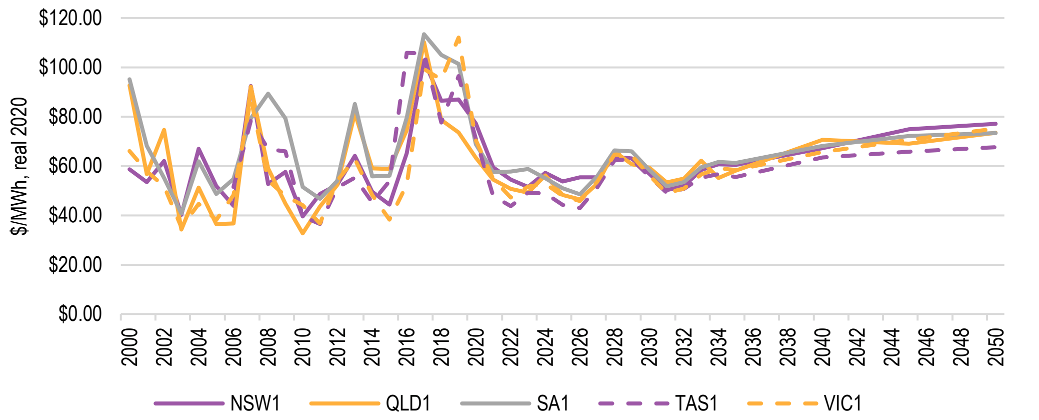
Regional prices in the mainland states tend to converge from 2027 onwards with the assumed completion of the new VNI West interconnector, as well as the other earlier assumed upgrades. The interconnection projects increase the ability for unconstrained flows between regions which reduces the propensity for regional price separation.

Time-weighted prices are projected to increase up to about $65/MWh in 2028 and 2029 as a result of the closure of Yallourn mid-2027, Vales Point B in mid-2028, and Gladstone and Callide C in 2029 – which more than offsets the reduction in demand due to the assumed closure of the Tomago and Boyne smelters[28]. Price volatility does not grow during this period due to the commissioning of Snowy 2.0.

Financial year 2031 marks the beginning of the EIS. The scheme is projected to drive the closure of Stanwell[29] in Queensland in 2031-32, which is projected to be replaced by 2,200 MW of new wind capacity in the region. In 2034, the 2,880 MW Eraring black coal power station in New South Wales is projected to become uneconomic and exits the market.

Time-weighted prices are gradually rising after 2031, but average annual prices are projected to stabilise from 2040 within the range of $63-$77/MWh. This is the sort of price level required (on a time weighted basis) over the long run to support investment in additional generation capacity, a combination of solar, wind, gas and storage plant. New investment in the NEM is dominated by renewables and utility scale storage post 2030, with some investment in gas plant. The investment in renewable plant is supported by the captured wholesale electricity prices as well as revenue from EIS permits.

FIGURE 5.6 PROJECTED TIME WEIGHTED ANNUAL AVERAGE PRICES (REAL 2020 $/MWH) – BAU CASE



SOURCE: ACIL ALLEN ANALYSIS

Change in plant capacity

Table 5.7 sets out the committed and projected plant closures. About 20,000 MW of plant is projected to close in the BAU case by 2050 – a combination of coal fired plant and older gas fired power stations using single cycle steam turbines.

Power stations using single cycle gas fired steam turbine technology are projected to close because they become uneconomic when faced with high gas prices. Gas fired steam turbines are based on conventional thermal boilers and are relatively inflexible. They have similar short run marginal costs to OCGT peaking plant but are unable to quickly start and stop to respond to short term spikes in prices. To operate they must run at a minimum load – typically 20 per cent of output. The minimum level of generation required by this technology and the fact that these power stations are gas fired means that

[28] The Boyne Island aluminium smelter in Gladstone and the Gladstone Power Station are intrinsically linked. The smelter is projected to cease operation from July 2029 with the conclusion of the smelter's competitive legacy power purchase agreement with Gladstone Power Station. The closure of the smelter reduces demand substantially which in turn reduces price outcomes in the NEM resulting in the closure of the Gladstone power Station.

[29] Stanwell's coal supply arrangements change in 2026-27 when the current coal supply arrangements expire.

these power stations can be forced to run for considerable periods even though the market price is below their short run marginal costs.

Yallourn power station is projected to close over a period of 18 months in 2026-27, due to suppressed wholesale prices resulting from a combination of declining grid demand and additional supply, in particular Snowy 2.0 and the VRET renewable capacity to reach the 50 per cent 2030 target.

A number of aluminium smelters were established in Australia supported by very low-priced electricity supply arrangements which were supplied through government owned utilities. Since the commencement of the NEM, these supply arrangements have been progressively unwound which has put cost pressures on the smelters. Two smelters have already closed (Point Henry in Victoria and Kurri Kurri in New South Wales). The Anglesea power station closure was linked to the closure of the Point Henry smelter. In addition to the assumed closure of the Portland smelter in Victoria in 2030, ACIL Allen projects additional smelters to close in Queensland and New South Wales in the mid to late part of the next decade. The combination of the fall in demand associated with the smelter closures and the age of some of the coal fired plant lead to the projected closure of the coal fired plant after 2028.This is the case for Gladstone, Callide B and Vales Point. Had these plants not closed, then the closure of the smelters would result in lower price outcomes – unsustainable for these less efficient coal plant.

The EIS mechanism and associated carbon budget also plays an important role in the closure of thermal plant in the BAU case post-2030. As the EIS permit price increases and the emissions intensity threshold decreases, the penalty for thermal plant also increases, which coupled with more renewable plant able to enter the market and suppressing wholesale electricity prices results in some of the less efficient and higher emitting thermal plant becoming uneconomic (for example Stanwell in 2031 and Eraring in 2034). The closures projected below are a modelled outcome based on the economic performance of the respective station.

TABLE 5.7 PLANT AND CLOSURE SCHEDULE – BAU CASE

Plant	Closure year	Capacity (MW)
Torrens Island A (gas steam – South Australia)	2022	480
Liddell (black coal – New South Wales)	2023	2,100
Newport (gas steam – Victoria)	2024	510
Torrens Island B (gas steam – South Australia)	2024	800
Yallourn (brown coal – Victoria)	2026-2027	1,538
Vales Point (black coal – New South Wales)	2028	1,320
Callide B (black coal – Queensland)	2028	700
Gladstone (black coal – Queensland)	2029	1,680
Stanwell (black coal – Queensland)	2031-2032	1440
Eraring (black coal – New South Wales)	2034	2,880
Tarong (black coal – Queensland)	2039	1,400
Bayswater (black coal – New South Wales)	2044	2,740
Loy Yang A (brown coal – Victoria)	2049	2,180
Total		**19,768**

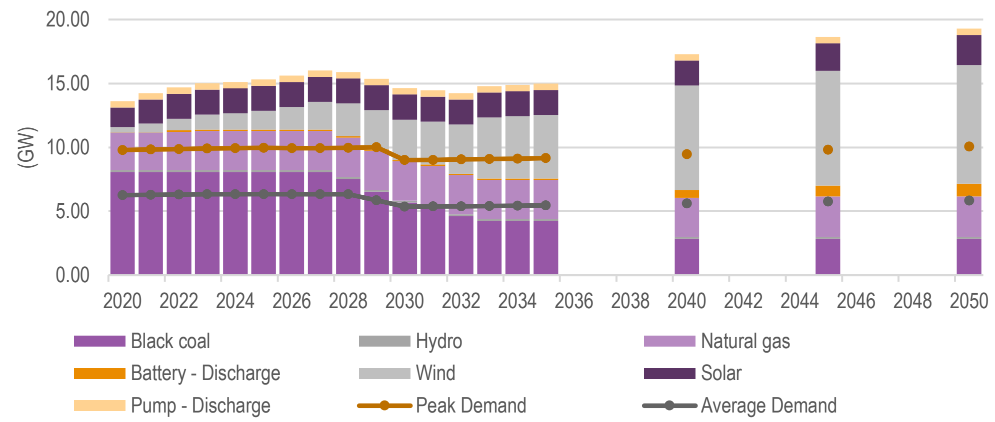
SOURCE: ACIL ALLEN ANALYSIS

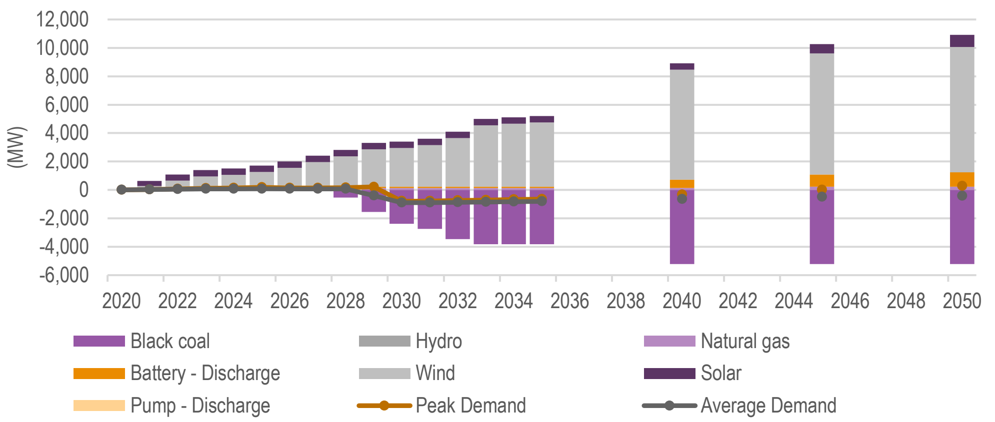
The graph below shows the projected aggregate capacity, cumulative and annual change in plant capacity in the Queensland region of the NEM.

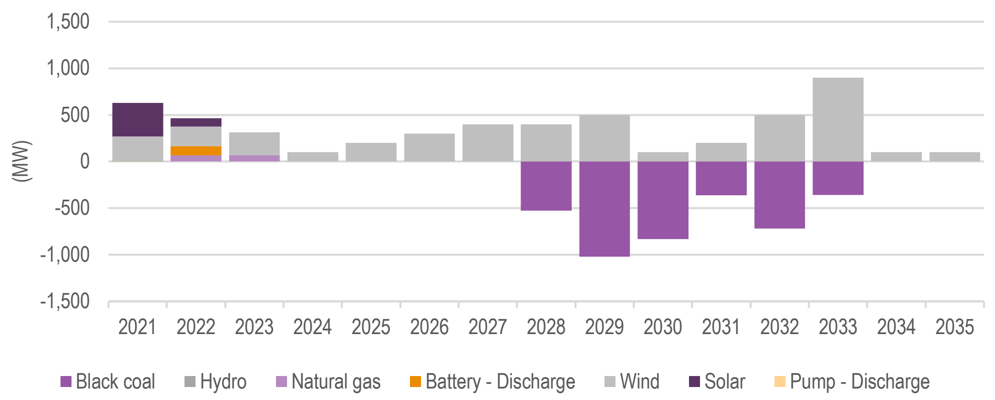
Up until recently, solar farm projects have been the dominant source of investment in Queensland under the LRET. However, in the BAU case, wind farm development is projected to overtake solar farm investment in Queensland in the future.

The very high level of correlation in hourly output from different solar farms acts as a natural cap on the magnitude of solar capacity that can enter the market within any given period of time. In short, solar farms tend to 'cannibalise' each other's ability to earn sufficient revenue from the NEM by suppressing price outcomes during daylight hours. Hence, the modelling does not suggest significant investment in solar beyond the LRET incentivised investment until storage costs sufficiently decline and utility scale storage enters the markets, providing some uplift in price outcomes during daylight hours when recharging. The assumed entry of Snowy 2.0 in 2026 delays the entry of utility scale battery storage post 2030 when the decline in storage costs coupled with the closure of some of the coal plant creates sufficient price signals to warrant investment. The modelling suggests little opportunity for further investment in gas fired generation – based on the input assumptions it cannot compete with storage.

FIGURE 5.7 PROJECTED AGGREGATE CAPACITY, CUMULATIVE AND ANNUAL CHANGE IN CAPACITY (MW) BY TECHNOLOGY – QUEENSLAND – BAU CASE







SOURCE: ACIL ALLEN ANALYSIS

Generation mix

Figure 5.8 shows the projection of generation by fuel-type for the Queensland region of the NEM.

There was an increase in gas fired generation from 2011 to 2016 because of the availability of lower priced LNG ramp gas. However, gas fired generation is projected to decrease as peaking plant revert back to a traditional peaking role (and this commenced in 2018).

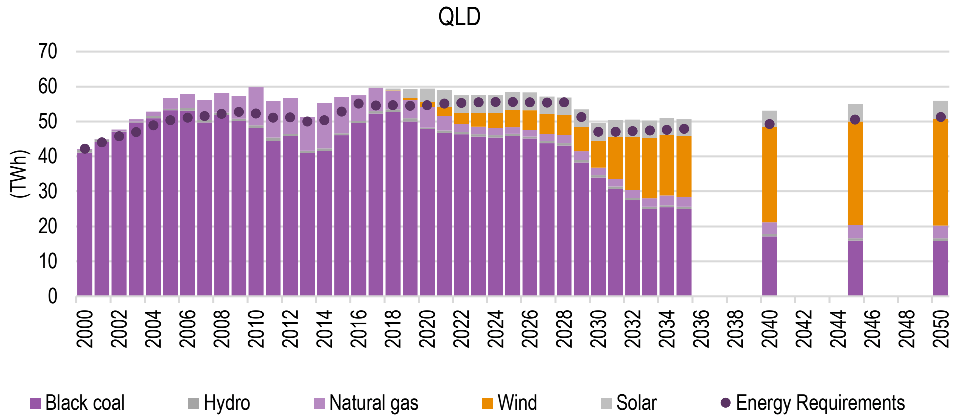
Black coal fired generation has recovered strongly since 2015 as a result of the increase in demand associated with the LNG industry (particularly in-field compression). However, it is projected to decline between 2019 and 2021 with the substantial increase in renewable generation as the committed renewable projects come online.

There is a further decline in black coal generation between 2028 and 2032 with the projected closure of Callide B, Gladstone and Stanwell.

Beyond 2030, further projected closures in coal fired generation reduce output such that by 2050 less than 20 per cent of the Queensland's generation is projected to be from coal (from Callide C, Millmerran, Tarong North, and Kogan Creek – the only remaining coal fired power stations).

By 2030, about 45 per cent of scheduled and semi-scheduled generation in the Queensland region is projected to be derived from renewable sources and by 2050, about two thirds of scheduled and semi-scheduled generation in Queensland is projected to be derived from renewable sources.

FIGURE 5.8 PROJECTED ANNUAL GENERATION BY FUEL-TYPE (TWH) – BUSINESS AS USUAL CASE – QLD



SOURCE: ACIL ALLEN ANALYSIS

Emissions

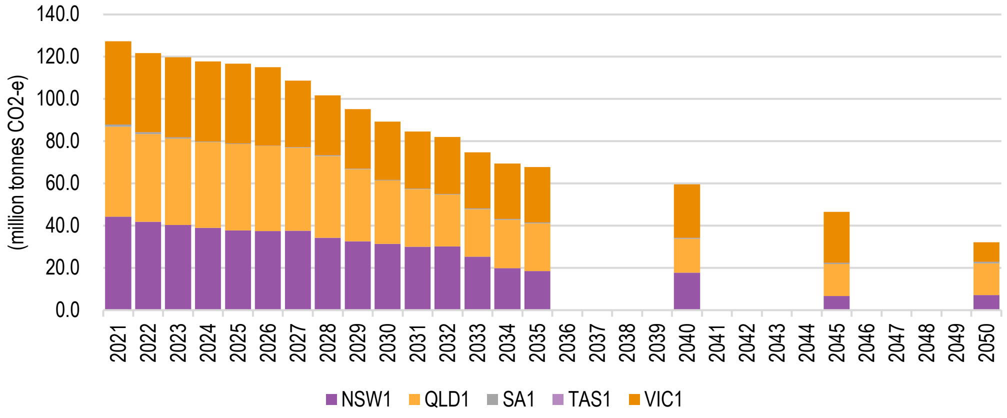
Figure 5.9 shows projected annual emissions from fuel combustion for power generation for each NEM region for the BAU case.

Between 2020 and 2022 the modelling projects a decline in emissions due to the commissioning of new wind and solar farms – falling to about 122 Mt CO_2-e in 2022. Emissions are projected to gradually decline to 110 Mt CO_2-e by 2027, as Yallourn exits the market and more renewable capacity comes in, namely the 1,000 MW CleanCo, wind and storage capacity from the ACT auction and VRET capacity.

The closures of the Tomago smelter, and the Vales Point B and Callide B power stations in 2028 mark the beginning of a more rapid decline in combustion emissions. These are followed by the closures of the Boyne Island smelter and Gladstone power station in 2029, and the Portland smelter in 2030. By 2031, NEM combustion emissions are projected to decrease to 85 Mt CO_2-e. Cumulatively, NEM emissions total 1,136 Mt CO_2-e over the period 2020-21 and 2029-30.

Post 2030, the introduction of the EIS scheme drives greater declines in emission reductions and results in the projected closures of coal fired plant and further projected investment in renewable capacity. By 2050 NEM emissions are projected to reach 32 Mt CO_2-e – which equates to about one quarter of current annual carbon emissions that are attributable to the market. Queensland's emissions are the highest of all regions in 2050 – due to Callide C, Tarong North, Millmerran and Kogan Creek projected to be operating at that time.

FIGURE 5.9 PROJECTED REGIONAL COMBUSTION EMISSIONS (MTCO2-E) – BAU CASE



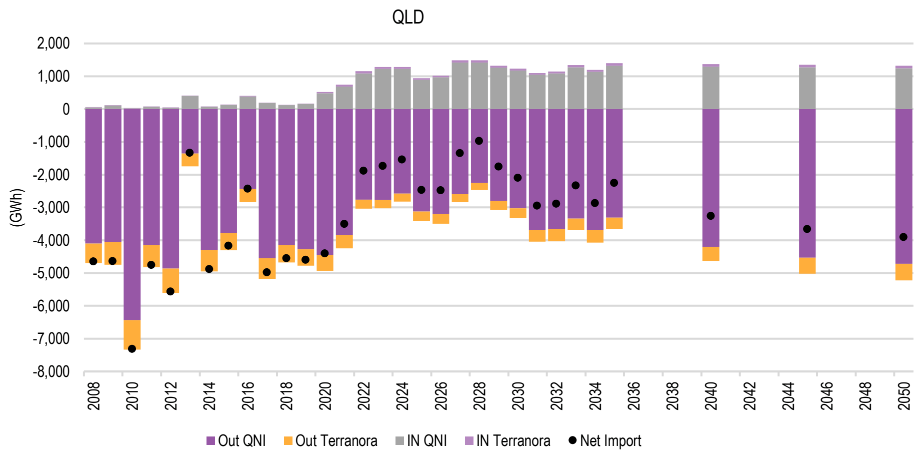
SOURCE: ACIL ALLEN ANALYSIS

Interconnectors

Figure 5.10 shows projected electricity flows across the QNI and Terranora.

Queensland is projected to remain a net exporter of energy into New South Wales throughout the projection period – although there are times throughout each year that New South Wales export into Queensland.

FIGURE 5.10 PROJECTED ANNUAL NET INTERCONNECTOR FLOWS (GWH) – BAU CASE



SOURCE: ACIL ALLEN

Note: A negative net import value is equivalent to a net export

5.6.2 Mount Isa region

Modelling of the Mount Isa region for the BAU case projects wholesale electricity prices of about $160/MWh between 2019 and 2024 as shown in Figure 5.11. This is based on the efficient costs of the current fleet and does not take into account any market power (which could result in higher prices – as observed currently due to the market having few sellers of electricity).

These prices represent the demand weighted average price across all loads in the Mount Isa region.

Post 2024, if there was to be no change in supply then prices would gradually increase to about $180/MWh by 2030 – reflecting an increase in gas price, and reduction in demand (and hence a lower energy base from which to recover costs).

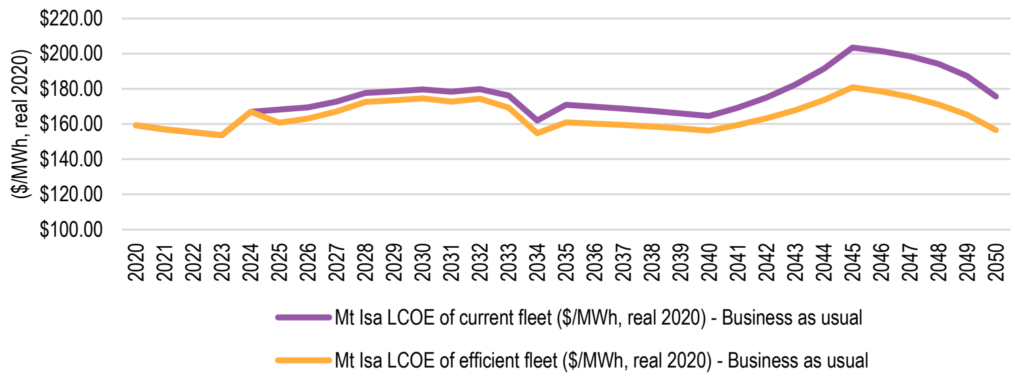
However, the modelling projects an opportunity for some solar to enter the system from 2025 onwards with expiry of existing GSAs. The LCOE of solar over a 25-year life is sufficiently less than the SRMC of the gas fired power stations in the current NWPS. Figure 5.12 shows that about 100 MW of utility scale solar is projected to enter the market if there are no barriers to entry. The modelling shows there is a limit to the extent of new renewable investment in the region in the absence of CopperString due to declining demand, and the assumption that the isolated mines are unlikely to underwrite new renewable generation given their mine lives being about half to 60 per cent of the economic life of a solar farm.

Hence, the modelling does not suggest the closure of all gas plant in the Mount Isa region. Rather, it shows that it is more efficient to continue to pay a capital access charge for existing gas plant, and run it at lower volumes to avoid the cost of consuming gas (as well as to maintain them as back up), and install and run solar.

As a consequence, the modelling projects wholesale electricity prices in the Mount Isa region on average to be between $10 and $20/MWh lower with the investment in solar, than if no further investment was to take place.

There are some temporary variations in projected prices due to step changes in demand and supply. For example, demand declines between 2040 and 2045, but not sufficiently to allow the closure of a gas plant until 2045, hence the LCOE increases during this period.

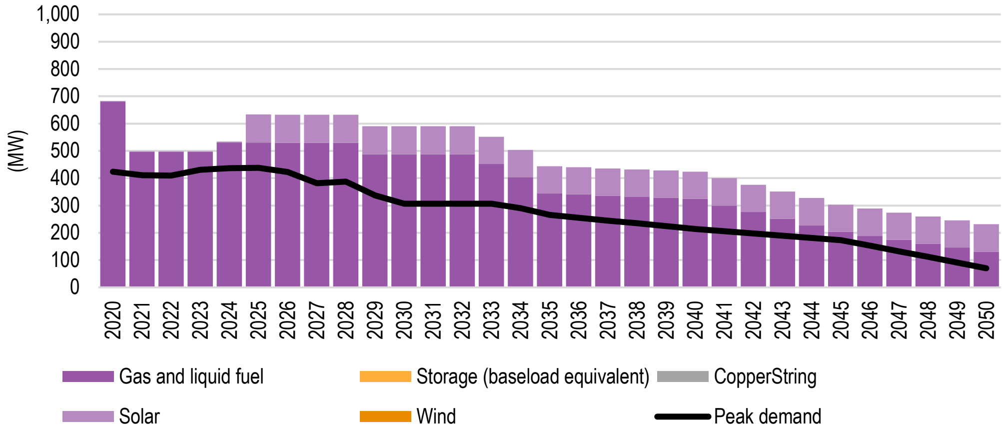
FIGURE 5.11 PROJECTED ANNUAL WHOLESALE ELECTRICITY PRICE (REAL 2020 $/MWH) – BAU CASE – MOUNT ISA REGION



SOURCE: ACIL ALLEN

In the BAU case, about 400 MW of existing power stations are projected to close – mainly as a result of age and mine closure. The only existing generators projected to remain open by 2050 are Diamantina and the smaller generators associated with isolated mines.

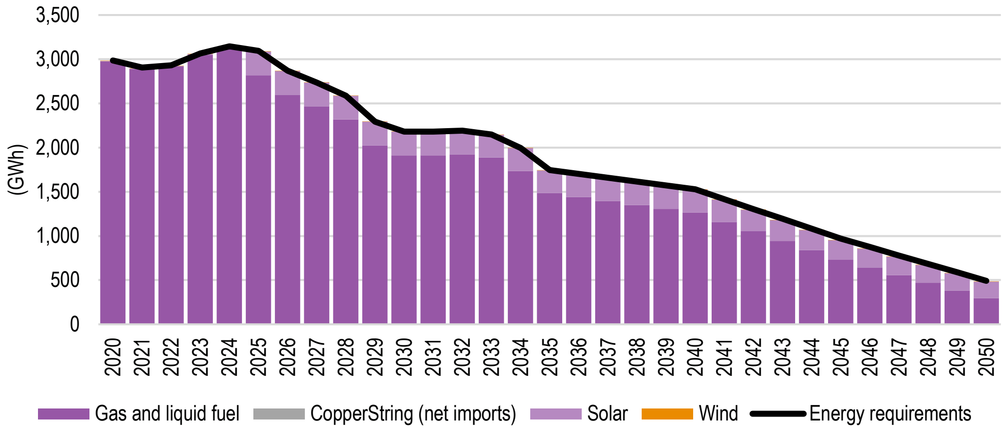
FIGURE 5.12 PROJECTED AGGREGATE CAPACITY (MW) BY TECHNOLOGY – MOUNT ISA REGION – BAU CASE



SOURCE: ACIL ALLEN ANALYSIS

Figure 5.13 shows the decline in generation from the current fleet in the Mount Isa region, coupled with the inclusion of the 100 MW of solar investment. The graph demonstrates the difficulty in allowing for more investment in renewables given the ongoing decline in energy requirements.

FIGURE 5.13 ANNUAL GENERATION BY FUEL-TYPE (GWH) – BAU CASE – MOUNT ISA REGION



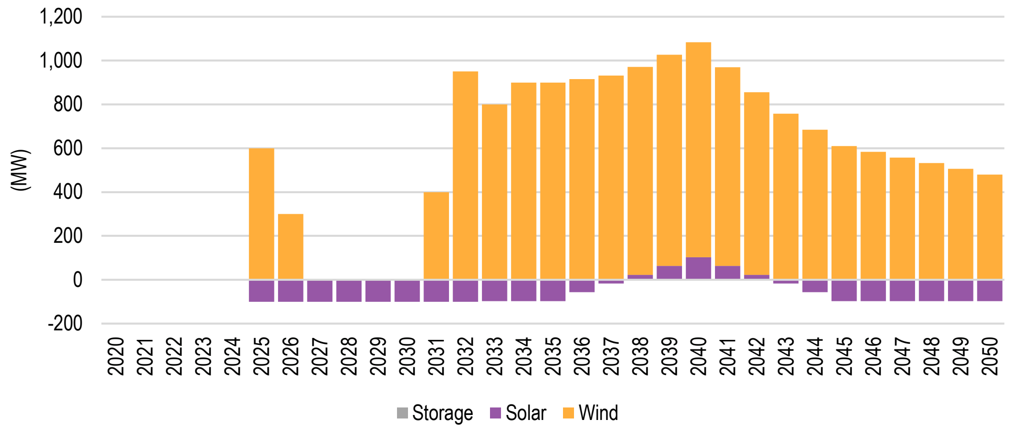
SOURCE: ACIL ALLEN ANALYSIS

5.7 NEM connected case – key results

The inclusion of CopperString 2.0 results in a change in investment in generation capacity in Queensland. The modelling projects that by increasing the connection of the Hughenden renewable energy zone to the NEM, as well as to the Mount Isa region, about 1,000 MW of wind farm capacity is developed in the Hughenden region between 2025 and 2030. This replaces the solar that is projected to have been developed in the Mount Isa region in the BAU case, as well as some wind in the rest of Queensland (as shown in Figure 5.14) between 2025 and 2030 (which is developed in response to the QRET policy). However, post 2030, the relatively higher demand in the Mount Isa region in the NEM connected case provides an opportunity for more wind farm investment in Queensland (in effect, the generation from this investment displaces gas fired generation in the Mount Isa region and the temporary increase in coal fired generation more generally in Queensland). The development of

CopperString 2.0 does not affect the projected new investment of capacity in other regions of the NEM.

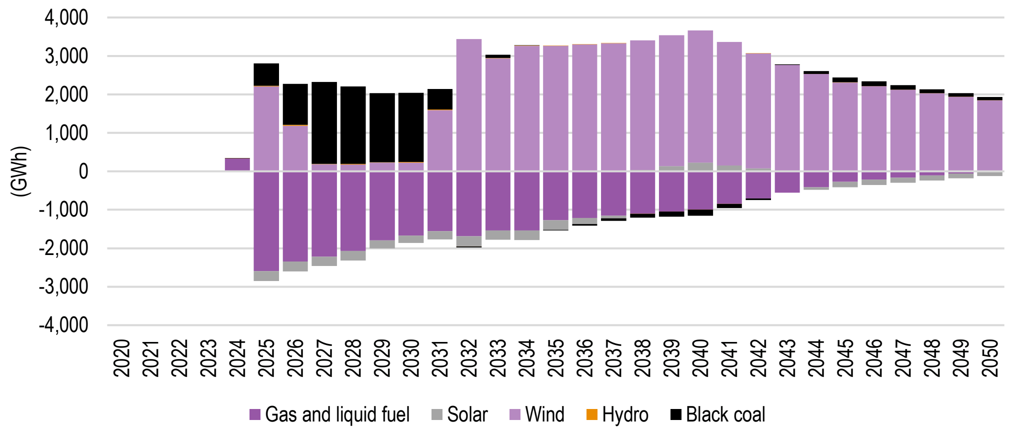
FIGURE 5.14 PROJECTED CHANGE IN AGGREGATE CAPACITY (MW) BY TECHNOLOGY – MOUNT ISA AND QUEENSLAND – WITH NEM CONNECTED CASE COMPARED WITH BAU CASE



SOURCE: ACIL ALLEN ANALYSIS

The projected change in generation by fuel type as a result of CopperString 2.0, shown in Figure 5.15, reflects the change in capacity. Wind farm output from the Hughenden region largely replaces solar farm output and gas fired generation in the Mount Isa region in the BAU case. Compared with the BAU case, there is a temporary increase in coal fired generation between 2025 and 2030. This is a result of there being no increase in renewable generation during that period (but there is a shift in the location of that renewable generation from southern Queensland to the Hughenden region), and the cheaper coal fired generation offsets the more expensive gas in the Mount Isa region. Post 2030, the increase in wind farm investment due to the higher demand in the Mount Isa region replaces the temporary increase in coal fired generation.

FIGURE 5.15 PROJECTED CHANGE IN AGGREGATE GENERATION (GWH) BY FUEL TYPE – MOUNT ISA AND QUEENSLAND – NEM CONNECTED CASE COMPARED WITH BAU CASE



SOURCE: ACIL ALLEN ANALYSIS

Inclusion of CopperString 2.0 reduces gas fired generation from the Mount Isa region to about 300 GWh per year, down from about 2,500 GWh in 2025. This reduced generation only occurs when there are opportunities for economic dispatch when prices in the NEM increase above the SRMC of the gas fired generators due to intermittent low levels of renewable energy generation. The remainder of the Mount Isa region's electricity requirements are satisfied by flows on CopperString from Hughenden.

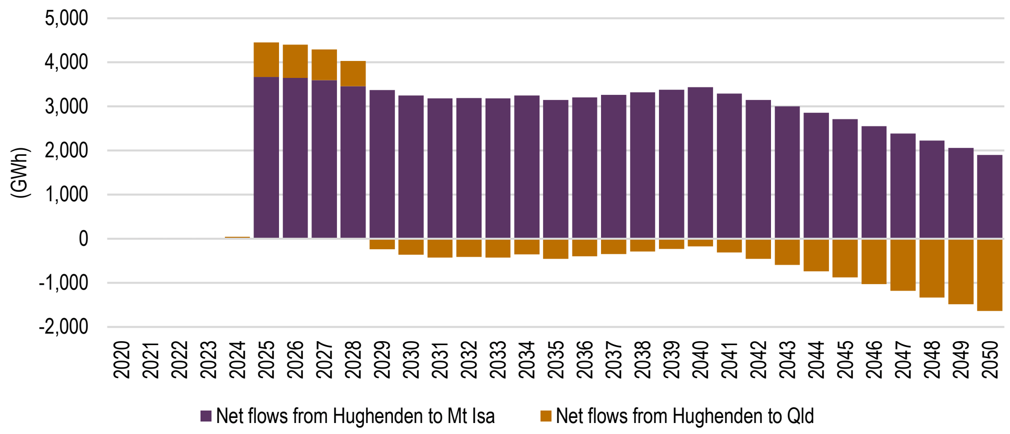
FIGURE 5.16 PROJECTED MOUNT ISA GENERATION (GWH) BY FUEL TYPE

SOURCE: ACIL ALLEN ANALYSIS

The following chart shows the projected net flows along CopperString 2.0 for the NEM connected case. The projected development of about 1,000 MW of wind capacity in the Hughenden area results in flows from Hughenden to Mount Isa, as well as flows from Hughenden to the rest of the Queensland region of the NEM. Strong flows from Hughenden to Mount Isa are projected between 2025 and 2040, before a decline between 2040 and 2050 with reduction of some of the mining loads which in turn leads to an increase in exports to the rest of Queensland[30][31].

[30] Inclusion of CopperString 2.0 has minimal impact on inter-regional flows since the demand in the Mount Isa region is largely matched by the additional wind farm capacity in the Hughenden region.
[31] ACIL Allen has not assessed intra-regional flows as part of this analysis. However, it is unlikely that these will change substantially since the demand in the Mount Isa region is largely matched by the additional wind farm capacity in the Hughenden region.

FIGURE 5.17 PROJECTED NET FLOWS (GWH) OF COPPERSTRING 2.0 – NEM CONNECTED CASE



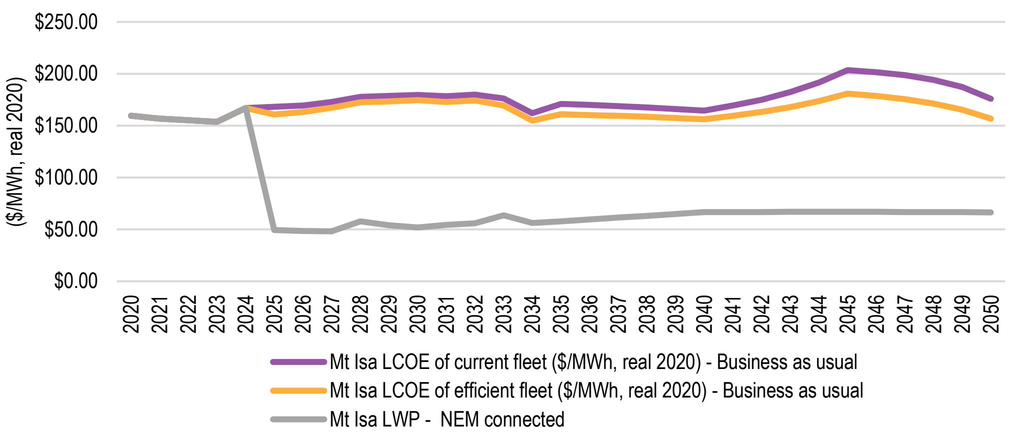
SOURCE: ACIL ALLEN ANALYSIS

Figure 5.18 compares the projected wholesale price of electricity in the Mount Isa region under the BAU case with the projected load weighted price of the Mount Isa region load if it were part of the NEM as per the NEM connected case.

Connection of the Mount Isa region to the NEM via CopperString 2.0 decreases wholesale electricity prices from about $160-$180/MWh to about $50/MWh in 2025 – a difference of over $100/MWh. This difference remains throughout the projection period.

This comparison excludes the cost of CopperString 2.0. The final cost of CopperString 2.0 borne by customers will depend on capital costs, operating costs, the cost of capital and any financial contribution from government. The allocation of these costs across different customer groups including between customers in the Mount Isa region and existing NEM customers in Queensland will also impact price changes.

FIGURE 5.18 PROJECTED ANNUAL WHOLESALE ELECTRICITY PRICE (REAL 2020 $/MWH) – MOUNT ISA REGION – BAU, AND NEM CONNECTED CASES



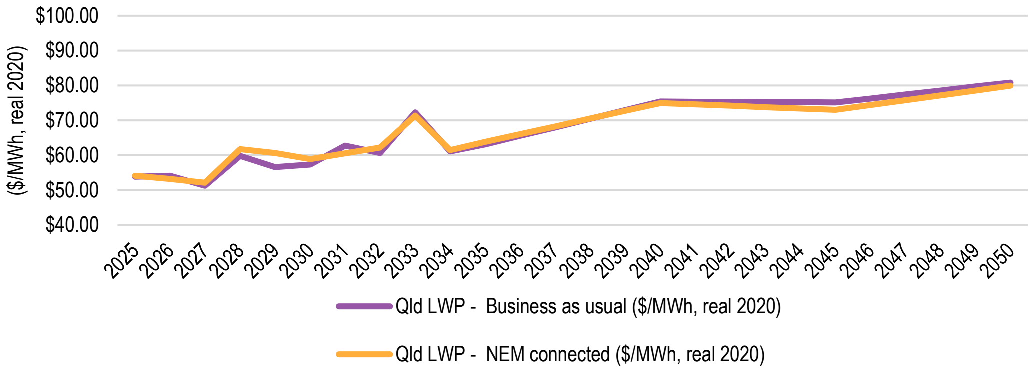
SOURCE: ACIL ALLEN ANALYSIS

The graph below compares the load weighted price of wholesale electricity in the current Queensland region of the NEM. For reference, load weighted prices in Queensland in 2019 were about $75/MWh.

Connection of the Mount Isa region to the NEM via CopperString 2.0 has negligible impact on prices in the current Queensland region of the NEM.

Compared with the BAU case, during the period between 2025 and 2030 there is a slight increase in the Queensland wholesale electricity prices costs, by about $1.30/MWh, when the Mount Isa region is connected to the NEM. This slight increase in price relative to the BAU case is driven by the current Queensland region of the NEM having access to more demand (due to the Mount Isa region being connected to the NEM) which would normally be served by relatively high cost power stations (located in the Mount Isa region). This is largely due to an increase in the cost of generation at the margin in the current Queensland region of the NEM, and to a lesser extent the opportunity for the larger generator portfolios in Queensland to attempt to exercise market power through their bidding behaviour in an attempt to maximise their net uncontracted revenues. However, post 2030, wholesale electricity prices are projected to reach new investment levels in both cases and hence the price differential diminishes to effectively no difference.

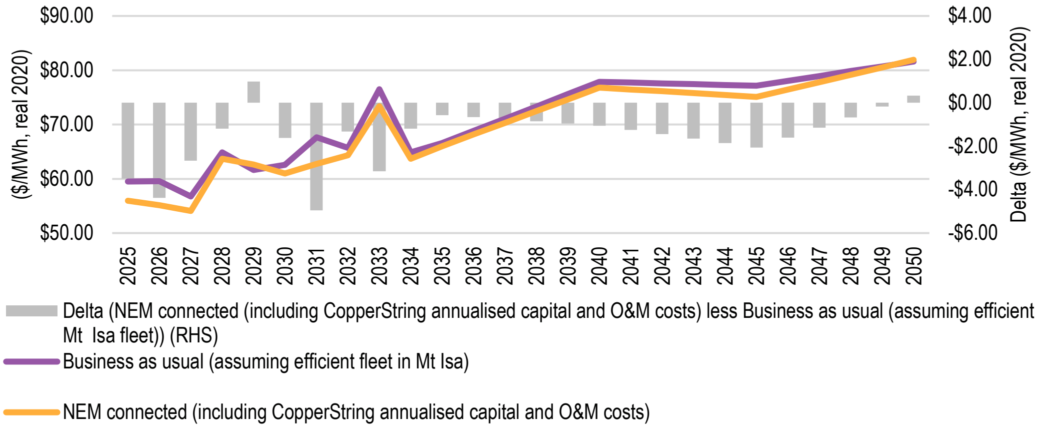
FIGURE 5.19 PROJECTED ANNUAL WHOLESALE ELECTRICITY LOAD WEIGHTED PRICE (REAL 2020 $/MWH) – CURRENT QUEENSLAND REGION OF THE NEM



SOURCE: ACIL ALLEN ANALYSIS

Figure 5.20 compares the projected load weighted price for the whole of Queensland under the two scenarios. In this graph we have included the amortised capital cost (EPC plus development costs) and the ongoing annual O&M cost of CopperString 2.0 of $2 billion and $16.7 million respectively. Connecting the Mount Isa region to the NEM via CopperString 2.0 reduces wholesale electricity prices across the whole of Queensland by about $1.50/MWh on average over the longer term.

FIGURE 5.20 PROJECTED ANNUAL WHOLESALE ELECTRICITY LOAD WEIGHTED PRICE (REAL 2020 $/MWH) – WHOLE OF QUEENSLAND



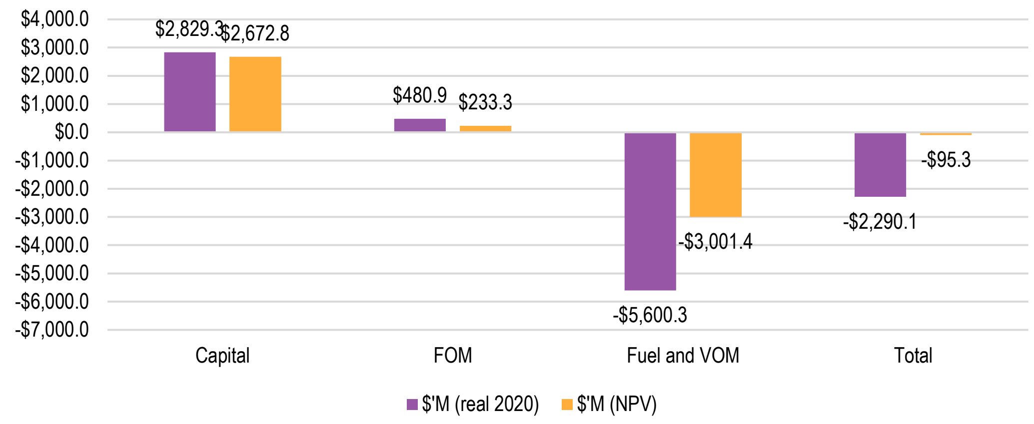
SOURCE: ACIL ALLEN ANALYSIS

Connection of the Mount Isa region to the NEM reduces emissions marginally across the NEM by about 6 $MtCO_2$-e or 0.3 per cent between 2020 and 2050 – largely by the substitution of wind farm generation for gas fired generation. The reduction is more noticeable in Mount Isa in percentage terms – where emissions are reduced by about 58 per cent as a result of CopperString 2.0.

Figure 5.21 shows that although the connection of the Mount Isa region to the NEM and the associated capital cost of CopperString 2.0 [32] and additional wind farm investment increases the level of capital spend across the NEM between 2025 and 2050, this is offset by the reduction in fuel costs (primarily from reduced gas fired generation in the Mount Isa region) and variable operating and maintenance costs (VOM). There is comparatively little difference in the level of fixed operating and maintenance (FOM) costs. Overall, resource costs (capital expenditure on generation and CopperString 2.0, operating costs, and fuel costs) in the wholesale electricity segment across the whole of Queensland are projected to decrease by $2.9 billion in real terms, and by $0.48 billion in present value terms – even with a relative increase in demand due to the increase in mining activity in the NWMP.

[32] Based on an assumed capital cost of $2 billion.

FIGURE 5.21 CHANGE IN PROJECTED NEM RESOURCE COSTS ($'M, REAL 2020 AND PV) DUE TO CONNECTION OF MOUNT ISA REGION TO NEM



Note: NPV uses a discount rate of five per cent. This chart refers to the whole of NEM but given there is no projected change in investment in the regions of the NEM outside of Queensland, the values essentially represent the whole of Queensland.

SOURCE: ACIL ALLEN ANALYSIS

6

ECONOMIC IMPACT ANALYSIS

This chapter provides an overview of the approach used to model the broader economic impact of the CopperString 2.0 project using CGE modelling and presents the projected impacts. Further detail regarding the model is provided in Appendix A.

6.1 Introduction

To provide information on the broader economic impacts on the NWMP and Queensland potentially arising from the construction and operation of CopperString 2.0, ACIL Allen has undertaken computable general equilibrium (CGE) modelling. For this analysis, ACIL Allen used its own CGE model, *Tasman Global*. It is a multi-sector dynamic model of the Australian and world economy that has been used for many similar modelling projects including new interconnectors, new generators, and a previous assessment of CopperString 2.0. An overview of the model is provided in Appendix A.

The estimated capital and operating expenses underlying CopperString 2.0 along with the projected electricity market variables were used to inform the *Tasman Global* Reference Case and policy scenarios. The differences between the economic projections of the BAU and NEM connected cases provide a forecast of its total economic impacts. These include the wider economic impacts associated with the construction and ongoing operation of the facilities and supporting services, as well as the impact of changes in the electricity market prices, as relevant.

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

— **Real economic output** (as measured by real Gross Regional Product (GRP) and real Gross State Product (GSP) or Gross Territory Product (GTP), the sub-national versions of gross domestic product or GDP) 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. 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 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** impacts of the construction and operations of a major project are produced by *Tasman Global*.

6.2 Framework of analysis

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 CGE modelling. The selection of the right tool is critical to the accuracy of the estimated impacts and depends upon the characteristics of CopperString 2.0/industry. Sometimes more than one tool may be required to provide a full picture of economic consequences.

By their nature, I-O 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 or greenhouse gas emissions, social justice implications and so forth may also be relevant in assessing the full implications of a project or policy, but are not captured within I-O multipliers and CGE models.

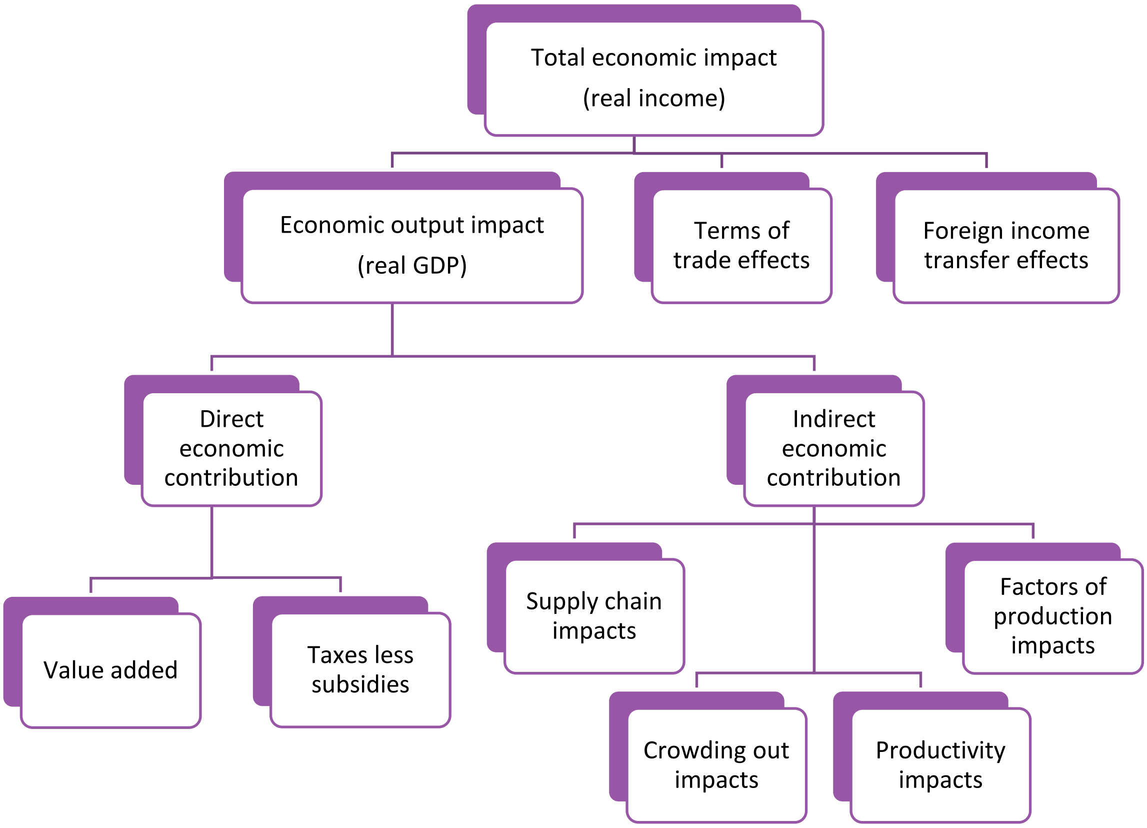
Fundamentally, although various aspects of a policy or project may be relevant to particular stakeholders—for example, the number of jobs created or the size of the investment expenditure—the key aggregate measure of the macroeconomic impact of a project or policy is the extent to which the ***total income of the economy*** has changed as a result of that policy or project. This is typically measured in terms of the change in real gross national disposable income (RGNDI), although real gross domestic product (GDP) and consumer surplus 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 or policy
— any crowding out implications as resources are potentially diverted away from other productive activities to undertake the project or policy 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
— the extent of any dynamic element to the size of any of the above effects (for example, associated with different phases of the project).

Figure 6.1 shows these components graphically. Some of these effects may be negligible while others may be significant. An understanding of the effects helps determine the most appropriate tool(s) for the analysis.

FIGURE 6.1 ESTIMATING THE MACROECONOMIC IMPACT OF A PROJECT OR POLICY



Note: In *Tasman Global*, the change in real income is equivalent to the change in equivalent variation – a standard economic measure of the change in consumer welfare resulting from exogenous shocks

SOURCE: ACIL ALLEN CONSULTING

For many projects, static estimates of the direct economic contribution and of supply chain indirect economic contribution implications can be obtained 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 of the components shown in Figure 6.1 with dynamic CGE models able to estimate the impacts through time.

Given that a project the size of CopperString 2.0 will have noticeable impacts on the cost of electricity CGE modelling has been chosen as the most appropriate tool to undertake the economic impacts assessment in this report.

For this analysis, ACIL Allen's CGE model *Tasman Global* was used to estimate the impacts of the construction and operation activities associated with CopperString 2.0. The primary economic measure reported throughout the analysis is the impact on **real income** although we have also reported **real GRP** and **real GSP** effects in the results.

6.2.1 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 Consulting. *Tasman Global* is a powerful and effective tool for undertaking economic analysis at the regional, 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 I-O database. These models provide a representation of the whole economy, set in a national and international trading context. Starting with individual producers and consumers, the model builds up the economy through the demands and production from each individual actor in the face of interlinked markets. When an economic "shock" or disturbance is applied to a model, each of the markets adjusts according to a 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.

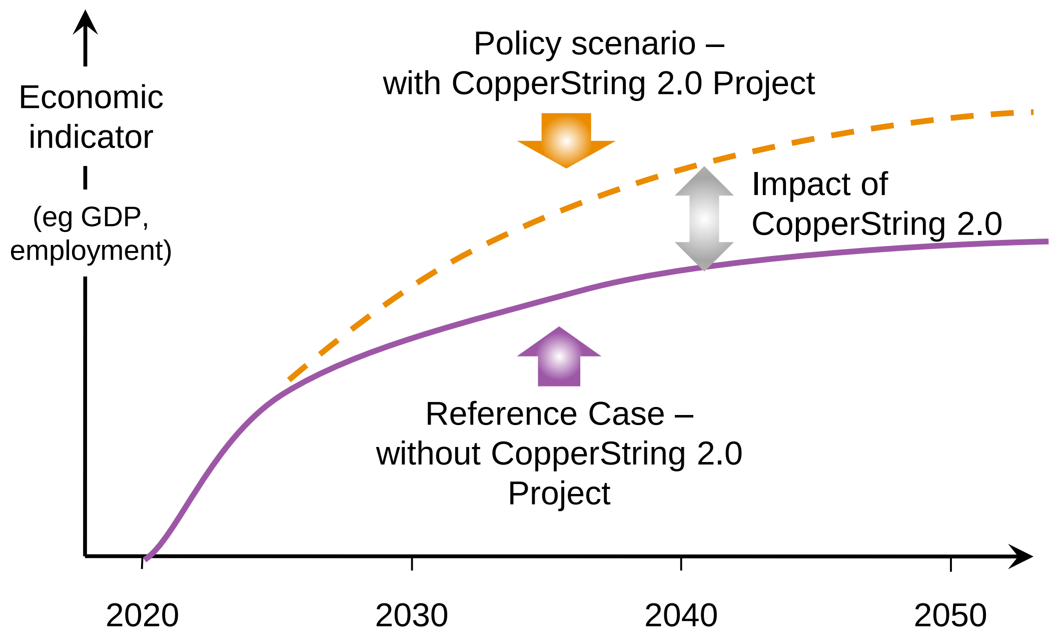
A more detailed discussion of *Tasman Global* and its operation is provided in Appendix A.

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 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 simulations. The Reference Case provides projections of growth in the absence of CopperString 2.0. It therefore provides the base line projections of GDP, population, labour supply, industry output, and other relevant measures, and provides projections of endogenous variables such as productivity changes and consumer preferences. The Policy Case assumes all productivity improvements, tax rates and consumer preferences change as per the Reference Case projections but also includes the proposed Project. The alternative scenarios result in different projections of the economy, and the net impacts of CopperString 2.0 can be calculated as the differences, for each relevant measure, between the Policy Case and the Reference Case (see Figure 6.2).

FIGURE 6.2 ILLUSTRATIVE SCENARIO ANALYSIS USING *TASMAN GLOBAL*



Note: In practice, impacts could be negative, positive, neutral or a mixture

SOURCE: ACIL ALLEN CONSULTING

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 analysis the database has been aggregated to 48 industries/commodities as presented in Table 6.1. The industry aggregation applied was chosen to provide the detail relevant for this analysis.

TABLE 6.1 INDUSTRY/COMMODITY AGGREGATION USED IN 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 AGGREGATION

Micro-industry approach

To accurately assess the economic impacts or economic contribution of a major project such as CopperString 2.0, it is necessary to represent CopperString 2.0 in the model's database. An accurate representation can be achieved 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 CopperString 2.0 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" Base Case outcomes.

Besides having a separate cost structure for CopperString 2.0 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* by incorporating detailed year on year input changes by source.

Using the micro-industry approach for project evaluations is the most accurate way to capture the detailed economic linkages between CopperString 2.0 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 48 industries identified in Table 6.1, the database also identifies the construction and operation phases of CopperString 2.0 as separate micro-industries with their own input cost structure, sales, employment, tax revenues and greenhouse gas emissions based on detailed information generated as part of CopperString 2.0 analysis.

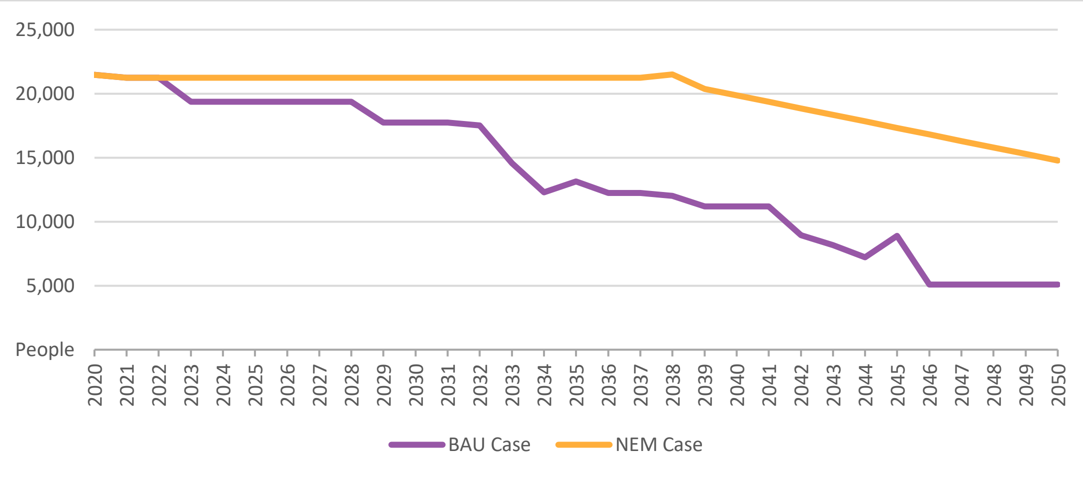
Another important aspect in the CGE modelling approach used for this analysis is to have separate identification of the capital stock created as part of CopperString 2.0's investment phase and isolating it until the capital is available for use, thereby preventing the economy gaining false benefits from, say, half a power station.

6.3 Key assumptions

In undertaking the CGE modelling for this analysis, Queensland has been divided into North-West Queensland (comprising the Mount Isa LGA[33] plus the LGAs along the CopperString corridor between Woodstock and Cloncurry), and the Rest of Queensland.

Assumptions for population in the Mount Isa LGA has been provided to ACIL Allen based on the projected town load demand under the BAU and NEM connected cases (Figure 6.3). Under the BAU case, the population of the Mount Isa region is projected to fall to approximately 13,000 people by 2035 and to 5,000 people by 2050 as mining activity in the region reduces. In contrast, population under the NEM connected case is projected to remain approximately constant at around 21,000 people through until 2038 before falling to approximately 15,000 people by 2050. Under the BAU case, population in the rest of the CopperString corridor and the total Queensland population through to 2041 have been assumed to be the same as those projected by the Queensland Government, followed by ACIL Allen projections.[34] Under these projections, the population in the CopperString corridor decreases slightly, from 32,307 in 2021 to 31,965 in 2041 and 31,676 by 2050, while the population of Queensland as a whole increases from 5.24 million in 2021 to 7.16 million by 2041 and 7.99 million by 2050.

FIGURE 6.3 MOUNT ISA LGA POPULATION AND BAU CASE AND NEM CONNECTED CASE



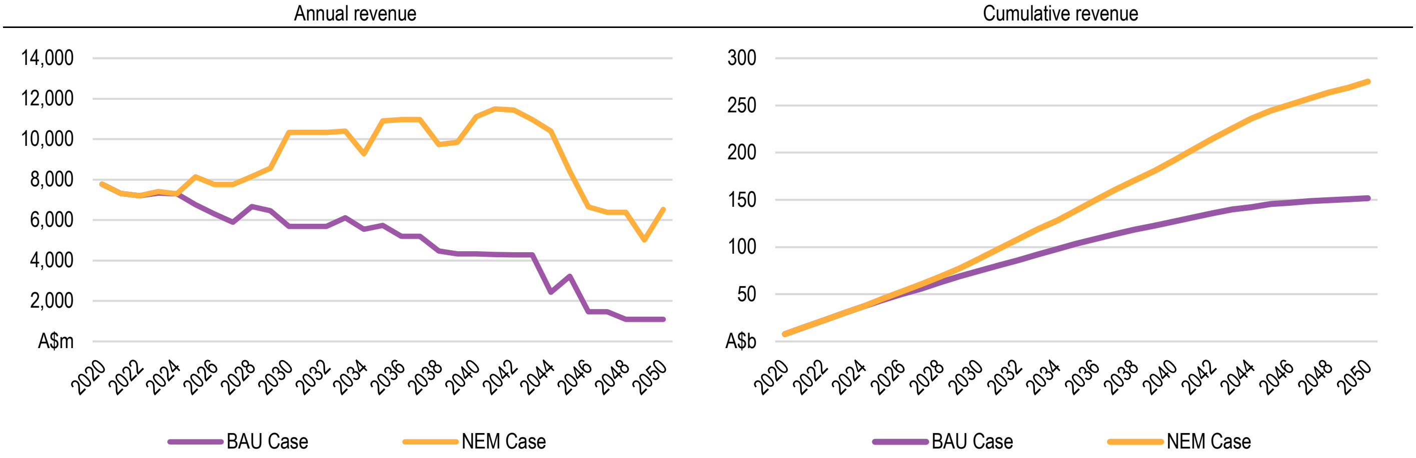
SOURCE: ACIL ALLEN BASED ON TOWN LOAD DEMAND FIGURE 6.3

[33] Including the Carpentaria LGA surrounding the Century Zinc mine.
[34] Queensland Government population projections, 2018 edition (link: https://www.qgso.qld.gov.au/statistics/theme/population/population-projections/regions). Medium series.

The *PowerMark* projections of the quantity and price of electricity generation by technology in each NEM region have been replicated in both the BAU and NEM Connected cases. This means that the CGE modelling incorporates the economic impacts associated with changes in the real cost of generation as a result of changes in the generation mix stimulated by CopperString 2.0, as well the economic impacts of the projected movement of generation capacity toward North-West Queensland, as well as the economic impact of changing wholesale and retail prices. Due to the high demand for gas (including internationally via LNG exports), the reduction in usage of gas by the electricity generation industry is rapidly taken up by other consumers with only a small projected impact on gas prices.

In this analysis, it has been assumed that the lower power costs under the NEM connected case compared to the BAU case will allow increased production at existing sites (lower cut-off grade increases amount of reserves that can be economically extracted) and will incentivise more new developments and the development of tailings deposits at some sites (see Section 4.3.1). Assuming an average exchange rate of 0.75 USD per AUD and allowing for an average 10 per cent loss factor in extraction and processing, the Izmin and Soren Consulting estimates imply an additional $123.5 billion of mining revenue under the NEM connected case compared to the BAU case (Figure 6.4).

FIGURE 6.4 PROJECTED NORTHWEST QUEENSLAND MINING REVENUE UNDER THE BAU CASE AND NEM CONNECTED CASE



SOURCE: ACIL ALLEN CONSULTING BASED ON IZMIN AND SOREN CONSULTING

As mentioned in Section A.3, the model has the ability to explicitly account for the repatriation of profits (for example through foreign ownership of capital or through the use of fly-in, fly-out or drive-in, drive-out workers). For this project, approximately 40 per cent of the returns to capital (after tax) has been assumed to be foreign owned with the returns to domestic shareholders assumed to be distributed evenly across Australia on a per capita basis. As with any asset, the ownership of the various mines is not guaranteed to remain the same in the future.

Investment and labour supply has been assumed to follow standard *Tasman Global* assumptions (see Appendix A), which, while constrained have some flexibility with respect to regional allocation as well as the potential for upward and downward changes based on underlying economic activity or labour prices, respectively. The budgets of each Australian government under the NEM connected case has been assumed to remain unchanged relative to the BAU case. This implies that changes in the real income of each region accrue to private households and savings (on a Cobb-Douglas basis).

6.4 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 of time (typically a year). GDP may be calculated in different ways:

— On the expenditure side by adding together total private and government consumption, investment and net trade.
— On the income side as the sum of returns to the primary factors of production (labour, capital and natural resources) employed in the national economy plus indirect tax revenue.

The regional level equivalent to GDP is GRP – at the state or territory level it is called GSP or GTP, respectively. 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 chapter.

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 real gross national disposable income or RGNDI as reported by the Australian Bureau of Statistics (ABS).

As shown in Figure 6.1, 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.

6.5 Discounted future costs and benefits

To compare future costs with future benefits, the future cash flows need to be discounted and brought into present value terms. The need to discount future cash flows can be viewed from two main perspectives, both of which focus on the opportunity cost of the cash flows implied by the timing of payments.

The first perspective is the general observation that individuals prefer a dollar today to a dollar in the future. This is most obvious in the fact that banks need to pay interest on deposits to entice individuals to forgo current spending. This general preference for current consumption is reflected by the 'rate of time preference' and relates to all economic benefits (and costs), not just those that are financial in nature. Since individuals are not indifferent between cash flows from different periods, those flows cannot be directly compared. For monetised flows to be directly comparable in a benefit-cost analysis, those costs or benefits incurred in the future need to be discounted back to current dollar terms. This reflects society's preferences, which place greater weight on consumption occurring closer to the present.

The second perspective is that flows of costs and benefits resulting from CopperString 2.0 also have an opportunity cost for investment. The construction and operation of CopperString 2.0 will impose costs on investors, and those costs will need to be funded in some way. This funding requirement imposes costs on the affected party, either through the interest paid for borrowing the money, or the returns forgone when equity funds are not available to be used for other purposes.

CopperString 2.0 would therefore only be beneficial if it provides a return in excess of the cost to society of deferring consumption, or of the return that could have been earned on the best alternative use of the funds. By applying a discount rate to future cash flows, the required rate of return is explicitly taken into account in the net present value calculation.

Both perspectives demonstrate that the need to discount future cash flows can be viewed in terms of the opportunity cost of the cash flows, whether this is the cost of delaying consumption or the alternative investment opportunities forgone. Since most of the costs and benefits of the mine are spread out over time, and their value depends on when they are received, discounting is important to summarising the total net benefit of CopperString 2.0.

Typically, each option is conducted with one discount rate applied to all benefits and all costs over the entire time frame of interest. In 1970, Kenneth Arrow and Robert Lind[35] explained that this may be inappropriate, because different discount rates should be used depending on the nature of the benefits and costs, including risk and uncertainty, and depending on who is affected. For example, if all costs and benefits are spread across the whole community it could be appropriate to use a risk-free rate. However, if sizeable benefits and costs accrue directly to particular individuals or groups, they also bear the cost of bearing risk and uncertainty, which may be significant. Then, the discount rate should be consistent with the preferences and attitudes of the relevant parties. Therefore, different streams of benefits and costs should be discounted differently, according to whether they accrue publicly or privately. Application of the insights of Arrow and Lind to an assessment of CopperString 2.0 would suggest using a risk-free discount rate for public benefits in the form of employment and provision of infrastructure effects, but a risk-inclusive discount rate for private benefits to investors in CopperString 2.0. The real options literature has also made a strong case for use of multiple discount rates for different streams of costs and benefits, with different risk and uncertainty attributes.

While quantitative methods for estimating the opportunity cost of capital employed in public projects exist (such as the capital asset pricing model), they are dependent on a range of regularly changing variables (such as the statutory tax rates, equity risk premiums, gearing levels and the risk-free rate). Because of the uncertainty and complexity involved in choosing the 'correct' discount rate for each cash flow stream, and the potential impact that alternative discount rates can have on the net benefit, it is often recommended that different rates should be used in the analysis to demonstrate the sensitivity of results to the discount rate assumption. For example, the Australian Office of Best Practice Regulation recommends the use of three discount rates. For this analysis, ACIL Allen has presented the net benefits of CopperString 2.0 using annual real discounts rates of 3, 7 and 10 per cent, with the lower and upper levels, respectively, reflecting a social rate of time preference and an indicative investor's internal cost of capital, while the 7 per cent rate effectively represents a hybrid of the social and commercial discount rates.

6.6 Economic modelling results

6.6.1 Real Economic Output and Real Income

As discussed in section 6.4, 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 GDP, and as GSP/GRP at the state/regional 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, real income provides a better measure of the welfare impact that changes in these aggregates have on people living in a region.[36]

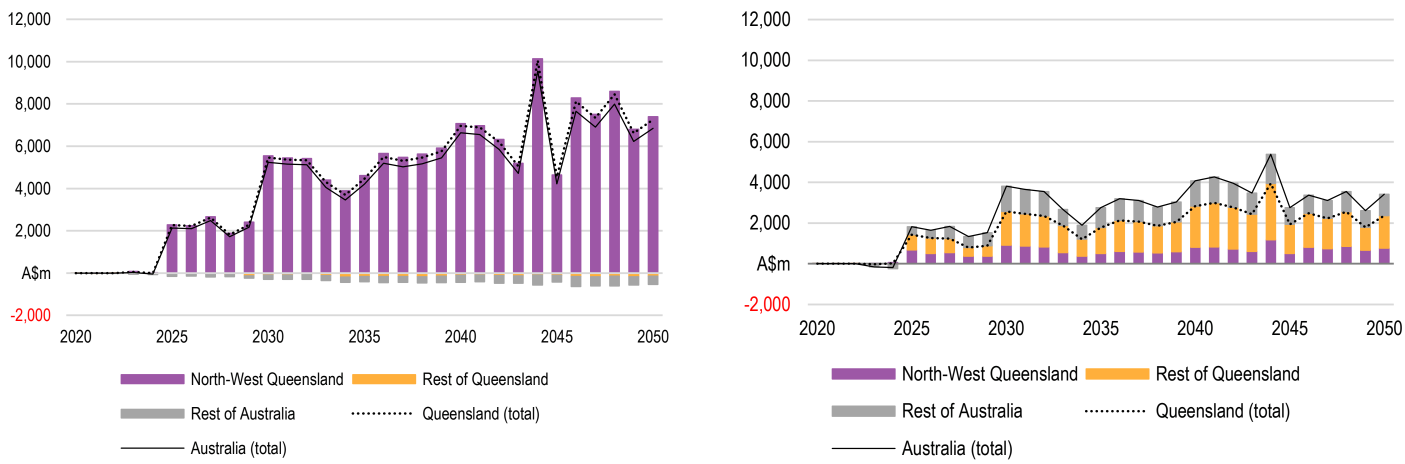
Figure 6.5 shows the estimated change in both real economic output and real income in each region of Australia due to the construction and operations of CopperString 2.0. A summary of the projected impacts is presented in Table 6.2, while Table 6.3 presents a decomposition of the macroeconomic impacts.

[35] K. J. Arrow and R. C. Lind, "Uncertainty and the Evaluation of Public Investment Decisions," Amer. Econ. Rev., June 1970, 60, 364-78

[36] 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 6.5 CHANGE IN AUSTRALIAN REAL ECONOMIC OUTPUT AND REAL INCOME AS A RESULT OF COPPERSTRING 2.0, NEM CONNECTED CASE RELATIVE TO BAU CASE (IN 2020 TERMS)

A. Real economic output (GRP/GSP) B. Real income



Note: All years are financial years ending June 30.

SOURCE: ACIL ALLEN CONSULTING

While the macroeconomic effects of CopperString 2.0 in the NEM connected case relative to the BAU case are driven by many factors, there are five broad elements:

1. The effect of the construction and operation of the CopperString 2.0 transmission line.
2. The underlying productivity improvement in the Queensland generation sector driven by the connection of the two grids resulting in changes in electricity prices.
3. As per the electricity market analysis in Chapter 5, there are a complex range of processes. In general, wholesale prices in North-West Queensland are lowered substantially (by over $100/MWh) while the wholesale electricity prices in the Rest of Queensland initially rise in the period 2026–2029 (by about $1.30/MWh), but are then approximately equal thereafter.
4. The movement of electricity generation toward North-West Queensland away from the Rest of Queensland, including the unlocking of additional supply opportunities (such as increasing the participation of the North Queensland Renewable Energy Hub in the NEM).
5. The stimulation of additional mineral production in the North-West driven by the lowering of the electricity prices.
6. The transfer of taxes and returns to capital associated with the increased mineral production in the North-West to other parts of Australia and overseas.

Previous modelling of CopperString 2.0 that did not include the effect of stimulating additional mineral production, projected a national increase in real GDP and real income of around $6.0 billion over the period to 2050, with approximately half of the effect related to the efficiency improvement in the electricity sector, half associated with the higher profitability of miners with less than 5 per cent attributable to the effect of building and operating the transmission line itself.

Unfortunately, in this analysis, the electricity market effects in the NEM connected case relative to the BAU case are intertwined with the additional mineral production so it is not straightforward to decompose the various effects. Saying that, the production and export of approximately $123.5 billion of previously uneconomic mineral resources will be the main driver of the projected macroeconomic effects. In general, the changes in real economic output occur broadly in line with the projected increase in mining production in the NWMP (see Figure 6.4).

The construction and operations of the transmission line itself, which, at $2 billion, is nominally large, is primarily increasing 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 CopperString 2.0 has a noticeable effect on the real income of residents in the construction corridor, as there is increased demand for labour and goods and services and this boosts local incomes under the NEM connected case relative to the BAU case (by a cumulative total of $77 million by 2024).

As shown in Table 6.2, the additional economic activity in the NEM connected case relative to the BAU case, occurs in North-West Queensland. There is a small projected decrease in real economic output in the Rest of Queensland and the Rest of Australia due to the movement of scarce primary factors (i.e. labour and capital) into the North-West Queensland region. As shown in Table 6.2, however, the real income generated by the increase in output is not kept within the North-West Queensland region, and is instead repatriated to other Australian and overseas residents through the payment of Queensland and Commonwealth Government taxes and through the payment of dividends to shareholders. For residents in the Rest of Queensland, the increase in real income is positive throughout the projection period from 2025, and more than compensates for any negative effects on real GSP. Similarly, over the whole modelling time frame, there is a clear, strong aggregate benefit to the real income of Queensland.

TABLE 6.2 PROJECTED CUMULATIVE CHANGE IN REAL ECONOMIC OUTPUT AND REAL INCOME IN EACH REGION AS A RESULT OF COPPERSTRING 2.0, NEM CONNECTED CASE RELATIVE TO BAU CASE (IN 2020 TERMS)

	Total (2020 to 2050)	NPV (3% real discount rate)	NPV (7% real discount rate)	NPV (10% real discount rate)
	2020 $Am	2020 $Am	2020 $Am	2020 $Am
Real economic output				
North-West Queensland	142,587	81,117	41,821	27,051
Rest of Queensland	–3,131	–1,819	–962	–632
Queensland (GSP)	**139,455**	**79,297**	**40,859**	**26,418**
Rest of Australia	–7,661	–4,342	–2,238	–1,454
Australia (GDP)	**131,794**	**74,955**	**38,621**	**24,964**
Real income				
North-West Queensland	17,435	10,426	5,779	3,951
Rest of Queensland	36,891	21,317	11,169	7,288
Queensland	**54,326**	**31,743**	**16,948**	**11,239**
Rest of Australia	24,033	14,096	7,500	4,925
Australia	**78,359**	**45,840**	**24,449**	**16,164**

Note: NPV = net present value.

SOURCE: ACIL ALLEN CONSULTING

For the purposes of this analysis, the economic impact of generation connected at Hughenden in the NEM connected case is included in the North-West Queensland region. Including Hughenden as part of the North-West Queensland region contributes to the transfer of real economic output between North-West Queensland and the Rest of Queensland since the inclusion of CopperString 2.0 is projected to shift investment in some generation capacity from central and southern Queensland into the Hughenden area. However, the net increase in economic output is shared to a large extent amongst regions.

TABLE 6.3 DECOMPOSITION OF PROJECTED CUMULATIVE TOTAL CHANGE IN REAL GDP AND REAL INCOME AS A RESULT OF COPPERSTRING 2.0, NEM CONNECTED CASE RELATIVE TO BAU CASE (IN 2020 TERMS)

	North-West Queensland	Rest of Queensland	Queensland (total)	Rest of Australia	Australia (total)
	A$m	A$m	A$m	A$m	A$m
Private consumption	14,291	19,839	**34,129**	13,377	**47,507**
Government consumption	0	0	**0**	0	**0**
Investment	35,601	–1,301	**34,300**	–2,507	**31,793**
Net foreign trade	92,695	–21,669	**71,026**	–18,532	**52,495**
– *Real exports*	*128,899*	*–15,621*	***113,278***	*–18,024*	***95,254***
– *Contribution of imports*	*–36,204*	*–6,048*	***–42,252***	*–508*	***–42,760***
Real economic output	**142,587**	**–3,131**	**139,455**	**–7,661**	**131,794**
Terms of trade	–4,326	5,980	**1,654**	5,894	**7,548**
Net income transfers	–120,825	34,042	**–86,783**	25,800	**–60,983**
Real income	**17,435**	**36,891**	**54,326**	**24,033**	**78,359**

Note: Real government consumption is assumed to be unchanged relative to the Reference Case, with any changes in taxation revenue given to private households as a lump sum transfer in each year.

SOURCE: ACIL ALLEN CONSULTING

Real Economic Output

Over the period to 2050, CopperString 2.0 is projected to increase the real economic output of:

— North-West Queensland by a cumulative total of $142.6 billion relative to the Reference Case (with a net present value of $81.0 billion, using a 3 per cent real discount rate)

— Queensland as a whole (i.e. real GSP) by a cumulative total of $139.5 billion relative to the Reference Case (with a net present value of $79.3 billion, using a 3 per cent real discount rate)

— Australia as a whole (i.e. real GDP) by a cumulative total of $131.8 billion relative to the Reference Case (with a net present value of $75.0 billion, using a 3 per cent real discount rate).

To place the projected changes in economic output estimates in perspective, the discounted present value (using a 3 per cent real discount rate) is equivalent to approximately 21 per cent of Queensland's current GSP. This is a significant potential impact that is unlocked by a single project.

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 CopperString 2.0.

The Queensland Government will receive some additional taxes (such as royalties and payroll taxes) because of CopperString 2.0, 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 2020 to 2050, under the NEM connected case, CopperString 2.0 is projected to increase the real income of:

— North-West Queensland by a cumulative total of $17.4 billion relative to the BAU Case (with a net present value of $10.4 billion, using a 3 per cent real discount rate)
— Queensland as a whole by a cumulative total of $54.3 billion relative to the BAU Case (with a net present value of $31.7 billion, using a 3 per cent real discount rate)
— Australia as a whole by a cumulative total of $78.4 billion relative to the BAU Case (with a net present value of $45.8 billion, using a 3 per cent real discount rate).

To place these projected changes in income in perspective, the discounted present values (using a 3 per cent real discount rate) are equivalent to a one-off increase in the average real income of all current residents of Queensland by approximately $6,000 per person (or approximately $16,000 per household).

6.6.2 Employment

As well as generating short-term jobs related to the construction of the transmission line, CopperString 2.0 will also create significant medium term employment in the Queensland economy, monetising the additional resources stimulated under the NEM connected case will generate a significant number of short-term jobs related to the construction phase of CopperString 2.0. In addition to the direct jobs generated on-site, the construction and installation, and production phases will require significant quantities of Queensland sourced goods and services including mining, engineering and management services, machinery and cement during construction and mining, manufacturing and various business services during operation. Production of these inputs will further increase the demand for labour across the Queensland economy.

A key issue when estimating the impact of a project is determining how the labour market will clear.[37] As discussed in Section A.2, for this analysis, increases in the demand for labour in the North-West Queensland Region can be met by three mechanisms: increasing migration from the Rest of Queensland and Rest of 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 North-West Queensland Region while the third is a function of the additional labour demand relative to the BAU case. Given the moderate unemployment rate assumed throughout CopperString 2.0 period, changes in the real wage rate accounts for the majority of the additional labour supply in the policy scenarios relative to the BAU case.

It should be noted that this analysis does not assume any change in net foreign migration as a result of CopperString 2.0 between the NEM connected case and the BAU case.

Employment creation – North-West Queensland

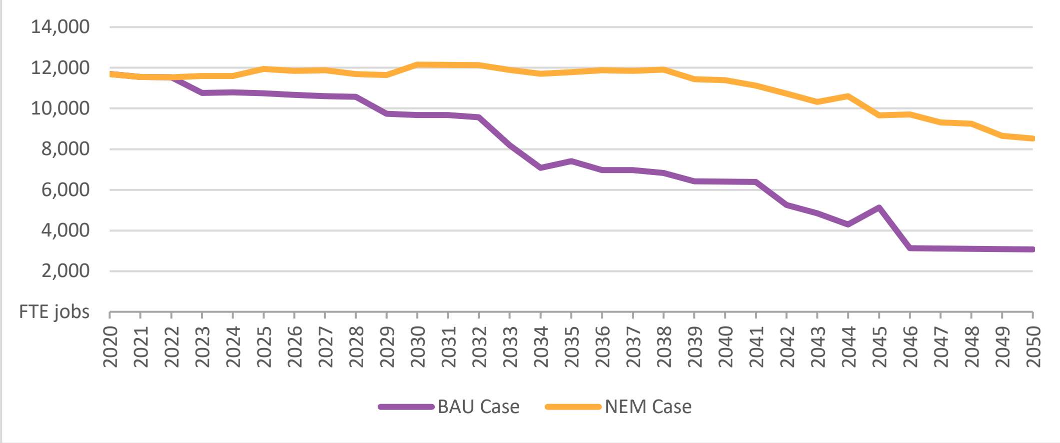
As per the projected changes in real economic output, the projected change in employment in North-West Queensland under the NEM connected case relative to the BAU case largely follows the change in mineral production (see Figure 6.7). The construction phase of the transmission line is projected to increase employment in North-West Queensland by 1,849 employee years between 2020–2024, with peak net employment of an additional 950 FTE jobs in 2024. As shown in Figure 6.6, under the NEM connected case, employment in North-West Queensland is projected to remain largely steady at around 12,000 FTE jobs through to 2040, compared to experiencing a gradual decline to approximately 6,400 FTE jobs under the BAU case.

All else equal, these projections highlight the potential significance of a major project like CopperString 2.0 in improving the economic viability of the resources present in the NWMP and maintaining the competitiveness of region in the future. This is in line with helping achieve the policy objectives in the

[37] 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.

Queensland Government's State Planning Policy, the North West Regional Plan 2010 and the North West Queensland Economic Diversification Strategy 2019.

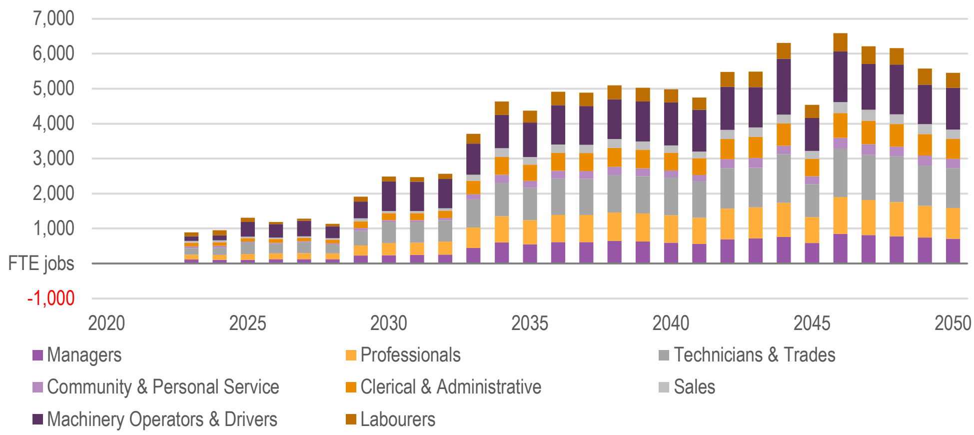
FIGURE 6.6 PROJECTED EMPLOYMENT IN NORTH-WEST QUEENSLAND



Note: All years are financial years ending June 30. FTE = full-time equivalent. Employment is based on place of work not place of residence.
SOURCE: ACIL ALLEN CONSULTING

A range of different skills will be impacted by the additional economic activity stimulated under the NEM connected case relative to the BAU case. Figure 6.7 shows the broad classifications and numbers of employees stimulated in North-West Queensland by CopperString 2.0 over its life. The data reflect the high proportion of technicians and trades workers, skilled machinery operators and drivers as well as professional personnel required to construct a project of this type. Other jobs are stimulated in response to consumer's consumption patterns and their higher incomes, relative to the BAU case.

FIGURE 6.7 PROJECTED ADDITIONAL NORTH-WEST QUEENSLAND EMPLOYMENT BY OCCUPATION, NEM CONNECTED CASE RELATIVE TO BAU CASE (FULL-TIME EQUIVALENT JOBS)



Note: FTE = full-time equivalent.
SOURCE: ACIL ALLEN CONSULTING

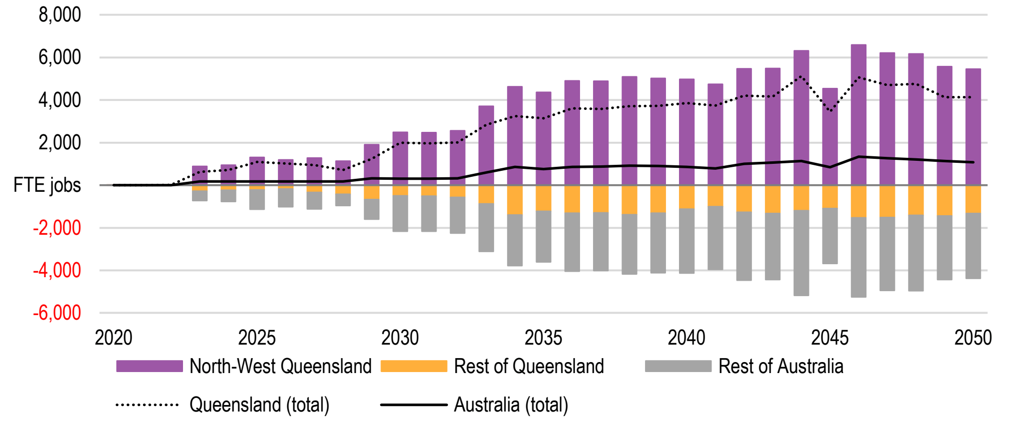
Employment creation by region

Over the modelled life of CopperString 2.0 to 2050, it is projected that around 19,834 employee years of full time equivalent direct and indirect jobs will be created nationally (annual average of 640 FTE jobs). More specifically, it is projected that CopperString 2.0 will increase employment in:

— North-West Queensland by 110,395 employee years (average annual increase of 3,561 FTE jobs)
— Queensland as a whole by 83,539 employee years (average annual increase of 2,695 FTE jobs)
— Australia as a whole by 19,834 employee years (average annual increase of 640 FTE jobs).

As illustrated in Figure 6.8, the total additional employment from about 2034 is projected to be broadly constant throughout the projection period at approximately 1,000 FTE jobs, but will experience some variation by region year to year.

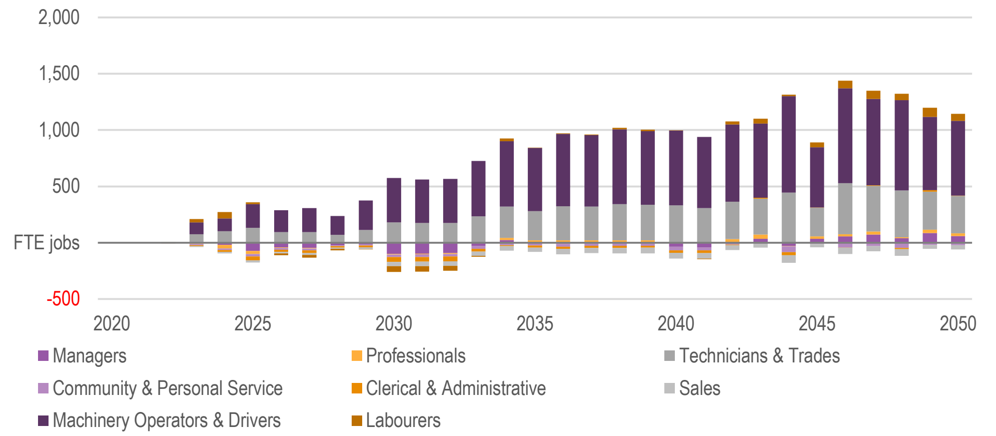
FIGURE 6.8 PROJECTED CHANGE IN EMPLOYMENT BY REGION, NEM CONNECTED CASE RELATIVE TO BAU CASE (FULL TIME EQUIVALENT JOBS)



Note: All years are financial years ending June 30. FTE = full-time equivalent.
SOURCE: ACIL ALLEN CONSULTING

Figure 6.9 presents the net change in Australian employment by occupation. As shown the main occupations that are projected to be affected are within the Technicians and Trades, and the Machinery Operators and Drivers categories. In net terms other occupations are largely being moved between regions.

FIGURE 6.9 PROJECTED ADDITIONAL AUSTRALIAN EMPLOYMENT BY OCCUPATION, NEM CONNECTED CASE RELATIVE TO BAU CASE (FULL-TIME EQUIVALENT JOBS)



Note: FTE = full-time equivalent.
SOURCE: ACIL ALLEN CONSULTING

6.6.3 Impacts on Townsville

While the modelling focussed on the region directly impacted by the construction or operation of CopperString 2.0, regions like Townsville are also expected to receive noticeable economic impacts from the project. As a significant urban centre and as the primary connection point of the NWMP to the rest of the world, the Townsville economy is likely to be a source of workers and goods and services required for not only the construction and operation of CopperString 2.0, but also for the construction and operation of the additional electricity generation in North-West Queensland as well as the additional mining activity.

The Port of Townsville will be one of the major beneficiaries through the import of various construction materials as well as through the export of bulk minerals, concentrates and metals. Under the NEM-connected case is projected that, on average between 2029–2050, there will be an additional 4.1 million tonnes of saleable minerals each year compared to the BAU case. Depending on the level of refining and absorption by domestic users, this could be exported as dry bulk, concentrates or refined metals. In terms of handling this volume, however, it is important to note that in the BAU case it is projected that the total mining activity is declining, and consequently, so will the total tonnage of mineral products handled by the Port of Townsville. Hence, under the NEM-connected case, the impact of CopperString 2.0 will be to maintain volumes going over the wharf at the Port of Townsville, or increase them by somewhere in the order of 1-3 million tonnes a year (depending on the level of refining undertaken prior to export). The Port of Townsville should be able to handle such an increase and has opportunities to expand activities and handle more tonnages if required.

Outside of the port, the general increase in mining activity in the NWMP under the NEM-connected case is likely to support the expansion or location of businesses in Townsville. This would be expected to benefit places like the new Lansdown Industrial Precinct.

6.7 Sensitivity analysis

6.7.1 Migration sensitivity analysis

This section analyses the sensitivity of the modelled impacts to an alternative future migration assumption. In particular, whilst labour is partially mobile through FIFO/DIDO[38], the sensitivity simulation prevents the migration of any additional people to Queensland under the NEM connected case relative to the BAU case. As per the analysis above, there is assumed to be no change in net international migration between the NEM connected and BAU cases.

The results are presented in Table 6.4.

TABLE 6.4 MIGRATION SENSITIVITY ANALYSIS – MACROECONOMIC IMPACTS (NEM-CONNECTED CASE RELATIVE TO THE BAU CASE)

	Real economic output (total 2020-2050)		Real income (total 2020-2050)		Employment (average 2020-2050)	
	No interstate migration	With interstate migration	No interstate migration	With interstate migration	No interstate migration	With interstate migration
	2020 A$m	2020 A$m	2020 A$m	2020 A$m	FTE jobs	FTE jobs
North-West Queensland	142,614	142,587	17,441	17,435	3,561	3,561
Rest of Queensland	–8,479	–3,131	31,935	36,891	–2,030	–866
Total Queensland	**134,135**	**139,455**	**49,376**	**54,326**	**1,531**	**2,695**
Rest of Australia	–2,742	–7,661	28,624	24,033	–910	–2,055
Total Australia	**131,393**	**131,794**	**78,000**	**78,359**	**621**	**640**

SOURCE: ACIL ALLEN CONSULTING

These results show that, while the national projected changes are relatively minor, there are some significant changes at the state level. In particular, under the no additional interstate migration

[38] FIFO/DIDO = fly in fly out/drive in drive out

assumption, over the period to 2050, the difference between the NEM connected case and the BAU case, it is projected that:

— Queensland total change in real GSP is approximately 4 per cent lower
— Queensland total change in real income is approximately 9 per cent lower
— Queensland total change in employment is approximately 43 per cent lower.

Consequently, allowing additional interstate migration as a result of the additional economic activity stimulated by CopperString 2.0 only has a small effect on total additional economic output, but does have a noticeable effect on the projected total number of additional Queensland-based jobs. This is primarily driven by the employment stimulated by consumers spending the additional income generated by CopperString 2.0 being either in Queensland or in the rest of Australia. Importantly, the annual aggregate Queensland employment impacts, whilst noticeably lower, are still projected to be positive throughout the projection period (see Figure 6.10).

FIGURE 6.10 CHANGE IN QUEENSLAND MACROECONOMIC OUTCOMES UNDER DIFFERENT INTERSTATE MIGRATION ASSUMPTIONS, NEM CONNECTED CASE RELATIVE TO BAU CASE

SOURCE: ACIL ALLEN CONSULTING

6.7.2 Labour market sensitivity analysis

As discussed in section 6.6.2, the projected economic impacts between the NEM Connected Case and the BAU case are constrained by the assumed availability of labour. In particular, the availability of labour has been tightly constrained meaning that increases in labour demand generated by CopperString 2.0 are primarily met by a movement of jobs around the nation rather than an increase in hours worked or through a decrease in the unemployment rates. This section analyses the sensitivity of the modelled impacts of relaxing the labour market constraints and allowing the supply of labour (at the BAU case wage rates) is fully responsive to demand.

In the Unconstrained Scenario where it is assumed that there is an “unlimited” pool of labour available to meet any additional labour demand generated by CopperString 2.0 under the NEM connected case, relative to the BAU case. Note, that this does **not** mean that there is an infinite supply of labour, rather that all *additional* labour demands generated by CopperString 2.0 (at the BAU case wage rates) can be met without needing to crowd out employment from other industries or regions. Except for the availability of other factors of production, this assumption is the same as those obtained from using the upper level estimates from input-output employment multipliers.[39] We believe that the projections under the Unconstrained Case represent an upper bound on the projected economic impacts.

The results are presented in Table 6.5 and Table 6.6.

TABLE 6.5 LABOUR MARKET SENSITIVITY ANALYSIS – MACROECONOMIC IMPACTS

	Real economic output		Real income	
	Standard Tasman Global labour market (Policy case)	Unconstrained (Upper bound)	Standard Tasman Global labour market (Policy case)	Unconstrained (Upper bound)
	2018-19 A$m	2018-19 A$m	2018-19 A$m	2018-19 A$m
North West Queensland	142,587	142,940	17,435	18,505
Rest of Queensland	–3,131	27,970	36,891	67,405
Total Queensland	**139,455**	**170,910**	**54,326**	**85,910**
Rest of Australia	–7,661	29,851	24,033	61,964
Total Australia	**131,794**	**200,762**	**78,359**	**147,874**

SOURCE: ACIL ALLEN CONSULTING

TABLE 6.6 LABOUR MARKET SENSITIVITY ANALYSIS – EMPLOYMENT IMPACTS

	Standard Tasman Global labour market (Policy case)	Unconstrained (Upper bound)
	FTE jobs (average 2020-2050)	FTE jobs (average 2020-2050)
North West Queensland	3,561	3,675
Rest of Queensland	–866	5,792
Total Queensland	**2,695**	**9,468**
Rest of Australia	–2,055	6,700
Total Australia	**640**	**16,168**

SOURCE: ACIL ALLEN CONSULTING

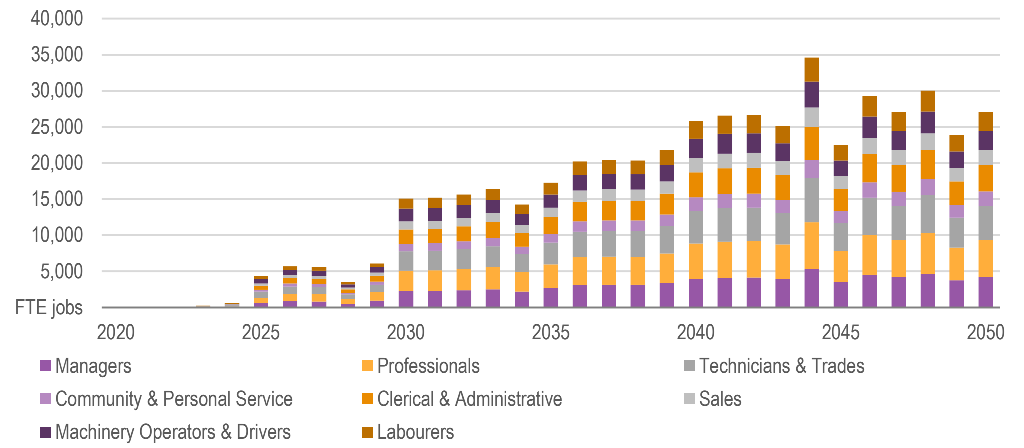
As presented in in Table 6.5 and Table 6.6, the greater availability of labour is projected to primarily benefit the regions that are indirectly benefitting from the additional economic activity generated in North West Queensland—namely, the Rest of Queensland and the Rest of Australia. The benefit of the unconstrained labour market assumption is greatest in the Rest of Australia as this is the region that is the least connected with the supply chain effects of CopperString 2.0 and the resultant mining activity, and is the largest source of labour relative to the BAU case. In aggregate, the impact on Queensland’s real GSP over the period to 2050 under the Unconstrained case is projected to be 23 per cent higher than the impact of the Policy case, while Australia’s real GDP is projected to be 52 per cent higher. Similarly, the impact on Queensland’s real income over the period is projected to be 58 per cent higher under the Unconstrained case than under the Policy case, while Australia’s real income is projected to be 89 per cent higher. Unsurprisingly, the employment impacts over the period are significantly higher without the constraints, with the annual average employment impacts

[39] More specifically, the Type 2A employment multipliers which include the direct, production induced and consumption induced effects.

associated with CopperString 2.0 across Queensland and Australia projected to be 9,468 FTE jobs and 16,168 FTE jobs, respectively.

Under the standard Tasman Global labour market assumptions, the main occupations that are projected to be affected are within the Technicians and Trades, and the Machinery Operators and Drivers categories as these are the jobs most directly required for producing the additional economic output (see Figure 6.9). In net terms, other occupations are largely being moved between regions. In contrast, under the Unconstrained Case, most of the additional employment stimulated by CopperString 2.0 occurs outside of the directly affected sectors and in sectors more associated with Australians spending their higher incomes, with a more even spread across various occupations (see Figure 6.11).

FIGURE 6.11 PROJECTED ADDITIONAL AUSTRALIAN EMPLOYMENT BY OCCUPATION, UNCONSTRAINED NEM CONNECTED CASE RELATIVE TO BAU CASE (FULL-TIME EQUIVALENT JOBS)



Note: FTE = full-time equivalent.

SOURCE: ACIL ALLEN CONSULTING

These results highlight the sensitivity of the projected impacts to the flexibility of the labour market in response to the jobs stimulated by CopperString 2.0. A key constraint to achieving the projected impacts under the Unconstrained labour market will be the availability of unemployed or underemployed workers with appropriate training around Australia to be placed into the relevant supply chains.

7 BENEFIT COST ANALYSIS

This chapter describes the methodology and results of the economic Cost Benefit Analysis (CBA) conducted for CopperString 2.0. It is an assessment of the economic costs and benefits to the CopperString 2.0 developer and operator, Queensland mining producers, and electricity sector, as a result of the development of CopperString 2.0.

Investment in the high voltage transmission line will affect the economy in various ways, notably by providing access to otherwise stranded renewable energy resources, by lowering the cost of energy in the NWMP, and by potentially enabling development to otherwise stranded mineral resources by providing access to more flexible and efficiently priced energy supply arrangements through connection to the NEM. As discussed in Chapter 6, CopperString 2.0 will create employment during the construction and operation phases. By providing access to more competitively priced energy sources, this new infrastructure can also act as a catalyst to an increased production of mineral resources that were not previously economically feasible.

The analysis in this chapter assesses the benefit-cost ratio (BCR) of the effect of CopperString 2.0 by comparing the BAU case in which CopperString 2.0 is not developed with the NEM connected case in which Mount Isa and the NWMP are connected to the NEM via CopperString 2.0.

In addition, the analysis in this chapter projects who would receive direct benefits or incur the costs in developing the transmission asset.

Generally, the direct costs of the transmission infrastructure development and operational costs will be borne primarily by the commercial investors and operators of CopperString 2.0. If it is part of the Queensland's NEM asset base (for example, as part of Powerlink), then the owners and operators of the NEM asset would incur them. Similarly, the direct monetary benefits will also accrue mostly to the commercial operators of transmission infrastructure if it is a private asset.

As discussed in Chapter 5, CopperString 2.0 could also be expected to deliver benefits to the economy by changing the real cost of electricity production in the NWMP.

Based on the mining production activity analysis undertaken (provided in Chapter 4), customers in the region benefit in the form of lower electricity prices and induced additional production from improved competitiveness of the mineral extraction and production.

There would also be a range of indirect benefits and costs as a result of the transmission line development. The indirect impacts are considered in the previous chapter using CGE modelling. For example, the additional output and employment generated by the CopperString 2.0 project would have an impact on GSP and real incomes. Similarly, governments would benefit from higher tax revenues generated by these additional economic activities.

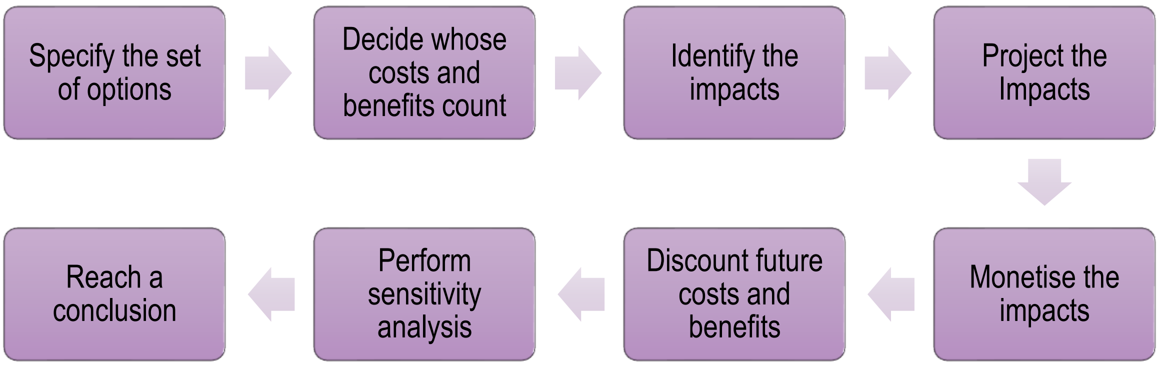
In calculating the costs and benefits, the financial modelling presented to Treasury has been used for the CopperString 2.0 asset itself. For consistency, this data has been modelled over the same period as the financial model (namely, to 2064). All other information is from the modelling used elsewhere in this report which was only conducted through to 2050. The effect of the different end dates on the calculated BCRs is small.

7.1 Assessment methodology

A CBA is an economic approach used to judge the economic merits of a proposed project. The anticipated future flows of costs and benefits of CopperString 2.0, over its operating life, are discounted to arrive at a 'present value' for each annual flow. By adding the present value of the future flows of costs and benefits, a net present value (NPV) is calculated for CopperString 2.0. The NPV is a dollar estimate of how much would be gained, or lost, by committing to, and commissioning the proposed project. A positive NPV means CopperString 2.0 has economic merit.

The broad approach used for the CBA is provided in Figure 7.1. This methodology is consistent with the Queensland Treasury's Guidelines on Project Assessment Framework.[40] Key steps are detailed below.

FIGURE 7.1 KEY STEPS IN OUR CBA APPROACH



SOURCE: ACIL ALLEN CONSULTING BASED COMMONWEALTH OF AUSTRALIA 206, COST-BENEFIT ANALYSIS GUIDANCE NOTE, P. 2.

7.2 Calculation of benefits

This section details the calculation of the five key sources of benefits, namely:

1. Value of CopperString 2.0 revenues (as per financial model to 2064)
2. Net efficiency benefits of electricity generation (principally associated with lower fuel and variable operating costs per unit of electricity generated), which are calculated after accounting for the value of CopperString 2.0 revenues (which is a cost to electricity customers)
3. Reduced emissions from electricity generation (but offset by changes in increased emissions from increased mining activity)
4. Additional electricity generation
5. Additional mineral production.

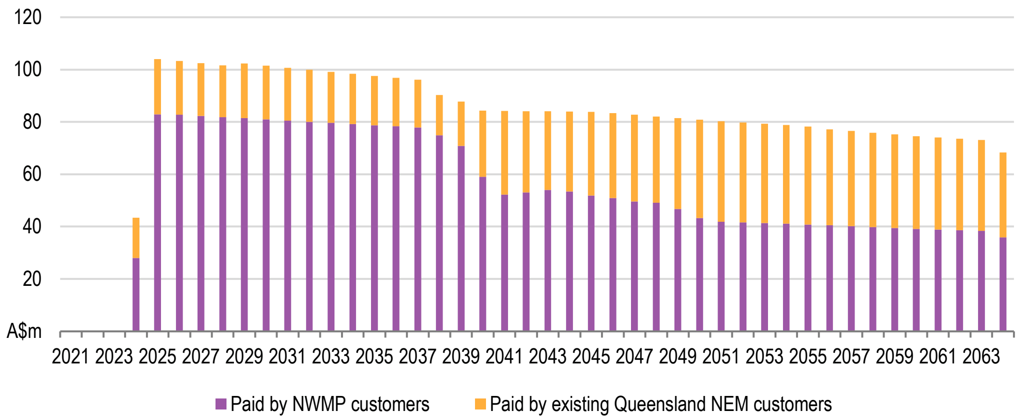
7.2.1 Project revenues

The transmission line will receive revenue from the services it supplies to the electricity network. In this analysis is assumed that the transmission line will be developed as a regulated asset rather than as a merchant asset. Revenue therefore, is expected to be calculated based on a regulated rate of return using a post-tax revenue model (PTRM) consistent with the guidelines set by the Australian Energy Regulator.

[40] https://s3.treasury.qld.gov.au/files/paf-cost-benefit-analysis.pdf

The implied revenue from the PTRM consistent with the capital and operating expenditures used in this report was provided to ACIL Allen by KPMG and are shown in Figure 7.2. On average, the estimated annual gross revenue over the 40-year operating life is $85.5 million in real terms or ($127 million in nominal terms) with total revenue estimated to be $3.5 billion in real terms. Of this revenue, two-thirds ($2.34 billion) is expected to be paid by customers in the NWMP while one-third ($1.17 billion) is expected to be paid by customers in the existing Queensland NEM region. The revenue split changes throughout the life of CopperString 2.0 as the extent of mining activity changes.

FIGURE 7.2 ANNUAL ESTIMATED REVENUE FOR COPPERSTRING 2.0 (REAL 2020 TERMS)

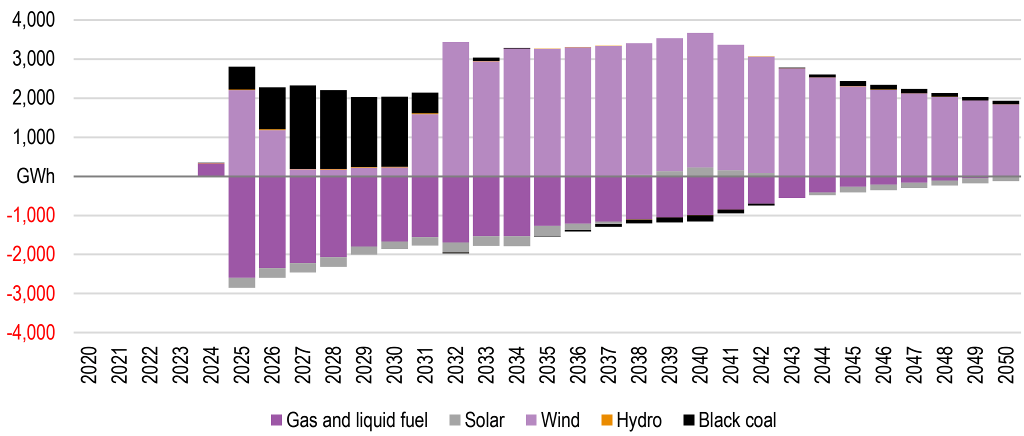


SOURCE: BASED ON KPMG'S FINANCIAL ANALYSIS

7.2.2 Net efficiency benefits of electricity generation

As discussed in Chapter 5, there are substantial changes in the mix of generator capacity and generator types throughout Queensland in the BAU case when compared with the NEM connected case (Figure 7.3). In particular, across the Queensland electricity network as a whole there is a reduction in the real cost of generating electricity (largely due to the reduction in volume of gas fired generation in the NWMP which is replaced with wind). This cost reduction frees up real resources (such as labour and fuels) that are available to be used elsewhere in the economy. It is essentially this reduction in the cost of generation that is passed onto consumers through lower electricity costs.

FIGURE 7.3 CHANGE IN TECHNOLOGIES IN NEM CONNECTED CASE RELATIVE TO BAU CASE

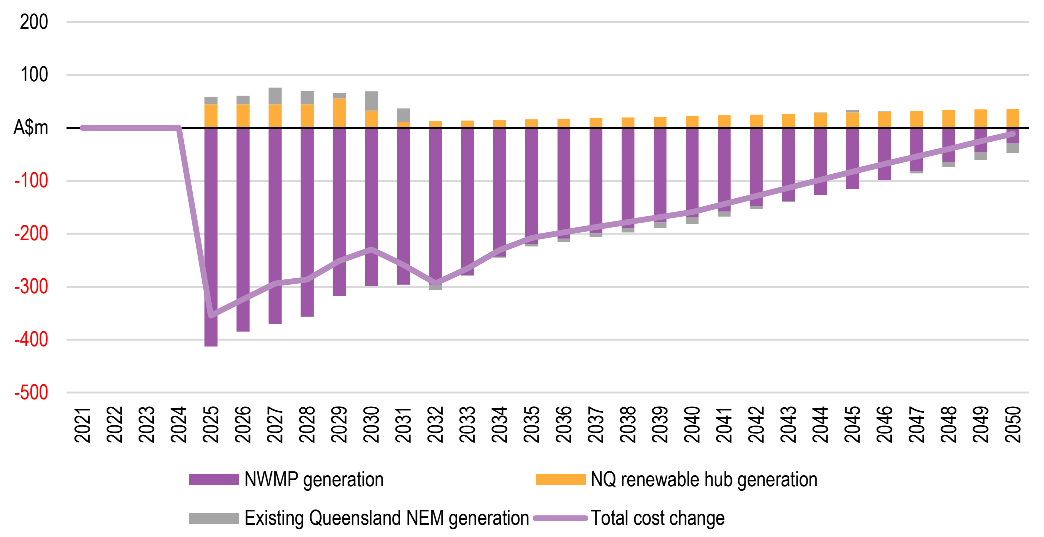


SOURCE: ACIL ALLEN ANALYSIS BASED ON CHAPTER 5 RESULTS

To avoid double counting and to measure just the net benefit to consumers, the efficiency benefits are calculated after the CopperString 2.0 transmission fees discussed in Section 7.2.1 above.

Figure 7.4 presents the change in electricity operating costs across the Queensland generation fleet, as well as for each of the three key regions, namely: the generation in the existing NWMP network, the generation in the existing Queensland region of the NEM, and the new generation built in the North Queensland Renewable Energy Hub. As can be seen, there is a substantial real cost reduction in generating electricity across Queensland as whole (cumulative reduction of $4.65 billion in real 2020 terms). This is driven by a $5.4 billion reduction in generation costs in the NWMP (primarily associated with lower gas fired generation in total), but offset by slightly higher costs of wind generation in the North Queensland Renewable Energy Hub ($734 million) and the existing Queensland NEM generators ($38 million).

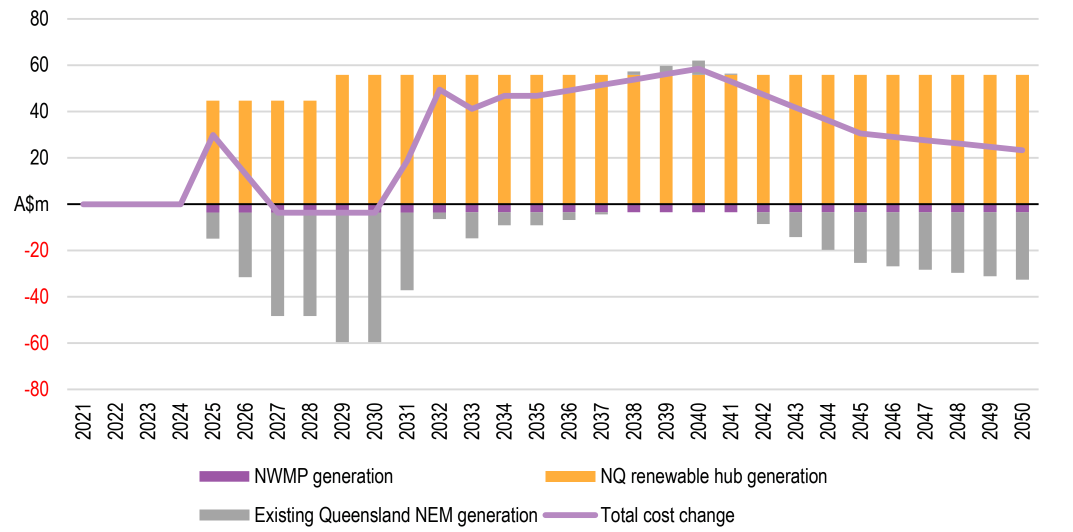
FIGURE 7.4 CHANGE IN ELECTRICITY GENERATION COSTS BY QUEENSLAND REGION (REAL 2020 TERMS, NEM CONNECTED CASE MINUS BAU CASE)



SOURCE: ACIL ALLEN ANALYSIS BASED ON CHAPTER 5 RESULTS

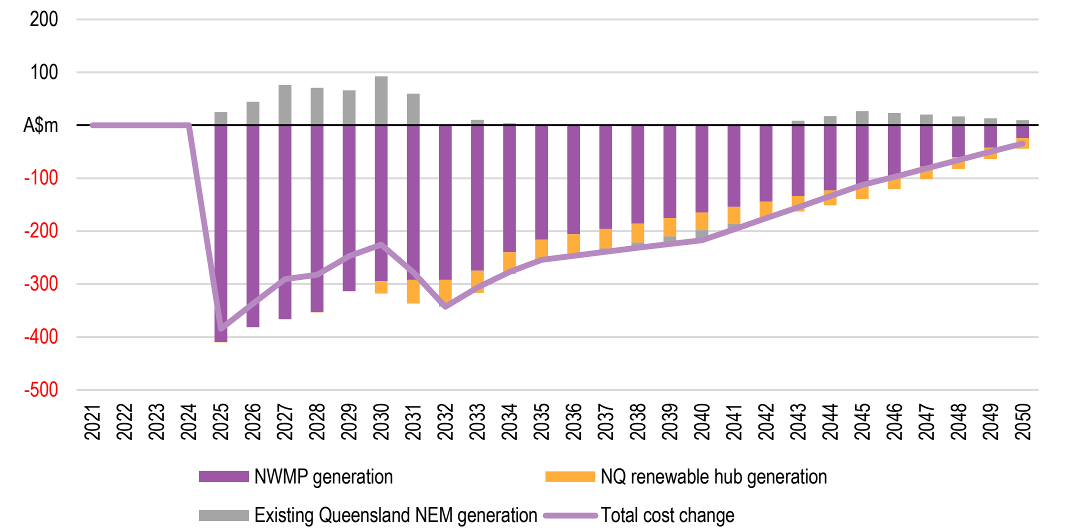
Figure 7.5 and Figure 7.6 break down the generation cost changes by fixed operating costs, and fuel and variable operating costs (including EIS receipts), respectively. When noting the scale differences of the graphs, this shows that the key driver of the cost reduction as a result of CopperString 2.0, are the savings in fuel and operating costs in the NWMP region.

FIGURE 7.5 CHANGE IN ELECTRICITY GENERATION FIXED OPERATING COSTS BY QUEENSLAND REGION (REAL 2020 TERMS, NEM CONNECTED CASE MINUS BAU CASE)



SOURCE: ACIL ALLEN ANALYSIS BASED ON CHAPTER 5 RESULTS

FIGURE 7.6 CHANGE IN ELECTRICITY GENERATION FUEL AND VARIABLE OPERATING COSTS BY QUEENSLAND REGION (REAL 2020 TERMS, NEM CONNECTED CASE MINUS BAU CASE)



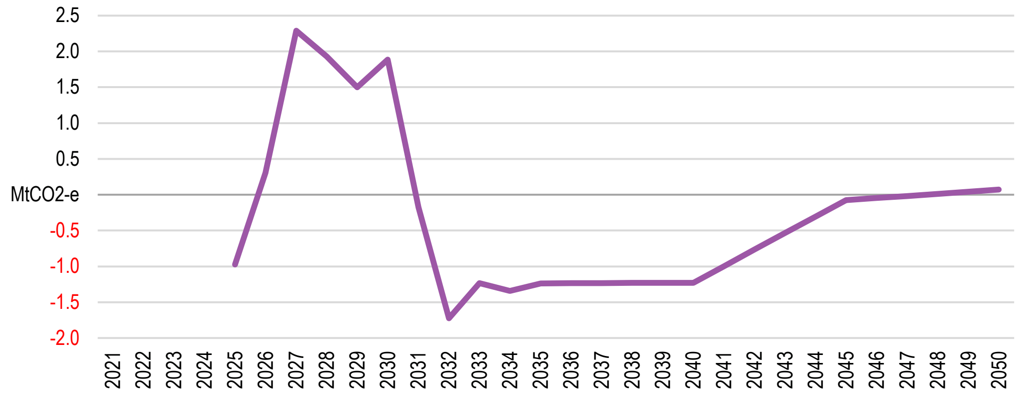
Note: Fuel and variable operating costs including EIS receipts. The negative net change in costs in the NQ Renewable Energy Hub reflects the fact that the value of the EIS receipts are greater than the fuel and variable operating costs of the additional wind generators.

SOURCE: ACIL ALLEN ANALYSIS BASED ON CHAPTER 5 RESULTS

7.2.3 Avoided emissions

The change in the generation technology mix as a result of CopperString 2.0 reduces the cumulative greenhouse gas emissions from Queensland power generation by about 7.3 Mt CO_2-e between 2020 and 2050 (Figure 7.7). This is mainly due to the substitution of wind farm generation for gas fired generation as discussed in Chapter 5. As can be seen, while greenhouse gas emissions from the Queensland electricity sector are projected to fall over the entire projection period, there is a temporary net rise in emissions in the period 2027–2031, followed by a net reduction over the period 2032–2045.

FIGURE 7.7 CHANGE IN ELECTRICITY COMBUSTION EMISSIONS IN NEM CONNECTED CASE RELATIVE TO BAU CASE, 2020 TO 2050

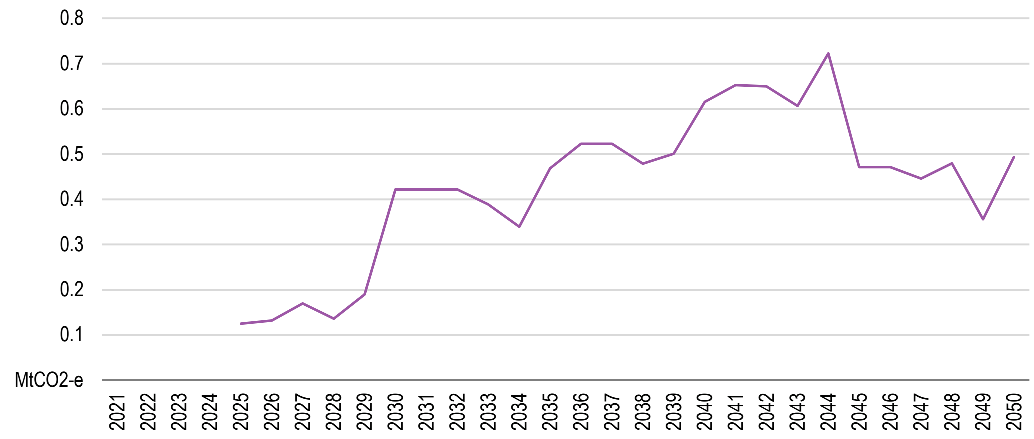


SOURCE: ACIL ALLEN ANALYSIS BASED ON CHAPTER 5 RESULTS

As discussed throughout this report, a key benefit of the CopperString 2.0 project is the stimulation of additional mining activity in the NWMP. Consequently, it is prudent to include an estimate of the cost of additional greenhouse gas emissions associated with the stimulated mining activity (excluding the emissions from power generation which are already accounted for above). Emissions from mining activities are highly variable and can differ significantly mine to mine and through time. For the purposes of this calculation the average cost share of diesel (3.5 per cent) in non-ferrous metals mining has been assumed to indicate the additional diesel required to extract the additional minerals presented in Figure 6.4. Combined with an assumed real cost of off-road diesel equal to 105 cents per litre, this calculation implies that an additional 4.1 million kilolitres will be combusted under the NEM connected case compared with the BAU case. Applying the Scope 1 emission factors from the Australian National Greenhouse Gas Inventory gives the estimated change in emissions (see Figure 7.8). In total, the cumulative additional emissions associated with diesel use by miners under the NEM connected case compared with the BAU case are approximately 11.2 MtCO_2-e between 2020 and 2050.

Thus, when taking into account the 7.3 Mt CO_2-e reduction in emissions from power generation, there is an overall net increase of 3.9 Mt CO_2-e in emissions.

FIGURE 7.8 CHANGE IN MINING SCOPE 1 COMBUSTION EMISSIONS IN NEM CONNECTED CASE RELATIVE TO BAU CASE, 2020 TO 2050

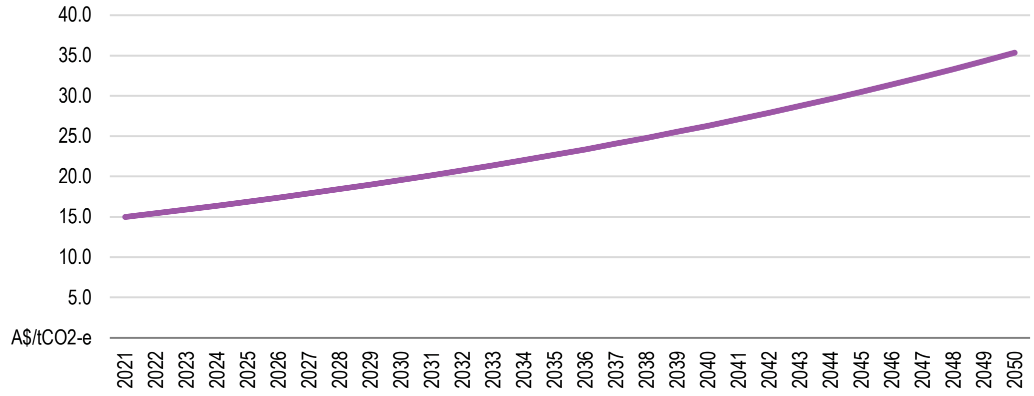


Note: Scope 1 emissions only.

SOURCE: ACIL ALLEN ESTIMATES

In the absence of a tangible price of greenhouse gas emissions, the social cost of greenhouse gases has been assumed to follow a price path starting at $15/tCO2-e in 2021 rising by 3 per cent a year in real terms (see Figure 7.9). This price is similar to the implied EIS price determined in *PowerMark* (see Figure 5.1) and is in the range of prices seen in major overseas emissions trading markets (such as in the European Union). Given the low relative magnitude of this line item, the impact of a different assumed social cost of emissions on the calculation of net benefits is small.

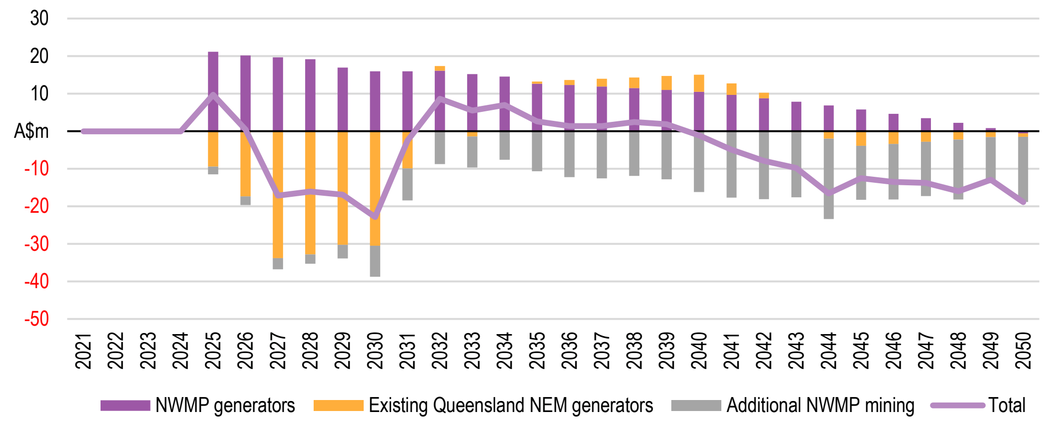
FIGURE 7.9 ASSUMED SOCIAL COST OF CARBON, 2020 TO 2050 (REAL 2020 TERMS)



SOURCE: BASED ON FIGURE 5.1

The net benefits of avoided emissions are summarised in Figure 7.10 and are estimated to have a cumulative undiscounted benefit of –$162 million (i.e. a cost). In total, the estimated undiscounted benefits of avoided emissions from electricity generation are projected to be approximately $58 million in real terms, while the estimated undiscounted benefit associated with emissions from the additional mining activity is –$295 million.

FIGURE 7.10 BENEFIT OF AVOIDED EMISSIONS IN NEM, 2020-2050 (REAL 2020 TERMS, NEM CONNECTED CASE RELATIVE TO BAU CASE)

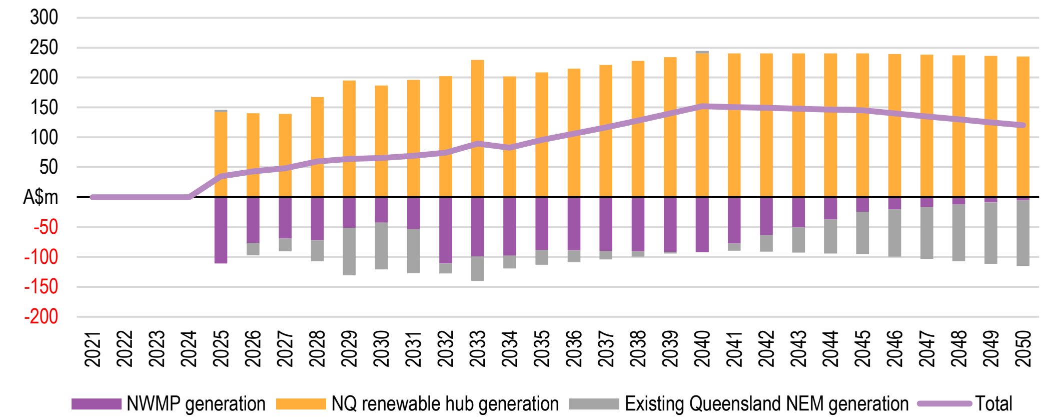


SOURCE: ACIL ALLEN ANALYSIS BASED ON CHAPTER 5 RESULTS

7.2.4 Additional electricity

In the NEM connected case, NWMP customers are projected to consume more electricity compared with the BAU case. Assuming that the value of retail electricity margins are unchanged, the value of the additional electricity (using the final prices under the NEM connected case) is $2.8 billion in real terms (Figure 7.11). Approximately $5.5 billion of this benefit is due to increased generation by generators in the North Queensland Renewable Energy hub, offset by a $1.6 and $1.1 billion fall in generation by generators in the NWMP region and the existing Queensland NEM region, respectively.

FIGURE 7.11 BENEFIT OF ADDITIONAL ELECTRICITY GENERATION IN QUEENSLAND, 2020-2050 (REAL 2020 TERMS, NEM CONNECTED CASE RELATIVE TO BAU CASE)



SOURCE: ACIL ALLEN ANALYSIS BASED ON CHAPTER 5 RESULTS

It is important to note that this benefit is part of the total electricity market benefits since the availability of the additional electricity for consumption is part of the suite of benefits that arise due to the investments in CopperString 2.0 and the additional electricity generators. However, when including the use of the additional electricity for the production of additional minerals (see section 7.2.5), it is not counted in the total project benefits (because the final additional product available for consumption becomes the additional minerals, not the additional electricity). That is, the additional electricity produced is value added into additional mineral products and including both would double count this element of the benefits.

7.2.5 Additional mineral production

As discussed in Chapter 4, mineral production under the NEM connected case is projected to increase compared with the BAU case due to the reduction in electricity prices improving the cut-off grades of mineral resources. In total, using current mineral prices, it is estimated that approximately $123 billion of additional minerals will be produced under the NEM connected case compared with the BAU case (see Figure 6.4). Two methods have been used to calculate this benefit. The first calculates the direct pre-royalty, pre-tax return to capital as a proportion of total anticipated revenues, while the second calculates an estimate of the additional consumer surplus associated with the additional electricity demand by miners using the 'rule of one-half' approach. This second approach was requested by Infrastructure Australia (IA) as an alternative methodology. It is a way of estimating the difference between what consumers are willing to pay for electricity and the price they are required to pay, and is often used for AEMO's regulatory investment tests. It is often used when information regarding what customers (in this case, the NWMP miners) do in the face of significant price changes is unknown – which is not the case in this study. The first method is more consistent with the approach used to calculate the efficiency improvement across the Queensland generation fleet and is more consistent with economic welfare analysis by estimating the pure additional value add benefit to the economy. Importantly, neither approach used includes any transfer of surplus between electricity consumers and producers.

As highlighted in Chapter 6, while there are significant productivity gains to be had across the Queensland generation fleet, the major benefit of CopperString 2.0 is associated with the large change in mineral production.

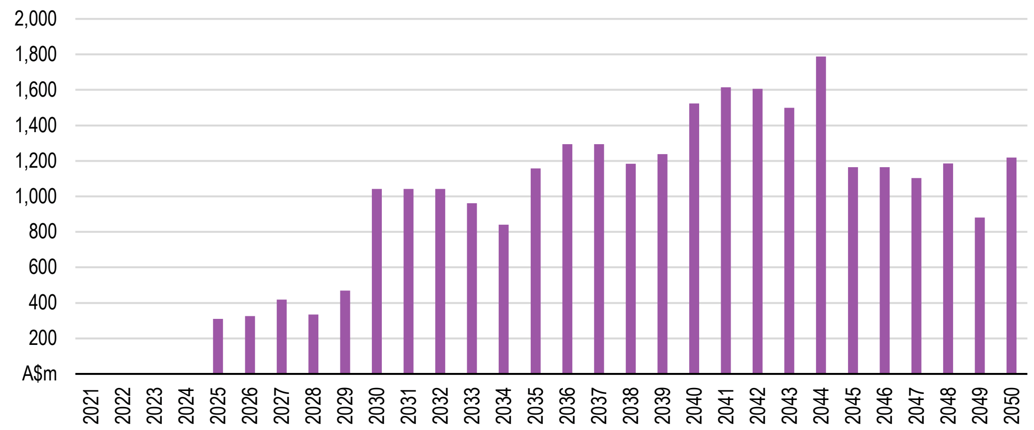
Method 1: Mining output less production costs

Based on ACIL Allen's CGE database, nonferrous metal ore mining in Queensland historically has had an average direct, pre-royalty, pre-tax return to capital (EBITDA[41]) equal to 22.4 per cent of revenues. Applying this percentage to the additional value of mineral production gives an implied additional gross operating surplus from mineral production of $27.7 billion with the annual benefit presented in Figure 7.12.

By only including the estimated direct, pre-royalty, pre-tax profit and not including the additional labour, real wages or value-added embodied in the supply chain, this is considered to be a conservative estimate of the benefits of the additional minerals production. The CGE analysis of the wider effects presented in Chapter 6 estimates the value of these effects (and others).

[41] Earnings before interest, tax, depreciation and amortisation. Note that royalties have been treated as a tax for the purposes of this calculation and the accounting treatment of royalties may differ.

FIGURE 7.12 BENEFIT OF ADDITIONAL MINERAL PRODUCTION IN NWMP, 2020-2050 (REAL 2020 TERMS, NEM CONNECTED CASE RELATIVE TO BAU CASE)



SOURCE: ACIL ALLEN ANALYSIS BASED ON CHAPTER 4 RESULTS

To include this estimated benefit into the benefit cost analysis, it is necessary to also estimate the capital costs that will be required to extract the additional minerals (thereby calculating the additional net benefit associated with the additional mineral production). Deriving reasonable estimates is complicated by the diversity of the minerals, deposits and that much of the additional production is expected to come from reprocessing existing tailings that would be likely to use many sunk capital assets.

At the time of this analysis, the expected capital investment required for the additional mineral production had not been estimated.

Method 2: Consumer surplus method

An alternative method is to calculate the consumer surplus using the 'rule of one-half' approach. Under this approach it is assumed that the demand for electricity by the miners is a linear demand curve, and that the additional consumer surplus (or post-tax return on capital) stimulated by the reduced electricity price is equal to the change in the electricity price multiplied by the additional amount of electricity used divided by two. This recognises that extracting the additional minerals has a negative consumer surplus (or negative post-tax return on capital compared to the cost of the capital) in the BAU case, but is positive with the lowered electricity prices under the NEM connected case.

The change in the value of the additional electricity consumed multiplied by the change in the price under the NEM connected case relative to the BAU case, is equal to $5,147 million over the period to 2050. Applying the rule of one-half, implies an additional consumer surplus of $2,574 million.

To this estimated consumer surplus needs to be added the additional royalties and company taxes that will be paid because of the additional mining activity. This will then provide the total benefit associated with the additional mineral production.

The estimated royalties payable to the Queensland Government from the additional mining activity has been estimated using current royalty rates[42] for each mineral and an assumed taxable value of 75 per cent of the value of production. While the average royalty rate payable differs year on year based on the relative amount of minerals mined (between 2.7 and 3.3 per cent), the estimated weighted average of royalties of the additional mining production revenues generated as a consequence of CopperString 2.0 over the period to 2050 equals 3.0 per cent. Based on the projected change in the value of production by mineral type, the total additional royalties payable to the Queensland Government is equal to $3.7 billion over the period to 2050.

[42] See https://www.business.qld.gov.au/industries/mining-energy-water/resources/minerals-coal/authorities-permits/payments/royalties/calculating/rates (accessed 1 July 2020).

Assuming an average effective tax rate of 22.5% (that is after accounting depreciation deductions), the implied additional company taxes paid by the additional mineral production activities will be $1.5 billion over the period to 2050 under the NEM connected case relative to the BAU case.

Adding the $2.6 billion consumer surplus, the $3.7 billion additional royalties, and the $1.5 billion additional company tax, implies that a total benefit of $7.8 billion associated with the additional mineral production over the period to 2050.

7.3 Calculation of costs

This section details the calculation of the two key sources of costs, namely:

1. The cost of building, operating and maintaining the CopperString transmission line
2. The cost of additional electricity generation

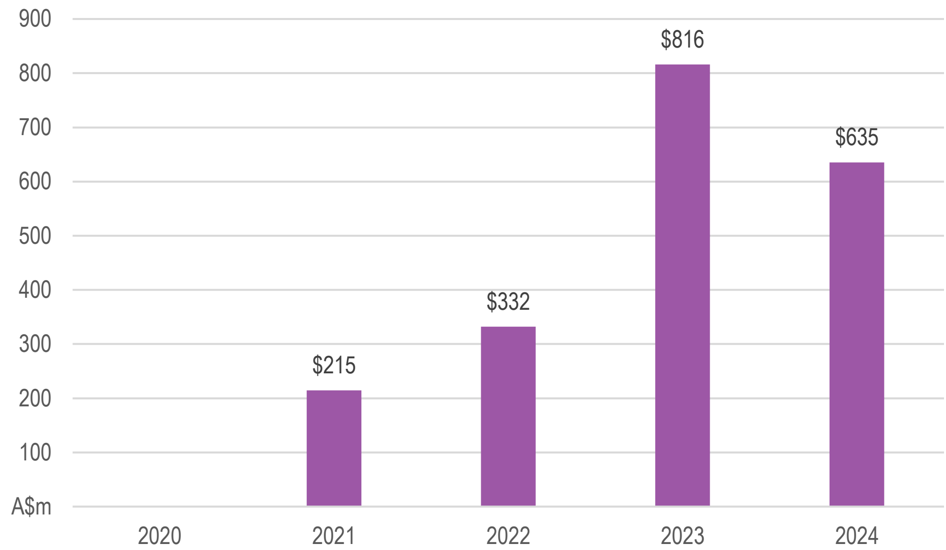
The cost of any additional mining capital has not been estimated. However, BCRs have been calculated with and without the additional mineral production which provide a floor to the estimated benefit-cost ratio.

7.3.1 Project construction and operating costs

Capital expenditure

The initial capital expenditure required to build the transmission line is estimated to be $1.998 million (in real 2020 terms), with the annual expenditure over the period to 2024 provided in Figure 7.13.

FIGURE 7.13 CAPITAL EXPENDITURE OF COPPERSTRING 2.0 BY YEAR (REAL 2020 TERMS)



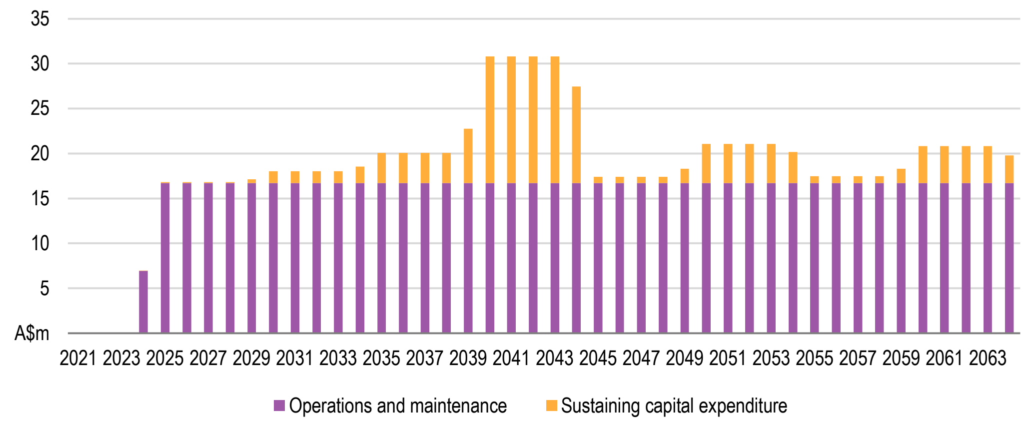
SOURCE: BASED ON KPMG'S FINANCIAL ANALYSIS

Operating and sustaining capital expenditure

Average operation and maintenance expenses are expected to be $16.7 million a year in real terms, with the total expenditure over the period to 2064 being $675 million (Figure 7.14). In addition, $144 million of sustaining capital expenditure is estimated to be required throughout the period to 2064.

The total undiscounted cost of CopperString 2.0 is therefore $2,817 million.

FIGURE 7.14 OPERATIONS AND SUSTAINING CAPITAL EXPENDITURE OF COPPERSTRING 2.0 BY YEAR (REAL 2020 TERMS,)



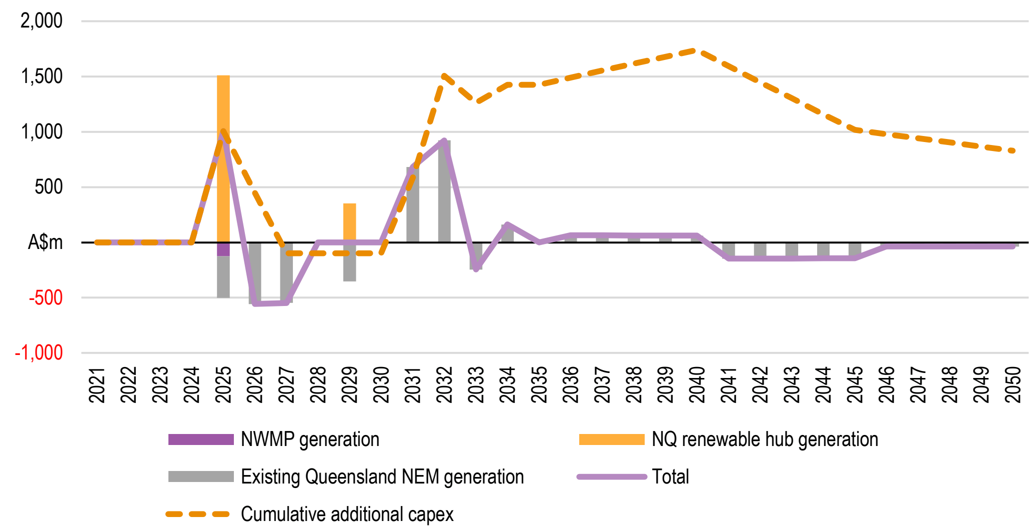
SOURCE: BASED ON KPMG'S FINANCIAL ANALYSIS

7.3.2 Additional electricity capital costs

As a result of connecting Mount Isa and the NWMP to the NEM and as a result of increasing the total mining activity in the region, there is a change in the timing and quantity investment in of new electricity generation capacity (as well as change in the location of new generation capacity between regions). As discussed in section 5.4.1, *PowerMark* has a new entrant model that determines on a commercial basis when and where additional generators enter the market. Included in this are detailed projections of the cost of generators by technology through time.

Over the period to 2050, it is estimated that an additional $829 million of capital expenditure will be required to supply the Queensland electricity market (Figure 7.15), with total expenditure in the North Queensland Renewable Energy hub increasing by $1,862 million offset by a $122 and $910 million fall in capital expenditure on new generators in the NWMP region and the existing Queensland NEM region, respectively.

FIGURE 7.15 CHANGE IN ELECTRICITY CAPITAL EXPENDITURE BY YEAR (REAL 2020 TERMS, NEM CONNECTED CASE RELATIVE TO BAU CASE)



SOURCE: BASED ON ACIL ALLEN DATA UNDERLYING CHAPTER 5

7.4 Benefit cost analysis results

Method 1: Mining output less production costs

A summary of the benefit cost analysis using Method 1 for estimating the benefits associated with the additional mineral production is provided in Table 7.1.

On the cost side the total project costs (excluding any additional capital expenditure associated with the expanded mining operations) are $3,646 million, with a net present value (using a 7 per cent real discount rate) of $2,632 million, comprising:

— Total project cost of $2,817 million (net present value = $1,976 million)
— Additional electricity generation capital cost of $829 million (net present value = $656 million).

On the benefit side the total project benefits are $35,695 million, with a net present value (using a 7 per cent real discount rate) of $11,935 million, comprising:

— Total project revenue of $3,506 million (net present value = $1,058 million)
— Net efficiency benefits of electricity generation $4,649 million (net present value = $2,161 million)
— Reduced greenhouse gas emissions benefit of –$162 million (net present value = –$48 million)
— Additional mining EBITDA of $27,702 million (net present value = $8,764 million).

The results show significant net benefits across all discount rates with high benefit cost ratios. In particular, the net benefit of the CopperString 2.0 project is estimated to be:

— $32.0 billion (undiscounted) with a BCR of 9.79
— $18.4 billion (3% real discount rate) with a BCR of 6.89
— $9.2 billion (7% real discount rate) with a BCR of 4.54
— $5.2 billion (10% real discount rate) with a BCR of 3.45.

TABLE 7.1 BENEFIT-COST ANALYSIS OF COPPERSTRING 2.0 – NEM-CONNECTED CASE RELATIVE TO BAU CASE (METHOD 1)

	Undiscounted	NPV 3%	NPV 7%	NPV 10%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
COST ITEMS				
A. Total project cost (CopperString 2.0)	**2,817.2**	**2,319.2**	**1,975.5**	**1,814.5**
– Initial capital and development costs	1,998.0	1,887.6	1,756.3	1,668.2
– Operating costs	674.9	359.6	187.4	127.9
– Ongoing capital expenditure	144.3	72.1	31.9	18.4
B. Additional electricity generation capital costs	**829.3**	**797.2**	**656.0**	**547.2**
– NWMP generation	–122.2	–109.2	–94.2	–84.6
– NQ Renewable Energy Hub generation	1,862.0	1,619.4	1,356.7	1,195.4
– Existing Queensland NEM generation	–910.5	–713.0	–606.5	–563.6
TOTAL PROJECT COSTS [Equals A+B]	**3,646.5**	**3,116.4**	**2,631.5**	**2,361.7**
BENEFIT ITEMS				
A. Project revenue (CopperString 2.0)	**3,506.8**	**1,944.4**	**1,058.3**	**739.6**
– Paid by NWMP customers	2,341.4	1,369.8	784.3	561.1
– Paid by existing Queensland NEM customers	1,165.4	574.6	274.0	178.5
B. Net efficiency benefits of electricity generation (total Queensland)	**4,648.7**	**3,261.8**	**2,160.6**	**1,646.8**
1. Fixed operating cost change	–839.8	–498.9	–266.7	–174.9
– NWMP generation	*92.6*	*58.4*	*34.6*	*24.7*
– NQ Renewable Energy Hub generation	*–1,407.7*	*–875.9*	*–508.4*	*–357.9*
– Existing Queensland NEM generation	*475.3*	*318.5*	*207.1*	*158.3*
2. Fuel and variable operating cost change	5,488.5	3,760.8	2,427.3	1,821.6
– NWMP generation	*5,328.2*	*3,738.0*	*2,483.5*	*1,899.5*
– NQ Renewable Energy Hub generation	*673.8*	*403.6*	*216.9*	*141.8*
– Existing Queensland NEM generation	*–513.5*	*–380.8*	*–273.1*	*–219.6*
C. Reduced emissions (social cost of GHG emissions)	**–162.0**	**–90.9**	**–48.0**	**–32.5**
– NWMP generation	*294.7*	*206.8*	*136.9*	*104.3*
– NQ Renewable Energy Hub generation	*0*	*0*	*0*	*0*
– Existing Queensland NEM generation	*–161.8*	*–129.7*	*–99.1*	*–82.0*
– Additional mining emissions	*–294.9*	*–168.0*	*–85.8*	*–54.8*
D. Additional electricity generation (valued at wholesale final prices)	**2,758.5**	**1,612.2**	**856.4**	**564.7**
– NWMP generation	*–1,647.4*	*–1,109.8*	*–698.1*	*–514.0*
– NQ Renewable Energy Hub generation	*5,537.4*	*3,377.0*	*1,908.4*	*1,318.6*
– Existing Queensland NEM generation	*–1,131.5*	*–655.0*	*–353.9*	*–239.9*
E. Change in NWMP mining EBITDA	**27,701.9**	**16,358.9**	**8,763.8**	**5,788.8**
TOTAL ELECTRICITY MARKET BENEFITS [Equals A+B+C+D]	**10,752.0**	**6,727.5**	**4,027.3**	**2,918.6**
QUEENSLAND ELECTRICITY MARKET BCR	**2.95**	**2.16**	**1.53**	**1.24**
TOTAL PROJECT BENEFITS [Equals A+B+C+E]	**35,695.3**	**21,474.3**	**11,934.7**	**8,142.7**
PROJECT BCR	**9.79**	**6.89**	**4.54**	**3.45**

Note: Total project cost and project revenue are calculated over full 40 year operational life. All other items calculated to 2050 only. Components may not sum to totals due to rounding. SOURCE: ACIL Allen

Method 2: Consumer surplus method

A summary of the benefit cost analysis used the consumer surplus method requested by IA is provided in Table 7.2. Using the alternative method only changes the estimation for the benefits associated with additional mineral production (component E in Table 7.2).

On the benefit side the total project benefits are $15,806 million, with a net present value (using a 7 per cent real discount rate) of $5,695 million, comprising:

- Total project revenue of $3,506 million (net present value = $1,058 million)
- Net efficiency benefits of electricity generation $4,649 million (net present value = $2,161 million)
- Reduced greenhouse gas emissions benefit of –$162 million (net present value = –$48 million)
- Additional mining gross surplus (including royalties) of $7,813 million (net present value = $2,524 million).

The results show significant net benefits across all discount rates with high benefit cost ratios. In particular, the net benefit of the CopperString 2.0 project is estimated to be:

- $12.2 billion (undiscounted) with a BCR of 4.33
- $6.6 billion (3% real discount rate) with a BCR of 3.13
- $3.1 billion (7% real discount rate) with a BCR of 2.16
- $1.7 billion (10% real discount rate) with a BCR of 1.71.

TABLE 7.2 BENEFIT-COST ANALYSIS OF COPPERSTRING 2.0 – NEM-CONNECTED CASE RELATIVE TO BAU CASE (METHOD 2: CONSUMER SURPLUS METHOD)

	Undiscounted	NPV 3%	NPV 7%	NPV 10%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
COST ITEMS				
A. Total project cost (CopperString 2.0)	**2,817.2**	**2,319.2**	**1,975.5**	**1,814.5**
B. Additional electricity generation capital costs	**829.3**	**797.2**	**656.0**	**547.2**
TOTAL PROJECT COSTS [Equals A+B]	**3,646.5**	**3,116.4**	**2,631.5**	**2,361.7**
BENEFIT ITEMS				
A. Project revenue (CopperString 2.0)	**3,506.8**	**1,944.4**	**1,058.3**	**739.6**
B. Net efficiency benefits of electricity generation (total Queensland)	**4,648.7**	**3,261.8**	**2,160.6**	**1,646.8**
1. Fixed operating cost change	–839.8	–498.9	–266.7	–174.9
2. Fuel and variable operating cost change	5,488.5	3,760.8	2,427.3	1,821.6
C. Reduced emissions (social cost of GHG emissions)	**–162.0**	**–90.9**	**–48.0**	**–32.5**
D. Additional electricity generation (valued at wholesale final prices)	**2,758.5**	**1,612.2**	**856.4**	**564.7**
E. Change in NWMP mining gross surplus (including royalties)	**7,812.5**	**4,644.7**	**2,524.1**	**1,690.9**
TOTAL ELECTRICITY MARKET BENEFITS [Equals A+B+C+D]	**10,752.0**	**6,727.5**	**4,027.3**	**2,918.6**
QUEENSLAND ELECTRICITY MARKET BCR	**2.95**	**2.16**	**1.53**	**1.24**
TOTAL PROJECT BENEFITS [Equals A+B+C+E]	**15,806.0**	**9,760.1**	**5,695.0**	**4,044.8**
PROJECT BCR	**4.33**	**3.13**	**2.16**	**1.71**

Note: Total project cost and project revenue are calculated over full 40 year operational life. All other items calculated to 2050 only. Components may not sum to totals due to rounding.
SOURCE: ACIL Allen

As can be seen, under both estimation methods, the projected increase in mining output is a significant driver of the total projected net benefits, representing around 50-70 per cent of the total benefits generated by CopperString 2.0. While care has been taken in providing realistic estimates of the potential change in mining activity that could result from the reduction in electricity prices in the NWMP region, there is still a large amount of uncertainty surrounding these estimates. Consequently, section 7.6 provides a floor to the estimated BCR by removing this effect.

7.4.2 Queensland electricity market BCR

Ring-fencing the project costs and benefits to just the electricity market effects (that is, excluding the additional mining benefits but including the value of the additional electricity generated). Then the total electricity market benefits are $10,752 million, with a net present value (using a 7 per cent real discount rate) of $4,027 million, comprising:

— Total project revenue of $3,506 million (net present value = $1,058 million)
— Net efficiency benefits of electricity generation $4,649 million (net present value = $2,161 million)
— Reduced greenhouse gas emissions benefit of –$162 million (net present value = –$48 million)
— Additional electricity generation of $2,758 million (net present value = $856 million).

As with the total project benefits, the net benefits associated with the Queensland electricity market are still positive across all real discount rates. In particular, the net benefit on the Queensland electricity market of the CopperString 2.0 project is estimated to be:

— $7.1 billion (undiscounted) with a BCR of 2.95
— $3.6 billion (3% real discount rate) with a BCR of 2.16
— $1.4 billion (7% real discount rate) with a BCR of 1.53
— $0.6 billion (10% real discount rate) with a BCR of 1.24.

7.5 BCR sensitivity to 10% change in cost and benefit components

7.5.1 Additional mineral production benefit: Method 1

Table 7.5 presents the sensitivity of the BCR to changes in each cost and benefit item in Table 7.1. Specially, it shows the change in the estimated BCR if the year on year costs and benefits change by ±10 per cent.

In terms of the numerator, changing the total benefits by ±10 per cent simply results in the calculated BCR changing by ±10 per cent. In terms of the denominator in the benefit-cost ratio, however, changing the costs by +10 per cent changed the calculated BCR by –9.09 per cent[43], while changing the costs by –10% increases the calculated BCR by +11.11 per cent[44].

To help interpret the information in Table 7.5, if total benefits and total cost change by a uniform ±10 per cent in each year, then the calculated BCR (discounted or undiscounted) will not change (as shown in the last row of the table). In terms of the sensitivity of the calculated BCR to the individual costs and benefits, if, for example, the project revenue (CopperString 2.0) increased by +10 per cent while all other line items remained unchanged, then the calculated BCR would increase by +0.98 per cent on an undiscounted basis (i.e. from 9.79 to 9.89), while the BCR with a 7 per real discount rate would change by +0.89 per cent (from 4.54 to 4.58).

Similarly, if the initial capital and development cost of building CopperString 2.0 increased by 10 per cent while all other line items remain unchanged, then the calculated BCR would change by –5.19% on an undiscounted basis (i.e. from 9.79 to 9.28), while the BCR with a 7 per real discount rate would change by –6.26 per cent (from 4.54 to 4.25).

As can be seen, the BCR is most sensitive to the benefits associated with the change in NWMP mining EBITDA (with a ±10 per cent change in this item leading to a ±7.76 per cent change in the calculated undiscounted BCR), and least sensitive to the estimated benefit of reduced emissions.

[43] That is, increasing the costs by 10% would change the BCR by [1/1.10 – 1] = –9.0909%.
[44] That is, decreasing the costs by 10% would change the BCR by [1/0.9 – 1] = 11.1111%.

TABLE 7.3 SENSITIVITY OF BENEFIT-COST RATIO TO ±10 PER CENT CHANGE IN EACH LINE ITEM – NEM CONNECTED CASE RELATIVE TO BAU CASE (METHOD 1)

	Undiscounted	NPV 3%	NPV 7%	NPV 10%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
COST ITEMS				
A. Total project cost (CopperString 2.0)	–7.17% / 8.37%	–6.93% / 8.04%	–6.98% / 8.12%	–7.13% / 8.32%
– Initial capital and development costs	–5.19% / 5.80%	–5.71% / 6.45%	–6.26% / 7.15%	–6.60% / 7.60%
– Operating costs	–1.82% / 1.89%	–1.14% / 1.17%	–0.71% / 0.72%	–0.54% / 0.54%
– Ongoing capital expenditure	–0.39% / 0.40%	–0.23% / 0.23%	–0.12% / 0.12%	–0.08% / 0.08%
B. Additional electricity generation capital costs	–2.22% / 2.33%	–2.49% / 2.63%	–2.43% / 2.56%	–2.26% / 2.37%
– NWMP generation	0.34% / –0.33%	0.35% / –0.35%	0.36% / –0.36%	0.36% / –0.36%
– NQ Renewable Energy Hub generation	–4.86% / 5.38%	–4.94% / 5.48%	–4.90% / 5.44%	–4.82% / 5.33%
– Existing Queensland NEM generation	2.56% / –2.44%	2.34% / –2.24%	2.36% / –2.25%	2.44% / –2.33%
TOTAL PROJECT COSTS [Equals A+B]	**–9.09% / 11.11%**	**–9.09% / 11.11%**	**–9.09% / 11.11%**	**–9.09% / 11.11%**
BENEFIT ITEMS				
A. Project revenue (CopperString 2.0)	**±0.98%**	**±0.91%**	**±0.89%**	**±0.91%**
– Paid by NWMP customers	±0.66%	±0.64%	±0.66%	±0.69%
– Paid by existing Queensland NEM customers	±0.33%	±0.27%	±0.23%	±0.22%
B. Efficiency benefits of electricity generation (total Queensland)	**±1.30%**	**±1.52%**	**±1.81%**	**±2.02%**
1. Fixed operating cost change	±-0.24%	±-0.23%	±–0.22%	±–0.21%
– *NWMP generation*	±0.03%	±0.03%	±0.03%	±0.03%
– *NQ Renewable Energy Hub generation*	±–0.39%	±–0.41%	±–0.43%	±–0.44%
– *Existing Queensland NEM generation*	±0.13%	±0.15%	±0.17%	±0.19%
2. Fuel and variable operating cost change	±1.54%	±1.75%	±2.03%	±2.24%
– *NWMP generation*	±1.49%	±1.74%	±2.08%	±2.33%
– *NQ Renewable Energy Hub generation*	±0.19%	±0.19%	±0.18%	±0.17%
– *Existing Queensland NEM generation*	±–0.14%	±–0.18%	±–0.23%	±–0.27%
C. Reduced emissions (social cost of GHG emissions)	**±–0.05%**	**±–0.04%**	**±–0.04%**	**±–0.04%**
– *NWMP generation*	±0.08%	±0.10%	±0.11%	±0.13%
– *NQ Renewable Energy Hub generation*	±0.00%	±0.00%	±0.00%	±0.00%
– *Existing Queensland NEM generation*	±–0.05%	±–0.06%	±–0.08%	±–0.10%
– *Additional mining emissions*	±–0.08%	±–0.08%	±–0.07%	±–0.07%
D. Additional electricity generation (valued at final wholesale prices)	**±0.77%**	**±0.75%**	**±0.72%**	**±0.69%**
– *NWMP generation*	±–0.46%	±–0.52%	±–0.58%	±–0.63%
– *NQ Renewable Energy Hub generation*	±1.55%	±1.57%	±1.60%	±1.62%
– *Existing Queensland NEM generation*	±–0.32%	±–0.31%	±–0.30%	±–0.29%
E. Change in NWMP mining EBITDA	**±7.76%**	**±7.62%**	**±7.34%**	**±7.11%**
TOTAL PROJECT BENEFITS [Equals A+B+C+E]	**±10.00%**	**±10.00%**	**±10.00%**	**±10.00%**
PROJECT BCR	**±0.00%**	**±0.00%**	**±0.00%**	**±0.00%**

SOURCE: ACIL ALLEN

7.5.2 Additional mineral production benefit: Method 2

Table 7.4 presents the sensitivity of the BCR to changes in each cost and benefit item in Table 7.2. Specially, it shows the change in the estimated BCR if the year on year costs and benefits change by ±10 per cent.

In terms of the numerator, changing the total benefits by ±10 per cent simply results in the calculated BCR changing by ±10 per cent. In terms of the denominator in the benefit-cost ratio, however, changing the costs by +10 per cent changed the calculated BCR by –9.09 per cent[45], while changing the costs by –10% increases the calculated BCR by +11.11 per cent[46].

To help interpret the information in Table 7.4, if total benefits and total cost change by a uniform ±10 per cent in each year, then the calculated BCR (discounted or undiscounted) will not change (as shown in the last row of the table). In terms of the sensitivity of the calculated BCR to the individual costs and benefits, if, for example, the project revenue (CopperString 2.0) increased by +10 per cent while all other line items remained unchanged, then the calculated BCR would increase by +2.22 per cent on an undiscounted basis (i.e. from 4.33 to 4.43), while the BCR with a 7 per real discount rate would change by +1.86 per cent (from 2.16 to 2.20).

Similarly, if the initial capital and development cost of building CopperString 2.0 increased by 10 per cent while all other line items remain unchanged, then the calculated BCR would change by –5.19% on an undiscounted basis (i.e. from 4.33 to 4.11), while the BCR with a 7 per real discount rate would change by –6.26 per cent (from 2.16 to 2.03).

As can be seen, the BCR is most sensitive to the benefits associated with the change in NWMP mining surplus (with a ±10 per cent change in this item leading to a ±4.94 per cent change in the calculated undiscounted BCR), and least sensitive to the estimated benefit of reduced emissions.

TABLE 7.4 SENSITIVITY OF BENEFIT-COST RATIO TO ±10 PER CENT CHANGE IN EACH LINE ITEM – NEM CONNECTED CASE RELATIVE TO BAU CASE (METHOD 2)

	Undiscounted	NPV 3%	NPV 7%	NPV 10%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
COST ITEMS				
A. Total project cost (CopperString 2.0)	–7.17% / 8.37%	–6.93% / 8.04%	–6.98% / 8.12%	–7.13% / 8.32%
B. Additional electricity generation capital costs	–2.22% / 2.33%	–2.49% / 2.63%	–2.43% / 2.56%	–2.26% / 2.37%
TOTAL PROJECT COSTS [Equals A+B]	**–9.09% / 11.11%**	**–9.09% / 11.11%**	**–9.09% / 11.11%**	**–9.09% / 11.11%**
BENEFIT ITEMS				
A. Project revenue (CopperString 2.0)	**±2.22%**	**±1.99%**	**±1.86%**	**±1.83%**
B. Efficiency benefits of electricity generation (total Queensland)	**±2.94%**	**±3.34%**	**±3.79%**	**±4.07%**
1. Fixed operating cost change	***±–0.53%***	***±–0.51%***	***±–0.47%***	***±–0.43%***
2. Fuel and variable operating cost change	***±3.47%***	***±3.85%***	***±4.26%***	***±4.50%***
C. Reduced emissions (social cost of GHG emissions)	**±–0.10%**	**±–0.09%**	**±–0.08%**	**±–0.08%**
D. Additional electricity generation (valued at final wholesale prices)	**±1.75%**	**±1.65%**	**±1.50%**	**±1.40%**
E. Change in NWMP mining surplus	**±4.94%**	**±4.76%**	**±4.43%**	**±4.18%**
TOTAL PROJECT BENEFITS [Equals A+B+C+E]	**±10.00%**	**±10.00%**	**±10.00%**	**±10.00%**
PROJECT BCR	**±0.00%**	**±0.00%**	**±0.00%**	**±0.00%**

SOURCE: ACIL ALLEN

[45] That is, increasing the costs by 10% would change the BCR by [1/1.10 – 1] = –9.0909%.
[46] That is, decreasing the costs by 10% would change the BCR by [1/0.9 – 1] = 11.1111%.

7.6 Sensitivity: no change in mining production

As discussed above, a significant portion of the projected net benefits of the CopperString 2.0 project are due to the additional mining activity in the NWMP projected to be made economic by the large change in electricity prices in the region. This section provides a summary of the projected costs and benefits excluding this effect.

Two alternative mineral production profiles have been analysed: one where the mineral production in the NEM connected case is the same as the BAU case and one where the mineral production in the BAU case is the same as the NEM connected case.

In removing the benefit of the additional mining activity, it is also necessary to remove the additional electricity generation required to meet the additional loads along with the various electricity market effects associated with the changes in total production. Ideally a new *PowerMark* simulation would be undertaken to provide the estimated impacts. In the absence of such, however, a decomposition of the various effects has been undertaken assuming that the generation changes in the market without the additional loads are proportionate. A summary of the alternative benefit cost analyses is provided in Table 7.5 and Table 7.6.

Importantly, while these sensitivity analyses do not include the benefits of the additional electricity or mining production, the fundamental benefit of reducing the total cost of electricity generation throughout Queensland (and in NWMP specifically) is retained.

7.6.1 No change in mining production – BAU mining level

As per Table 7.5, on the cost side the total project costs are $2,739 million (net present value, using a 7 per cent real discount rate = $1,970 million) comprising:

— Total project cost of $2,817 million (net present value = $1,976 million)

— Change in electricity generation capital cost of –$77.9 million (net present value = –$5.1 million)[47].

On the benefit side the total project benefits are $7,753 million, with a net present value (using a 7 per cent real discount rate) of $3,059 million, comprising:

— Total project revenue of $3,506 million (net present value = $1,058 million)

— Net efficiency benefits[48] of electricity generation $4,187 million (net present value = $1,995 million)

— Reduced greenhouse gas emissions benefit of $58 million (net present value = $5 million).

Despite removing the major source of benefit, the results continue to show net benefits across all discount rates. In particular, the net benefit of the CopperString 2.0 project without additional mining production using the BAU mining level is estimated to be:

— $5.0 billion (undiscounted) with a BCR of 2.83

— $2.6 billion (3% real discount rate) with a BCR of 2.13

— $1.1 billion (7% real discount rate) with a BCR of 1.55

— $0.5 billion (10% real discount rate) with a BCR of 1.28.

[47] The reduction in electricity capital cost requirement is due to the technology mix changes in the NEM-Connected Case relative to the BAU Case to generate the same total amount of electricity.

[48] As per the calculation in Section 7.2.2, to avoid double counting and to measure just the net benefit to consumers, the efficiency benefits are calculated after the CopperString 2.0 transmission fees discussed in Section 7.2.1.

TABLE 7.5 SENSITIVITY ANAYLSIS – WITHOUT CHANGE IN MINING PRODUCTION OR ADDITIONAL ELECTRICITY GENERATION USING THE BAU MINING LEVEL (NEM CONNECTED CASE RELATIVE TO BAU CASE)

	Undiscounted	NPV 3%	NPV 7%	NPV 10%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
COST ITEMS				
A. Total project cost (CopperString 2.0)	**2,817.2**	**2,319.2**	**1,975.5**	**1,814.5**
– Initial capital and development costs	1,998.0	1,887.6	1,756.3	1,668.2
– Operating costs	674.9	359.6	187.4	127.9
– Ongoing capital expenditure	144.3	72.1	31.9	18.4
B. Additional electricity generation capital costs	**–77.9**	**8.2**	**–5.1**	**–35.3**
– NWMP generation	–122.2	–109.2	–94.2	–84.6
– NQ Renewable Energy Hub generation	954.7	830.4	695.7	613.0
– Existing Queensland NEM generation	–910.5	–713.0	–606.5	–563.6
TOTAL PROJECT COSTS [Equals A+B]	**2,739.3**	**2,327.4**	**1,970.5**	**1,779.2**
BENEFIT ITEMS				
A. Project revenue (CopperString 2.0)	**3,506.8**	**1,944.4**	**1,058.3**	**739.6**
– Paid by NWMP customers	*2,341.4*	*1,369.8*	*784.3*	*561.1*
– Paid by existing Queensland NEM customers	*1,165.4*	*574.6*	*274.0*	*178.5*
B. Net efficiency benefits of electricity generation (total Queensland)	**4,187.5**	**2,974.8**	**1,995.2**	**1,531.7**
1. Fixed operating cost change	**–818.4**	**–486.6**	**–260.4**	**–170.9**
– NWMP generation	*91.8*	*58.0*	*34.4*	*24.6*
– NQ Renewable Energy Hub generation	*–1,394.7*	*–949.5*	*–619.2*	*–474.4*
– Existing Queensland NEM generation	*484.4*	*324.3*	*210.6*	*160.9*
2. Fuel and variable operating cost change	**5,005.9**	**3,461.4**	**2,255.6**	**1,702.7**
– NWMP generation	*5,151.7*	*3,629.4*	*2,424.2*	*1,860.7*
– NQ Renewable Energy Hub generation	*638.5*	*382.2*	*205.4*	*134.3*
– Existing Queensland NEM generation	*–784.3*	*–550.2*	*–374.0*	*–292.4*
C. Reduced emissions (social cost of GHG emissions)	**58.4**	**26.5**	**5.1**	**–2.3**
– NWMP generation	*284.4*	*200.4*	*133.4*	*102.0*
– NQ Renewable Energy Hub generation	*0*	*0*	*0*	*0*
– Existing Queensland NEM generation	*–226.0*	*–173.9*	*–128.3*	*–104.3*
TOTAL PROJECT BENEFITS [Equals A+B+C]	**7,752.7**	**4,945.8**	**3,058.6**	**2,269.0**
PROJECT NET BENEFIT	**5,013.4**	**2,618.3**	**1,088.1**	**489.8**
PROJECT BCR	**2.83**	**2.13**	**1.55**	**1.28**

Notes: Total project cost and project revenue are calculated over full 40-year operational life. All other items calculated to 2050 only. Electricity generation benefits were not calculated from alternative *PowerMark* simulation without additional load. Rather, they are indicative estimates only calculated on the basis of proportionate changes in costs per unit of generation assuming that total electricity consumption across Queensland is unchanged.

SOURCE: ACIL ALLEN

7.6.2 No change in mining production – NEM connected mining level

As per Table 7.6, on the cost side the total project costs are $3,486 million (net present value, using a 7 per cent real discount rate = $2,583 million) comprising:

- Total project cost of $2,817 million (net present value = $1,976 million)
- Change in electricity generation capital cost of $669 million (net present value = $607 million).

On the benefit side the total project benefits are $13,843 million, with a net present value (using a 7 per cent real discount rate) of $5,059 million, comprising:

— Total project revenue of $3,506 million (net present value = $1,058 million)
— Net efficiency benefits[49] of electricity generation $9,970 million (net present value = $3,907 million)
— Reduced greenhouse gas emissions benefit of $366 million (net present value = $93 million).

Despite removing the major source of benefit, the results continue to show net benefits across all discount rates. In particular, the net benefit of the CopperString 2.0 project without additional mining production using the NEM connected mining level is estimated to be:

— $10.4 billion (undiscounted) with a BCR of 3.97
— $8.6 billion (3% real discount rate) with a BCR of 2.84
— $5.1 billion (7% real discount rate) with a BCR of 1.96
— $3.6 billion (10% real discount rate) with a BCR of 1.55.

[49] As per the calculation in Section 7.2.2, to avoid double counting and to measure just the net benefit to consumers, the efficiency benefits are calculated after the CopperString 2.0 transmission fees discussed in Section 7.2.1.

TABLE 7.6 SENSITIVITY ANALYSIS – WITHOUT CHANGE IN MINING PRODUCTION OR ADDITIONAL ELECTRICITY GENERATION USING THE NEM CONNECTED MINING LEVEL (NEM CONNECTED CASE RELATIVE TO BAU CASE)

	Undiscounted	NPV 3%	NPV 7%	NPV 10%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
COST ITEMS				
A. Total project cost (CopperString 2.0)	**2,817.2**	**2,319.2**	**1,975.5**	**1,814.5**
– Initial capital and development costs	1,998.0	1,887.6	1,756.3	1,668.2
– Operating costs	674.9	359.6	187.4	127.9
– Ongoing capital expenditure	144.3	72.1	31.9	18.4
B. Additional electricity generation capital costs	**669.2**	**705.0**	**607.5**	**515.2**
– NWMP generation	–282.3	–201.3	–142.7	–116.6
– NQ Renewable Energy Hub generation	1,862.0	1,619.4	1,356.7	1,195.4
– Existing Queensland NEM generation	–910.5	–713.0	–606.5	–563.6
TOTAL PROJECT COSTS [Equals A+B]	**3,486.4**	**3,024.3**	**2,583.0**	**2,329.7**
BENEFIT ITEMS				
A. Project revenue (CopperString 2.0)	**3,506.8**	**1,944.4**	**1,058.3**	**739.6**
– Paid by NWMP customers	*2,341.4*	*1,369.8*	*784.3*	*561.1*
– Paid by existing Queensland NEM customers	*1,165.4*	*574.6*	*274.0*	*178.5*
B. Net efficiency benefits of electricity generation (total Queensland)	**9,969.8**	**6,446.6**	**3,907.0**	**2,825.0**
1. Fixed operating cost change	**–767.2**	**–460.1**	**–248.5**	**–163.9**
– NWMP generation	*153.2*	*90.4*	*49.3*	*33.5*
– NQ Renewable Energy Hub generation	*–1,404.9*	*–874.8*	*–508.4*	*–358.3*
– Existing Queensland NEM generation	*484.4*	*324.3*	*210.6*	*160.9*
2. Fuel and variable operating cost change	**10,737.0**	**6,906.7**	**4,155.4**	**2,988.9**
– NWMP generation	*10,850.8*	*7,055.4*	*4,313.7*	*3,140.3*
– NQ Renewable Energy Hub generation	*670.5*	*401.5*	*215.7*	*141.0*
– Existing Queensland NEM generation	*–784.3*	*–550.2*	*–374.0*	*–292.4*
C. Reduced emissions (social cost of GHG emissions)	**366.4**	**200.9**	**93.4**	**53.6**
– NWMP generation	*592.4*	*374.9*	*221.7*	*157.9*
– NQ Renewable Energy Hub generation	*0*	*0*	*0*	*0*
– Existing Queensland NEM generation	*–226.0*	*–173.9*	*–128.3*	*–104.3*
TOTAL PROJECT BENEFITS [Equals A+B+C]	**13,843.0**	**8,592.0**	**5,058.7**	**3,618.2**
PROJECT NET BENEFIT	**10,356.6**	**5,567.7**	**2,475.6**	**1,288.5**
PROJECT BCR	**3.97**	**2.84**	**1.96**	**1.55**

Notes: Total project cost and project revenue are calculated over full 40-year operational life. All other items calculated to 2050 only. Electricity generation benefits were not calculated from alternative *PowerMark* simulation without additional load. Rather, they are indicative estimates only calculated on the basis of proportionate changes in costs per unit of generation assuming that total electricity consumption across Queensland is unchanged.

SOURCE: ACIL ALLEN

7.7 Distribution of costs and benefits

7.7.1 Electricity customers

This section presents the distribution of costs and benefits. Overall, CopperString 2.0 has no adverse distributional consequences except for a small smearing of a portion of the projected costs to customers in the existing Queensland region of the NEM greater than the value of the projected price reduction. However, because of the way the NEM rules operate, this is much smaller than would be the case for a standard NEM transmission asset (approximately 33 per cent smearing for CopperString versus 50 per cent following standard NEM rules). Moreover, the way in which the NEM rules operate mean that CopperString customers will pay a share of the next transmission asset built, in just the same way as current NEM customers pay a share of CopperString's costs. Thus, the distributional effect may be temporary, not permanent. Moreover, Queenslander's outside of the NWMP region are likely to receive benefits from the additional mining activity stimulated by CopperString 2.0, including through additional royalties, taxes and shareholder returns.

The calculated distributional effects between electricity customers in different parts of Queensland are presented in Table 7.7. As can be seen, there are three main elements underlying the calculated net benefits:

1. The benefit of lower electricity prices equal to $5.4 billion, undiscounted (with $5.1 billion passed through to customers in the NWMP region and $0.3 billion passed through to customers in the existing Queensland NEM region)[50]
2. *Plus*, the value of additional electricity generation equal to $2.8 billion, undiscounted (all of which is assumed to be passed through to customers in the NWMP due to the assumption of the same load in the existing Queensland NEM region between the BAU case and the NEM connected case)
3. *Less*, the payments by customers to the owners of CuString based on the assumed regulated rate of return ($2.3 billion of which is anticipated to be paid by customers in the NWMP region and $1.2 billion paid from customers elsewhere in existing Queensland NEM region.

In total, the net benefit to electricity customers of CopperString 2.0 is estimated to be $4.7 billion, undiscounted, with the net benefits to customers in the NWMP estimated to be $5.5 billion and the net benefits to customers in the existing Queensland NEM region estimated to be –$0.9 billion. It should be noted that these estimates are confined *only* to the electricity market benefits to customers and do not include the effect of things like greater employment opportunities in the NWMP generated by the expansion in mining activity, or the potential for benefits from increased transfers from the Queensland or Australian governments and potential ownership in the relevant companies benefitting from CopperString 2.0 (which are discussed in the following section). As shown in the next section, the Queensland Government is calculated to receive a net benefit in the order of $6.7 billion on an undiscounted basis. If this money was used to reduce other Queensland Government taxes (such as payroll tax or stamp duty, for example), then it is highly likely that the customers in the existing Queensland NEM region will receive a net benefit from the project due to such transfers rather than the small net cost estimated without provision for such transfers.

The last line in Table 7.7 presents the net benefits to the CuString owners. As can be seen this is expected to be positive on an undiscounted basis (equal to $689.6 million) but is negative for all real discounts rates presented. This is driven by the assumed nominal cost of debt and total share of debt used to finance construction in KPMG's financial model.

[50] Note: the actual pass through of lower wholesale prices to final consumers is dependent on a range of factors, including the effect of any regulated retail prices.

TABLE 7.7 DISTRIBUTION ANALYSIS – CUSTOMERS, NEM-CONNECTED CASE RELATIVE TO BAU CASE

	Undiscounted	NPV 3%	NPV 7%	NPV 10%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
DISTRIBUTION OF BENEFITS TO CUSTOMERS				
A. Price benefits (total Queensland)	**5,410.4**	**3,557.0**	**2,219.3**	**1,644.0**
– Electricity price reduction to NWMP customers	5,091.5	3,516.6	2,304.3	1,750.8
– Electricity price reduction to existing Queensland NEM customers	318.9	40.4	–85.1	–106.8
B. Additional electricity generation (valued at final wholesale prices)	**2,758.5**	**1,612.2**	**856.4**	**564.7**
– Consumed by NWMP customers	2,758.5	1,612.2	856.4	564.7
– Consumed by existing Queensland NEM customers	0	0	0	0
C. Transfers for cost of CopperString 2.0	**0**	0	0	0
– Payments to CuString owners	3,506.8	1,944.4	1,058.3	739.6
– Paid by NWMP customers	–2,341.4	–1,369.8	–784.3	–561.1
– Paid by existing Queensland NEM customers	–1,165.4	–574.6	–274.0	–178.5
D. Total project cost [paid by CuString owners]	**2,817.2**	**2,319.2**	**2,093.2**	**2,415.8**
NET QUEENSLAND CUSTOMER BENEFITS [Equals A+B+C]	**4,662.1**	**3,224.8**	**2,017.4**	**1,469.1**
– Net benefit to NWMP customers	5,508.6	3,759.0	2,376.4	1,754.4
– Net benefit to existing Queensland NEM customers	–846.6	–534.2	–359.0	–285.3
NET BENEFITS TO CUSTRING OWNERS [Equals C–D]	**689.6**	**–374.8**	**–917.3**	**–1,074.9**

SOURCE: ACIL ALLEN WITH COPPERSTRING 2.0 REVENUES AND ALLOCATION OF COSTS FROM KPMG FINANCIAL MODEL (AS AT 30 JUNE 2020)

7.7.2 Benefits to governments and shareholders

Table 7.8 presents the breakdown of the various income benefits to Queenslanders and others. To estimate these benefits, it has been assumed that the ownership of CuString is 30 per cent Australian and 70 per cent overseas, while the average Australian ownership of the profits generated by the additional mining activity is 40 per cent. The Australian Government company tax rate has been assumed to be 30 per cent of EBIT (with depreciation calculated on a prime cost (straight line) basis). The share of Australian government taxes and shareholder dividends has been assumed to be paid proportionate to Queensland's current share of the Australian population (20.1%). Finally, the estimated royalties payable to the Queensland Government from the additional mining activity has been estimated using current royalty rates[51] for each mineral and an assumed taxable value of 75 per cent of the value of production. While the average royalty rate payable differs year on year based on the relative amount of minerals mined (between 2.7 and 3.3 per cent), the estimated weighted average of royalties of the additional mining production revenues generated as a consequence of CopperString 2.0 over the period to 2050 equals 3.0 per cent.

It is estimated that Australian governments and shareholders will benefit by $7.5 billion (undiscounted) as a result of the CopperString 2.0 project. Of this, Queenslanders are estimated to benefit by $4.5 billion (comprising $3.7 billion of royalties and $750 million of company taxes).

[51] See https://www.business.qld.gov.au/industries/mining-energy-water/resources/minerals-coal/authorities-permits/payments/royalties/calculating/rates (accessed 1 July 2020).

TABLE 7.8 DISTRIBUTION ANALYSIS – GOVERNMENTS AND SHAREHOLDERS, NEM CONNECTED CASE RELATIVE TO BAU CASE

	Undiscounted	NPV 3%	NPV 7%	NPV 10%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
BENEFITS TO GOVERNMENTS AND SHAREHOLDERS	**10,411.4**	**6,100.6**	**3,296.9**	**2,212.6**
– Queensland share (Royalties plus 20% of company tax on CuString and Australian shareholding)	4,494.4	2,665.4	1,442.7	962.4
– *Of which, Queensland Government royalties*	*3,744.6*	*2,229.1*	*1,207.0*	*803.5*
– Rest of Australia share (80% of company tax on CuString and Australian shareholding)	2,980.6	1,734.3	937.1	631.8
– Overseas shareholders	2,936.3	1,700.8	917.1	618.4

Note: The calculation of the Queensland share of company taxes and dividends paid to Australian-based shareholders are based on Queensland's current share of Australian population as per ABS December 2019 estimates (=20.1%). CuString shareholding is based on a current anticipated project funding of 30% Australian and 70% overseas. Average Australian shareholding of the additional profits generated by the additional mining activity is assumed to be 40%.

SOURCE: ACIL ALLEN

7.8 Northern Australia benefits

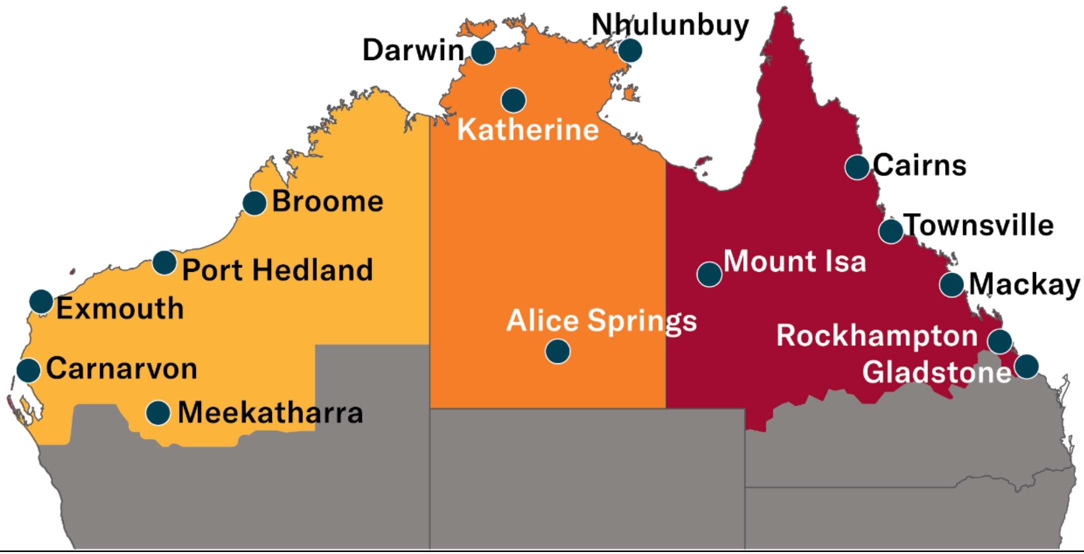
CopperString under its project development has engaged with the Northern Australia Infrastructure Facility (NAIF) as part of its financing arrangements. To assist NAIF with its due diligence a summary of the Northern Australia specific benefits has been included

As presented in the detailed benefit cost analyses in Table 7.1, the costs and benefits can be broadly allocated to those in northern Queensland. In addition to these effects, however, as discussed in chapter 6, there are a range of other benefits that will accrue to northern Queensland — notably additional population, employment and other economic activity beyond the induced mining effect. Some of these benefits come at the expense of the rest of Australia with the net benefit treated as being zero or outside of the scope of the CBA. For example, while there is projected to be a movement of people toward north Queensland, the total Queensland population is assumed to remain unchanged between the BAU and NEM connected cases.

The CGE modelling in chapter 6 incorporated the economic impacts measured within the CBA's presented in this chapter (such as the various electricity generation impacts along with the additional mining activity). In addition, the CGE modelling estimated the economic impacts in north Queensland associated with higher population level, higher employment and the higher economic activity associated with CopperString 2.0. From these results it is possible to obtain estimates of the additional value add in northern Queensland attributable to the additional employment within the region as well as to estimate the net additional non-labour value add embodied in the local supply chains associated with the broader economy not specifically analysed in the CBAs in this chapter.

In terms of the geography of northern Australia as a whole, the downstream effects of additional activity at the Port of Townsville and the Townsville transport and logistics industry has been included. However, any wider economic impacts to northern Australia outside of the CopperString regions modelled (including Far North Queensland, Northern Territory, northern Western Australia and the region of northern Queensland south of the CopperString regions covered by NAIF as per Figure 7.16) cannot be easily separated out of the CGE modelling. Given the nature of most of the supply chains, except for other beneficial effects on Townsville, any impacts on other northern Australia regions are expected to be relatively small, however.

FIGURE 7.16 NORTHERN AUSTRALIA REGIONS COVERED BY NAIF



SOURCE: HTTPS://NAIF.GOV.AU/WHO-WE-ARE/ABOUT-US/

Consequently, the estimated wider net economic benefits estimated from the CGE analysis are deemed to be a fair estimation of the net economic benefits to northern Australia as a whole.

Taking the north Queensland effects from Table 7.2 and including the additional value add benefits associated with the increased north Queensland employment and other additional value add outside of the mining sector results in the costs and benefits summarised in Table 7.9.

On the cost side the total project costs within north Queensland/northern Australia are $4,557 million, with a net present value (using a 7 per cent real discount rate) of $3,238 million, comprising:

— Total project cost of $2,817 million (net present value = $1,976 million)
— Additional electricity generation capital cost of $1,740 million (net present value = $1,263 million).

On the benefit side the total project benefits in north Queensland/northern Australia are $64,108 million, with a net present value (using a 7 per cent real discount rate) of $19,778 million, comprising:

— Total project revenue of $3,506 million (net present value = $1,058 million) (noting that revenue paid by customers outside of north Queensland is an export)
— Net efficiency benefits of electricity generation $4,649 million (net present value = $2,161 million)
— Reduced greenhouse gas emissions benefit of –$162 million (net present value = –$48 million)
— Export of electricity to southern Queensland of $1,132 million (net present value = $354 million)
— Additional mining surplus (Method 2) of $7,813 million (net present value = $2,524 million)
— Additional labour value add in north Queensland/northern Australia of $15,279 million (net present value = $4,587 million)
— Additional non-labour value add outside of the mining and electricity sectors in north Queensland of $11,964 million (net present value = $2,837 million).

The results show significant net benefits across all discount rates with high benefit cost ratios. In particular, the net benefit of the CopperString 2.0 project to north Queensland/northern Australia is estimated to be:

— $39.7 billion (undiscounted) with a BCR of 9.70
— $21.7 billion (3% real discount rate) with a BCR of 6.67
— $10.3 billion (7% real discount rate) with a BCR of 4.18
— $6.1 billion (10% real discount rate) with a BCR of 3.07.

TABLE 7.9 NORTHERN AUSTRALIA BENEFIT-COST ANALYSIS OF COPPERSTRING 2.0 – NEM-CONNECTED CASE RELATIVE TO BAU CASE (CONSUMER SURPLUS METHOD)

	Undiscounted	NPV 3%	NPV 7%	NPV 10%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
COST ITEMS (north Queensland only)				
A. Total project cost (CopperString 2.0)	**2,817.2**	**2,319.2**	**1,975.5**	**1,814.5**
B. Additional electricity generation capital costs	**1,739.8**	**1,510.2**	**1,262.8**	**1,110.8**
TOTAL PROJECT COSTS [Equals A+B]	**4,557.0**	**3,829.5**	**3,238.0**	**2,925.3**
BENEFIT ITEMS (north Queensland only)				
A. Project revenue (CopperString 2.0)	**3,506.8**	**1,944.4**	**1,058.3**	**739.6**
B. Net efficiency benefits of electricity generation (north Queensland generation only)	**4,686.9**	**3,324.1**	**2,226.7**	**1,708.1**
1. Fixed operating cost change	–1,315.1	–817.5	–473.8	–333.1
2. Fuel and variable operating cost change	6,002.0	4,141.6	2,700.4	2,041.2
C. Reduced emissions (social cost of GHG emissions)	**–0.2**	**38.8**	**51.1**	**49.5**
D. Export of additional electricity generation (valued at wholesale final prices)	**1,131.5**	**655.0**	**353.9**	**239.9**
E. Additional mining activity	**7,812.5**	**4,644.7**	**2,524.1**	**1,690.9**
SUB-TOTAL PROJECT BENEFITS [Equals A+B+C+D+E]	**16,975.7**	**10,477.3**	**6,114.9**	**4,346.0**
F. Change in employment – additional wages	**15,279.2**	**8,788.6**	**4,586.7**	**2,991.3**
G. Additional supply chain non-labour value added	**11,963.9**	**6,276.9**	**2,837.0**	**1,640.4**
TOTAL PROJECT BENEFITS [Equals A+B+C+D+E+F+G]	**44,218.9**	**25,542.8**	**13,538.6**	**8,977.7**
PROJECT NET BENEFIT (north Queensland)	**39,661.9**	**21,713.3**	**10,300.6**	**6,052.4**
PROJECT BCR (north Queensland)	**9.70**	**6.67**	**4.18**	**3.07**

Note: Total project cost and project revenue are calculated over full 40 year operational life. All other items calculated to 2050 only. Totals may not add due to rounding.

SOURCE: ACIL Allen

7.9 Unquantified effects

In addition to the wide range of benefits and costs calculated above there are a number of unquantified effects. These include:

— Any impact CopperString 2.0 has on the loss of energy flowing through the transmission network of the Queensland power generation fleet – particularly in Northern Queensland – due to the change in location of generation relative to demand

— Any impact CopperString 2.0 has on network constraints, particularly when there's a network outage

— Any impact CopperString 2.0 has on delaying network augmentations (particularly, whether it delays the timing of capital expenditures on the north-south trunk link)

— Any decreases in emissions associated with mines in the BAU case using diesel for on-site electricity generation that connect to the NEM as a result of CopperString 2.0

— Any wider changes in emissions not related to the electricity generation and direct diesel combustion emissions already included

— Any socio-economic benefits or costs associated with sustaining the population and economic activity in the Mount Isa region for longer, including any reduction in the cost of providing government services in the region.

7.10 Summary

Table 7.10 summarises the key quantified costs and benefits associated with the CopperString 2.0 under the NEM connected case relative to the BAU case (which includes an induced mining effect and a consequent increase in electricity generation) along with the two alternative sensitivities which assume that the large reduction in electricity prices in the Mount Isa region does not induce additional mining activity.

The robustness of the CopperString 2.0 project, is highlighted by the strong positive BCR under different benefit calculation methods, alternative future mining activity projections, and whether the largest source of anticipated benefits (namely, the additional mining activity) is included or excluded.

TABLE 7.10 BENEFIT-COST ANALYSIS OF COPPERSTRING 2.0 – NEM-CONNECTED CASE RELATIVE TO BAU CASE

	No additional mining production		With additional mining production	
	BAU mining level	NEM connected mining level	Method 1: Gross operating surplus	Method 2: Consumer surplus
	NPV 7%	NPV 7%	NPV 7%	NPV 7%
	2020 A$m	2020 A$m	2020 A$m	2020 A$m
COST ITEMS				
A. Total project cost (CopperString 2.0)	**1,975.5**	**1,975.5**	**1,975.5**	**1,975.5**
B. Additional electricity generation capital costs	**–5.1**	**607.5**	**656.0**	**656.0**
TOTAL PROJECT COSTS [Equals A+B]	**1,970.5**	**2,583.0**	**2,631.5**	**2,631.5**
BENEFIT ITEMS				
A. Project revenue (CopperString 2.0)	**1,058.3**	**1,058.3**	**1,058.3**	**1,058.3**
B. Net efficiency benefits of electricity generation (total Queensland)	**1,995.2**	**3,907.0**	**2,160.6**	**2,160.6**
C. Reduced emissions (social cost of GHG emissions)	**5.1**	**93.4**	**–48.0**	**–48.0**
D. Additional electricity generation (valued at wholesale final prices)	**0**	**0**	**856.4**	**856.4**
E. Additional mining activity	**0**	**0**	**8,763.8**	**2,524.1**
TOTAL ELECTRICITY MARKET BENEFITS [Equals A+B+C+D]	**3,058.6**	**5,058.7**	**4,027.3**	**4,027.3**
QUEENSLAND ELECTRICITY MARKET BCR	**1.55**	**1.96**	**1.53**	**1.53**
TOTAL PROJECT BENEFITS [Equals A+B+C+E]	**3,058.6**	**5,058.7**	**11,934.7**	**5,695.0**
PROJECT NET BENEFIT	**1,088.1**	**2,475.6**	**9,303.1**	**3,063.5**
PROJECT BCR	**1.55**	**1.96**	**4.54**	**2.16**

Note: Total project cost and project revenue are calculated over full 40 year operational life. All other items calculated to 2050 only. Totals may not add due to rounding.

SOURCE: ACIL Allen

8 STRATEGIES FOR LOCAL PARTICIPATION

The information provided in this chapter of the report has been provided to ACIL Allen directly by CuString at the time of this report and is subject to change.

8.1 Employment strategies for local residents

CopperString 2.0 will favour employment of local residents. In compliance with government policy, CopperString 2.0 will include a Training Policy and an Indigenous Economic Opportunities Plan to maximise local employment, training and business supply opportunities for Aboriginal and Torres Strait Islander Queenslanders. For example, at least 15 per cent of the total person-hours will be undertaken by apprentices and/or trainees and through other workforce training. Head office and administration roles will work Monday to Friday to minimise staff upload costs associated with weekend work and to attract local workers.

The labour force will be composed by the following types of workers.

1. **Civil** workers, which will include piling rig offsiders, roads crew, vegetation clearing crew, concreting crew and steel fixers in yard. The skills required for this type of work are generic and local workers will be given preference wherever possible. In general, these workers will be based in regional Queensland.
2. **Steel Construction** workers will include riggers, truck drivers and crane operators. CuString is confident that most of these workers will be Australian residents on a FIFO basis to Townsville or Cloncurry, but with some itinerant workers from overseas (possibly from Asia or South America).
3. **Aerial Crew** composed of riggers, helicopter pilots and truck drivers. As with the steel construction crew, CuString is confident that most of these workers will be Australian residents on a FIFO basis to Townsville or Cloncurry (depending on the phase). The remaining will be itinerant workers from overseas (possibly Asia or South America).
4. **Fibre jointers**. This work will most likely be undertaken by a Queensland-based company.

In all instances, CopperString 2.0 will strive to include members of Indigenous communities and people with a disability. Skills assessment and recruitment and training programs will be offered.

8.2 Strategies to address government policy

There are two key policy areas which CopperString 2.0 are aiming to achieve alignment with Queensland government policies:

1. The level of training provided for construction contracts on Queensland Government building and construction contracts, with regard to the *Queensland Government Building and Construction Training Policy* (Training policy).
2. The use of the locally sourced goods and services, with regard to the Training policy.

These are discussed in more detail in the following sections.

8.2.1 Strategies for addressing the Training Policy

The Training Policy states that a minimum of 10 per cent of the total labour of the total labour hours on Queensland Government building or civil construction projects (valued over $250,000 for building or $3,000,000 for civil construction) be undertaken by Indigenous workers, apprentices, trainees or cadets or used for the upskilling of existing employees. Construction projects with a contract sum of $100 million or greater have a minimum requirement of 15 per cent.

The policy requires contractors to provide employment and structured training on State Government building and construction contracts to address skills shortages and create additional employment opportunities in the building and construction industry.

Because CopperString 2.0 is based in a regional area and travel will include off road driving, 4WD training will be a pre-requisite for engineers and site-based staff.

CuString envisages that the admin, camp cleaning/kitchen hand, peggy roles will be filled by local people and businesses. Employees will be given training and develop new skills in reception, administration, cost control systems and software packages as required.

All employees and contractors will undertake the site and project inductions and these would include training in safety systems, cultural awareness and environmental controls and procedures.

The environmental and safety teams will run toolbox talks regularly at sites (at least every month) where they introduce a training/awareness session such as how to protect the job site from scour when rain is forecasted.

Within the civil crews, there is a continual development program so that the crew members can progress their qualifications.

In addition to the above, the following training programs will take place:

1. Approximately 20 workers will be on the Civil Training programme.
2. For every 5 people on site there would be one first aid officer.
3. Site engineers are mentored by CopperString 2.0 Engineers will be offered various developmental programmes.

Furthermore, the rigging contractors operate training systems within their crews to continually upskill. It is estimated that it takes 4-6 months to train new recruit to be able to do all the stringing and steel tasks. It is envisaged that approximately 50-100 new recruits will be hired.

These training programs and the intended hiring of Indigenous people is expected to more than suffice for compliance with the Training Policy and Indigenous Economic Opportunities Plan.

8.2.2 Strategies for assessing the cost effectiveness of sourcing local inputs

The *Queensland Charter for Local Content* (Department of State Development, Tourism and Innovation) provides a framework for helping local producers secure business whilst remaining internationally competitive. The policy supports a competitive local industry and provides fair and reasonable opportunity to for the local industry to tender for work on infrastructure and resource-based projects and major procurements in Queensland. CopperString 2.0 will engage the following high-level strategies to operationalise this policy:

— Recognise that involving local industry in projects provides economic benefits to all parties
— ensure that Queensland and Australian suppliers, contractors and manufacturers are given full, fair and reasonable opportunity to tender and participate in all stages of CopperString 2.0
— use Australian standards and codes in the formulation of specifications, tenders and the letting of contracts (except where it is unreasonable to do so)
— seek to maximise levels of goods and services, including design services, from local companies where they are competitive with respect to cost, quality and timeliness
— seek to incorporate the *Queensland Charter for Local Content* policy into contracts entered into with third parties for the supply of goods and services

— encourage private sector project proponents, who are not formally subject to the provisions of the policy, to apply the principles espoused in the policy to their projects on a voluntary basis as 'good corporate citizens'.

The provision of effective opportunities for local industry is designed to ensure that investment decisions are not adversely affected.

8.3 Helping achieve other Queensland Government policies

In addition to the above policies, by connecting the Mount Isa region and NWMP to the NEM and significantly lowering local energy prices and improving the economics of resource extraction, CopperString 2.0 will assist the implementation of a number of other Queensland Government policies, including:

1. **The State Planning Policy** (SPP): The SPP outlines the guiding principles and State interests that underpin the delivery of local and regional plans, and development that will advance the social, economic and environmental needs of all Queenslanders. The purpose of the SPP and the state interest policies is to secure a liveable, sustainable and prosperous Queensland. It requires that state interests are integrated in local planning instruments, regional plans and development decisions in order to strengthen the Queensland economy, promote strong communities, protect the environment, wisely manage resources and inform and respond to investment in infrastructure.
2. **Powering Queensland Plan:** The Powering Queensland Plan sets out the State's strategy to guide Queensland through the short term and long-term challenges facing Australia's energy markets to ensure Queenslanders receive affordable and secure supply of electricity. The overall objectives of the plan are to deliver stable energy prices, ensure long-term security of electricity supply, transition to a cleaner energy sector and create new investment and jobs.
3. **North West Regional Plan 2010:** The Plan seeks to manage regional growth and change in the most sustainable way to protect and enhance quality of life in the region. The regional plan identifies the regional framework and desired regional outcomes for the North West region. The regional plan is the pre-eminent plan for the region, and takes precedence over all planning instruments, other than state planning regulatory provisions.
4. **The Strategic Blueprint for Queensland's North West Minerals Province (the blueprint):** The blueprint contains a suite of actions to secure the long-term future of the North West region and its communities. It aims at facilitating the continued development of the resources sector and diversifying the regional economy and creating employment opportunities.

9 IMPACT ON PROPERTY MANAGEMENT

This section estimates qualitatively the likely impacts of the establishment and ongoing maintenance of the CopperString 2.0 infrastructure. The impacts are different for the preparation, construction and maintenance phases of CopperString 2.0.

Prior to discussing impacts and mitigation strategies it is important to note that all landholders will be directly compensated for the impact of the easement crossing their property. The compensation process is being implemented concurrently to the Environmental Impact Statement process and CopperString have engaged and consulted with all potentially affected landholders.

The impacts for each stage will also be different for each land use type that the transmission line transects. Therefore, this impact assessment details:

1. each stage of the preparation, construction and maintenance phase of CopperString 2.0
2. the land use types transected by the transmission line and substations
3. how the transmission line impacts at each stage on each land use type.

9.1 Stages of installing and maintaining the transmission infrastructure

There are a number of on-site activities involved in preparing for, constructing and maintaining the transmission infrastructure. They are:

- Survey and assessment of the land to determine the transmission line route and substation locations. This requires:
  - Access to properties and consultations with property owners
  - Site and access preparation. This requires:
  - Clearing of the land to easement standards for this type of line
  - Fencing and insertion of stock proof access gates, where required
  - Preparation of access track suitable for heavy vehicles to deliver construction materials and prefabricated sections of the towers
  - Preparation of construction material sites, construction camps and machinery depots (stock proof fencing, access tracks, rainfall runoff management)
- Establishment of construction material sites, constructions camps and machinery depots:
  - Building of temporary site offices and facilities
  - Construction of secure fencing and access roads
- Construction of substations and towers
  - On site construction of tower foundations
  - On site construction of towers
  - Delivery of tower materials

- Erection of towers (usually involving large capacity cranes to stand up assembled tower sections and secure to foundations
- Roll out of transmission line (stringing up the conductor)
- Delivery of materials
- Roll out and attachment of lines to towers
- Connecting to substations
- Installation of anti-climb structures on the towers
- Testing and commissioning
- Reparations to the land on the route and construction camps
- Resowing and vegetation
- Maintenance of access and routine inspections
- Access to the transmission line along the access track as required
- Control of vegetation and trees along the access track and within the easement of the transmission line
- Maintenance of the transmission infrastructure and repairs when needed.

9.2 Land uses transected by the transmission infrastructure

For the Woodstock to Dajarra Road route the predominant agricultural land use is beef cattle production. There are several types of cattle production enterprises run in the region:

- Breeding
- Trading
- Combinations of breeding and trading.

Cattle breeding involves the management of a large number of cows that calve annually. The calves are weaned at approximately 6 months of age (although this can vary according to seasonal conditions and management preferences for later or earlier weaning). The calves are then raised on the property and sold at a later date or sold soon after weaning to other producers who specialize in fattening cattle.

Cattle trading involves the buying and selling of cattle usually with the intention of purchasing younger lighter cattle and selling them older and heavier and fatter.

The four broad land class types along the proposed transmission line route (in order from west to east – Woodstock to Dajarra Road):

- Einasleigh Uplands
  - This bioregion has a tropical climate with high summer rainfall and drier winters. The mean summer temperatures range of 20.1^{0}C to 36.5^{0}C. The southern area of this region has an annual average rainfall of 400mm. The main land use is cattle grazing (Australian Natural Resource Atlas).
- Desert Uplands
  - The Desert Uplands are broadly defined as consisting of ranges and plains. They are dominated by woodlands of *Eucalyptus whitel* and *similis* and *Corymbia trachyphlola.* The climate is semi-arid and soils are mostly of poor structure and low fertility. Buffel grass has been introduced to improve cattle grazing in this region which is the main land use type (Australian Natural Resource Atlas).
- Mitchell Grass Plains
  - This bio-region extends from Charleville in the south to Daly Waters in the North. The area of interest for this study is between Hughenden and Mount Isa. Mitchell Grass plains are typically rolling treeless grass plains used for cattle and sheep grazing. The soils are heavy cracking clay soils covered by Mitchell grass, tussock, and with some low tree overstorey of gidgee and other species (Australian Natural Resource Atlas)
- Gulf Plains
  - The climate of the Gulf Plains is distinctly monsoonal with a dry winter season and summer wet season. The average rainfall in the south of this region (close to Hughenden) is 400mm. The main land use is cattle grazing on native pastures (Australian Natural Resource Atlas).

9.3 Impacts – Agricultural land

The impacts of the preparation, construction, and maintenance of the transmission infrastructure on the predominant enterprises along the route are described in detail in Table 9.1.

There are few differences in impacts between the trading and breeding enterprises. However, breeding enterprises that closely control mating to establish pedigrees or allocate certain cows to specific bulls or groups of bulls may be more sensitive to interruptions and potential mixing of mobs if gates are accidentally left open than other types of cattle enterprises.

TABLE 9.1 IMPACTS ON LAND USE OF VARIOUS STAGES OF COPPERSTRING 2.0

		PREPARATION	
	Field surveys and studies	**Site access and preparation**	**Establishment of construction camps and material dumps**
Cattle breeding	– Risk of gates being left open and stock becoming mixed	– Risk of stock becoming mixed – Damage to grass lands reducing stock carrying capacity – Clearing of trees likely to improve pasture production – Cleared easements provide mustering lines/corridors	– Damage to grasslands reducing stock carrying capacity – Noise and disturbance from increased activity
Sheep Breeding	– Limited impact	– If lambing ewes are disturbed they may leave their lambs resulting in mis-mothering and death	– If lambing ewes are disturbed they may leave their lambs resulting in mis-mothering and death
Cattle trading	– Limited impact	– Damage to grass lands reducing stock carrying capacity	– Damage to grass lands reducing stock carrying capacity
		CONSTRUCTION	
		Construction of substations and towers, and roll out of transmission lines	**Reparations of the route, construction camps and material storage sites**
Cattle breeding and cattle trading		– Potential exclusion of cattle for certain periods while construction is under way to prevent cattle damaging equipment – Risk of stock mixing if gates left open – Stock eating flagging tape, barrier materials or waste products. – Damage to pastures – Fire risk depending on time of year and ground cover – Disturbance of stock in surrounding paddocks – Cattle reluctant to cross construction zones to access water sources – Mustering activities restrained by construction activities	– Exclusion from areas while grass etc establish – Once established the pastures may be an improvement on the native grass if that was there before – Access roads could be useful to property owners for future property management – Disturbance of stock in surrounding paddocks
		MAINTENANCE	
		Maintenance of access route and easement	**Routine maintenance and repairs (as required)**
Cattle breeding		– Risk of cattle mixing of gates left open	– Potential exclusion of cattle to prevent damage to plant and equipment
Cattle trading		– Limited impact	– Potential exclusion of cattle to prevent damage to plant and equipment

Aerial mustering	– Stock disturbance from low-flying helicopters	– Limited impact

SOURCE: ACIL ALLEN

Once constructed and all reparations have been made, some farmers may actually view the installation of the transmission line easement as being beneficial due to:

— the potential for reduced tree competition for moisture with pastures in the easement (depending on the current – if any – competition from trees within the easement)
— rehabilitating construction areas could provide an opportunity to improve the pastures in the affected areas
— a well maintained access track could be useful infrastructure on the farm providing improved access to some areas for the farmer.

Any such benefits will be very case specific.

9.4 Mitigation measures – Agricultural land

Mitigation of stock control risks may be easily achieved by establishing a set of paddock access protocols between each property manager and CopperString personnel prior to commencement of preparations and construction. This is, of course, dependent on the current state of fencing on the property and the agreed installation of suitable access gates.

It is anticipated that the vast majority of impacts to property management through both the construction, and operation and maintenance phases of CopperString 2.0 can be mitigated with the implementation of effective landholder communication strategies.

Other negative near- and long-term impacts will be addressed directly with each individual landholder through negotiation of an appropriate level of financial compensation for the disturbance to their current and/or future activities.

9.5 Extractive industries

An easement width of 120 m is planned along the Woodstock to Dajarra Road section of CopperString 2.0, with an easement width of 60 m planned for the western and southern extensions from Dajarra Road. It is ACIL Allen's understanding that the proposed alignment has avoided mining tenure as part of the initial route selection. If this conflicts with any planned resource extraction activities, CopperString will try to minimise disruption to such activities, where publicly known or notified by relevant stakeholders. Most resource extraction activities can be designed to avoid the necessity of using the proposed easement. For example, lateral or diagonal drilling techniques are a possibility for well-based extraction activities, and in the case of open pit mines, underground systems could achieve satisfactory outcomes

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 from 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 an economic disturbance and one following). A dynamic model such as *Tasman Global* is beneficial when analysing issues for which 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 or at the state/territory/provincial level for various countries.

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 has its 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.

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 beet	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

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 in which 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'52 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 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

[52] 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).

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, for each consumer (private, government, industries and the local investment sector), consumption goods can be sourced either from domestic or imported sources. In any country that has disaggregated regions (such as Australia), 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 commodities and a higher preference for intrastate- or interstate-produced commodities than foreign commodities.
- 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 a report released by the 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 projected 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 CopperString 2.0 regional participation rates by age by gender. Over the projected 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 demographic 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 that 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:

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).

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.

A.4.2 Labour Market Database

The *Tasman Global* database includes a detailed representation of the Australian labour market that 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.4.3 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.[53] 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

[53] 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.

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.[54]

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

– 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)
– 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)
– a portion of the potentially available workforce is unemployed, implying a given available labour force
– labour chooses to move between occupations based on relative real wages
– 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[55], while the fuel-factor and technology bundle elasticities are the same as those specified in GTEM.[56] 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[57]. 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:

– brown coal (with and without carbon capture and storage)
– black coal (with and without carbon capture and storage)
– petroleum
– base load gas (with and without carbon capture and storage)
– peak load gas
– hydro

[54] 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.
[55] Narayanan et al. (2012).
[56] Pant (2007).
[57] 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).

- geothermal
- nuclear
- biomass
- wind
- solar
- 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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