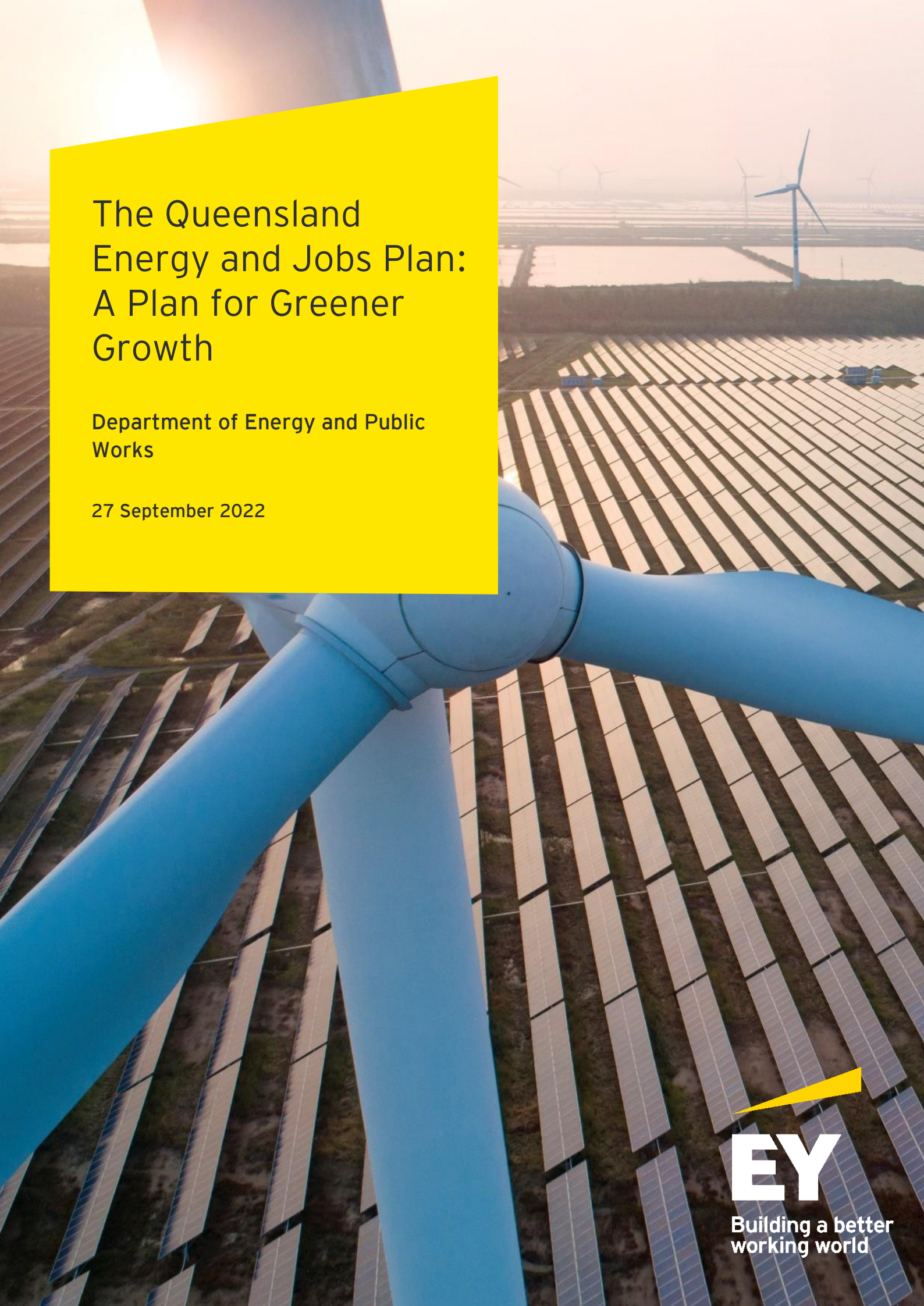

The Queensland Energy and Jobs Plan: A Plan for Greener Growth

Department of Energy and Public Works

27 September 2022

Building a better working world

Building a better working world

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The key inputs, assumptions, methodology, scenarios and qualifications made in preparing the modelling are set out in EY's report dated 27 September 2022 ("Report"). You should read the Report in its entirety including any disclaimers and attachments. This Report has been prepared on the specific instructions of the Department and incorporates key outcomes from EY's report, *The Queensland Energy and Jobs Plan: electricity market and economic modelling outcomes* dated 23 September 2022. This Report does not contain detailed assumptions, methodology, scenarios and qualifications and it may not give complete understanding of the background, context, findings and the analysis. A reference to the Report includes any part of the Report. No further work has been undertaken by EY since the date of the Report to update it.

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Executive summary

Environmental sustainability is becoming an increasing priority for consumers, businesses, and governments worldwide. As countries and industries move towards low-carbon practices, renewable energy commitments are being set to provide clarity and confidence to business and consumers. The Queensland Government has a 50% Renewable Energy Target by 2030 and has developed the Energy Plan as a roadmap to reach this Target and decarbonise the electricity grid.

Global technology, markets, and policies directed towards developing and implementing emissions reductions targets are impacting Queensland's industrial base. These are major structural drivers which present opportunities and challenges for the state's economy. To address challenges and capture green growth, the Queensland Government has put forward an Energy and Jobs Plan (the Energy Plan) to provide market confidence and investment into the state's electricity grid. The Energy Plan details a pipeline of investment into renewable energy generation, storage and transmission that will reduce the emissions intensity of Queensland's electricity supply.

As major trading partners and investors move towards low-carbon futures, the performance and future growth of Queensland's economy will become increasingly tied to its environmental sustainability. To advance Queensland's economy along a low-carbon pathway, a credible and stable policy environment will be critical to attract investment and grow established and emerging industries, as well as support the new jobs of the future.

The Energy Plan aims to establish the environmental and economic preconditions for capturing growth opportunities in the most prospective low emissions emerging industries, such as green hydrogen production, battery storage manufacturing and green manufacturing. Indeed, as these sunrise industries grow year-on-year, there are first-mover advantages to be realised by making foundational investments.

This report assesses the impact of implementing Queensland's Energy Plan. The economic assessment compares the market and investment opportunities under the Energy Plan against an Uncoordinated Outlook in which no plan was implemented. Three key dimensions are examined:

- The electricity market, including electricity prices and the emissions intensity of electricity, which was modelled using EY's 2-4-C electricity market model.

- Potential industry impacts under the Energy Plan which were examined using industry-specific analysis, including potential economic output and employment across:
  - Metal refining
  - Resource mining
  - Green hydrogen
  - Battery manufacturing

- The broader economic impacts of the Energy Plan on output, investment, and household incomes, which was modelled using EY's GEM computable general equilibrium model.

This report summarises outcomes from EY's report *The Queensland Energy and Jobs Plan: electricity market and economic modelling outcomes* which contains additional detail on the input assumptions, methodology and findings of the electricity market modelling and whole-of-economy modelling referenced in this report.

The Energy Plan lowers electricity prices across Queensland

Queensland's Energy Plan is a policy and investment blueprint to transform the state's electricity market to deliver low-cost renewable electricity to households and industry. This investment, which is expected to reach almost $76 billion in real terms by 2040, will expand Queensland's renewable energy assets across wind, solar, battery storage, pumped hydro, and transmission as coal-fired generation withdraws.

This capital installation will replace the state's predominately coal-fired electricity supply, while keeping wholesale electricity prices at an average of 15% lower each year until 2040, compared to the Uncoordinated Outlook. Lower forecast electricity prices will benefit households and established industry.

Further, by deploying new renewable energy assets, Queensland is expected to meet its 2030 Renewable Energy Target of 50% early, creating economic and employment benefits for established and emerging industries. In the Uncoordinated Outlook scenario, the renewable energy target is not expected to be met.

Helping Queensland's metal refining industries decarbonise

Queensland's metal refining industry contributes significantly to economic activity, employment, and exports. The industry is dominated by non-ferrous metal refineries including aluminium, copper, and zinc. As one of the most electricity-intensive industries in the state, the Energy Plan is expected to deliver low-cost renewable electricity to these refineries and reduce input costs while improving the environmental credentials of the industry.

The aluminium and alumina refining industries are expected to benefit greatly from the Energy Plan due to their high Scope 2 greenhouse gas emissions, while zinc and copper refining are likely to see moderate additional growth. Overall, the Energy Plan is forecast to support a further $3 billion in metal refining output in 2040, supporting 2,500 direct additional jobs in the industry.

New resource extraction to underpin a low-carbon future

A decarbonised electricity grid is expected to drive limited or moderate additional growth in Queensland's resource mining industry under the Energy Plan. Strong global demand for aluminium (produced from bauxite), zinc, and copper is expected to lift the industry in both scenarios. Most mining operations are located outside of the state's electricity grid and therefore are unlikely to benefit directly from lower electricity prices and emissions under the Energy Plan. However, critical minerals such as vanadium are emerging as crucial to the transition towards a low-carbon future, presenting Queensland with a significant growth opportunity. Overall, production in the resource mining industry, excluding coal, could increase by $5 billion under the Energy Plan in 2040, supporting 5,200 direct additional jobs.

Green hydrogen gathering momentum as a global energy solution

Green hydrogen involves the use of renewable and zero-emissions energy to produce hydrogen. Queensland is emerging as one of the lowest cost locations for producing green hydrogen in the world due to its abundance of solar and wind resources. There is already a strong pipeline of green hydrogen production such as the Fortescue Future Industries hydrogen hub in Gladstone. Further investment in renewable energy through the Energy Plan could continue to support this growth. By implementing the Energy Plan, the state's hydrogen industry could be $19 billion larger in 2040, creating 4,350 direct additional jobs.

Battery manufacturing and related services have growth potential

The battery manufacturing supply chain is complex, ranging from resource mining to the integration and development of innovative technologies. Queensland already has a strong position in the upstream mining and refining of resources such as alumina, aluminium and copper. There is potential for the state to mine and process critical minerals such as vanadium. Further, the state's demand for small and big battery storage is expected to grow significantly. It is anticipated households will continue to install residential-scale batteries to complement their solar generation, utility-scale batteries are expected to be deployed to service the grid, and large off-grid industries are expected to install industrial batteries to secure reliable, renewable energy supply.

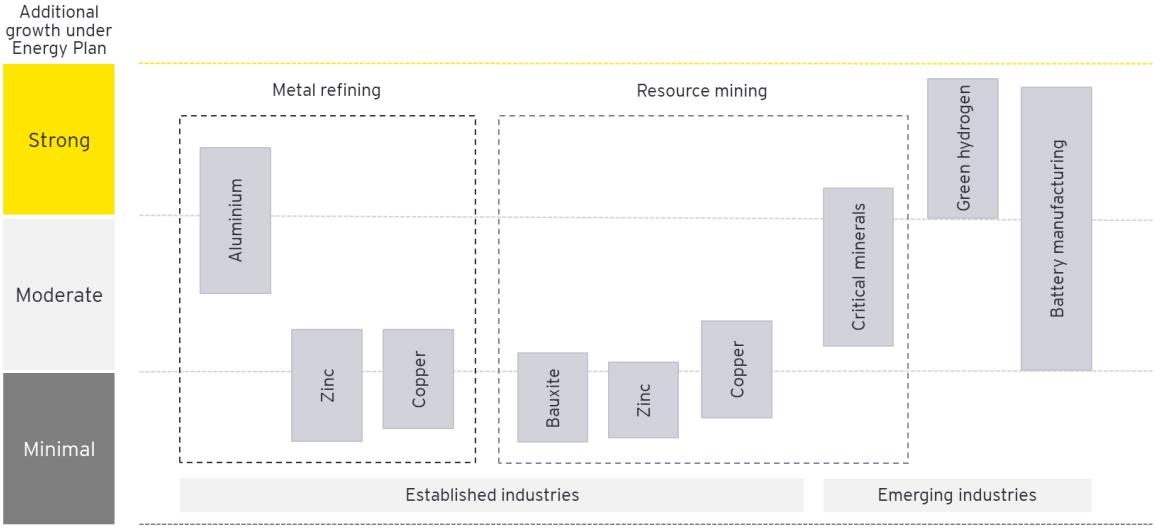
Queensland's ability to capture all parts of the battery supply chain faces some uncertainty, including developments in global manufacturing supply chains. However, by implementing the Energy Plan alongside targeted policies and investments to grow the battery manufacturing industry in Queensland, expanded growth opportunities could total $2 billion in 2040, supporting 9,800 direct additional jobs.

Broad-based industry gains could be significant

By decarbonising the electricity grid and providing long term policy certainty for industry, the Energy Plan has the potential to unlock opportunities in Queensland's established and emerging industries. The economic payoff from this growth is forecast to be significant.

Figure 1 shows the potential impact of the Energy Plan across key established and emerging industries. The figure highlights the Energy Plan's additional growth impact which would be over and above a baseline growth trajectory, which for many of Queensland's industries is already buoyant.

Figure 1: Additional industry output under the Energy Plan compared to the Uncoordinated Outlook



Source: EY analysis
Note: The length of the bar reflects the scale of potential uncertainties in each industry outlook.

The Energy Plan could generate an additional $21 billion in output in emerging industries (predominantly, green hydrogen and battery manufacturing) and almost $8 billion additional output for established industries (for example, metal refining and resource mining) by 2040. Overall, the Energy Plan could create 22,000 direct jobs, most of which are likely to be in regional Queensland[1], and a further 14,200 indirect jobs by 2040 relative to the Uncoordinated Outlook.

[1] Regional Queensland is defined as all regions outside of South East Queensland for the purpose of this report.

Broader economic impacts of the Energy Plan

Queensland's Energy Plan is a policy which drives significant public and private investment into the state's electricity infrastructure. This investment involves increasing Queensland's renewable energy generation by five times over the next two decades. Significant benefits are expected to emerge in regional areas as 95% of the Energy Plan's investment is set to occur in regional Queensland.

Macroeconomic analysis suggests that the additional $19 billion (in NPV terms) of infrastructure investment under the Energy Plan could contribute up to $25.7 billion to the Queensland economy by 2040. The economic benefits are derived through three key channels:

- Investment and economic activity flow into Queensland as capital investments by government and the private sector into renewable generation and transmission stimulates growth
- Lower electricity prices provide cost and cash flow benefits to households and industry
- A green grid facilitates new investment in clean energy industries.

Reflecting the scale of investment and capital modernisation within the Plan, it has the potential to generate significant employment benefits for Queensland, especially in regional areas where much of the new infrastructure will be installed.

The development of energy infrastructure outlined in the Energy Plan could support 28,500 direct jobs on average each year through construction, manufacturing, and operation of renewable energy assets. Around 70% of these jobs could be in regional Queensland as investment flows to the regions. This capital investment is expected to support a further 35,000 indirect jobs in services, hospitality, and other industries across Queensland. Importantly, these jobs are over and above the boost to employment that is possible as new sunrise sectors, like green hydrogen, take hold and accelerate.

Overall, the Energy Plan is a coordinated investment roadmap which signals to domestic and international markets Queensland's pathway for decarbonising the grid. Through the Plan, Queensland's position in global capital markets as a competitive investment destination is likely to be enhanced, generating significant new growth opportunities across Queensland.

The economic impact of

Queensland's Energy and Jobs Plan

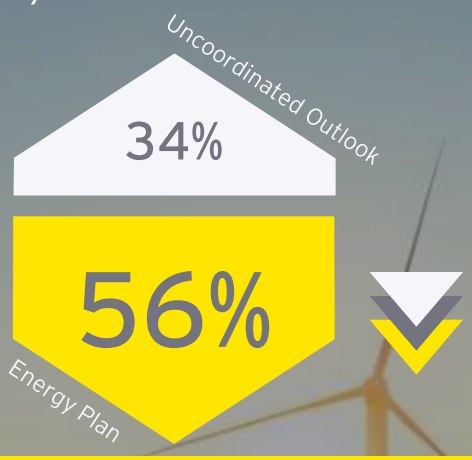
To capture the opportunities of a low carbon future Queensland has developed the Energy and Jobs Plan. This plan will seek to decarbonise the electricity grid and meet the State's renewable energy target of 50% by 2030 and beyond.

About the Energy Plan

The Queensland Government has put forward an Energy and Jobs Plan to guide the market and drive investment into the State's electricity grid. The Plan will drive significant investments, including by Queensland government-owned corporations, into wind and solar generation, pumped hydro storage and expanding the transmission network.

These new investments are expected to reduce the emissions intensity of electricity generated in the State and deliver lower electricity prices for customers.

By 2030 the Energy Plan is forecast to reduce emissions by 56% relative to 2005 levels



Two scenarios were modelled from 2023 to 2040

An outlook where there is a robust vision and infrastructure blueprint for the transformation of Queensland's energy sector resulting in:

Energy Plan

$76 billion invested by 2040

Uncoordinated Outlook

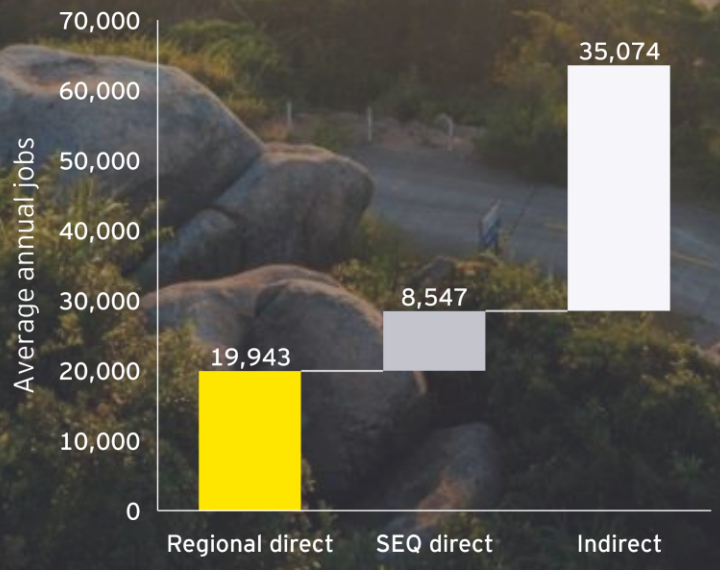
No early investments in the electricity sector and no clear plan for the energy transformation available in the public domain

The Energy Plan investment could boost economic activity by

$26 billion

supporting 64,000 jobs

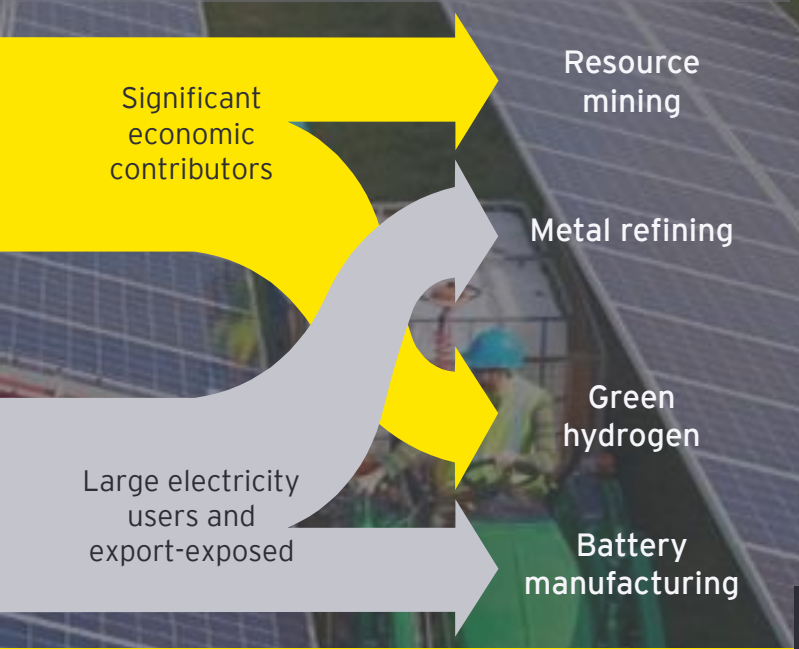
The Energy Plan could create 28,500 direct jobs across construction, manufacturing, and operations, with almost 20,000 of these jobs located in regional Queensland. This significant investment is also expected to support more than 35,000 indirect jobs.



The economic impact of Queensland's Energy and Jobs Plan

The Energy Plan could unlock opportunities for established and emerging industries

By delivering low emissions and low-cost electricity to Queensland, the Energy Plan is likely to impact on industries that are economically significant, large electricity consumers, and have export-exposed supply chains.



Additional economic activity in 2040 could support 36,000 direct and indirect jobs

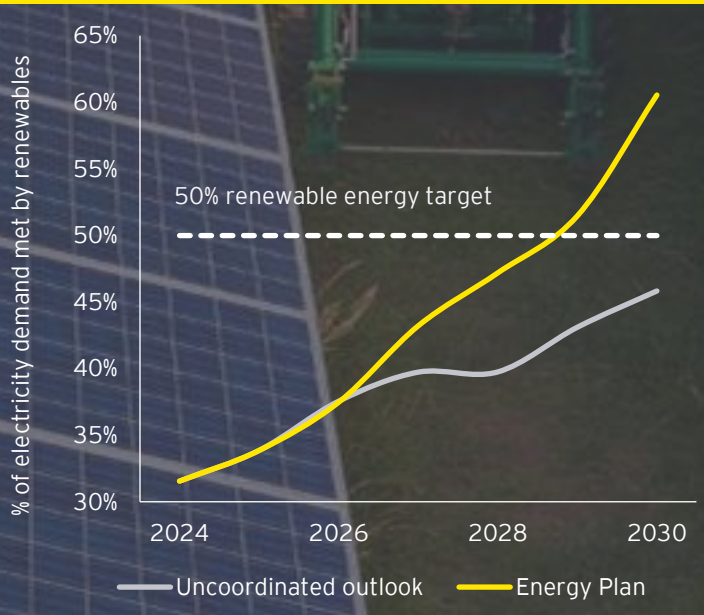
$5 billion
8,600 jobs

$3 billion
5,500 jobs

$19 billion
10,000 jobs

$2 billion
12,000 jobs

The Energy Plan supports the state in attracting green investments by reaching its renewable energy target of 50% by 2030



Without the Energy Plan, the state is not expected to reach its target by 2030

These outcomes reflect the benefits of

Lower electricity prices improving profitability

Cleaner energy unlocking green premiums

Earlier access to renewable energy

Growth in clean energy industries

EY

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1. Introduction

The Australian and Queensland economies will continue to face pressures as global environmental standards and expectations change, including efforts to curtail carbon emissions. Many countries and major companies have implemented renewable energy targets and emissions reduction targets, with Queensland having a renewable energy target of 50% by 2030.

To mitigate challenges in established industries and capture growth opportunities in emerging industries, the Queensland Government has developed an Energy Plan which aims to transform and decarbonise the Queensland energy system and increase public and private investment into renewable energy generation. The Energy Plan also considers longer-term targets for the energy system. This report examines the potential industry development pathways that could emerge under the conditions set by the Energy Plan.

- **Scope 1 emissions** are emissions directly created through production processes.
- **Scope 2 emissions** are emissions generated from purchased electricity. Electricity can be produced through various energy types such as coal, gas, or renewables, each generating different levels of emissions.
- **Scope 3 emissions** are indirect emissions which are generated by upstream or downstream activities beyond the operational control of the entity.

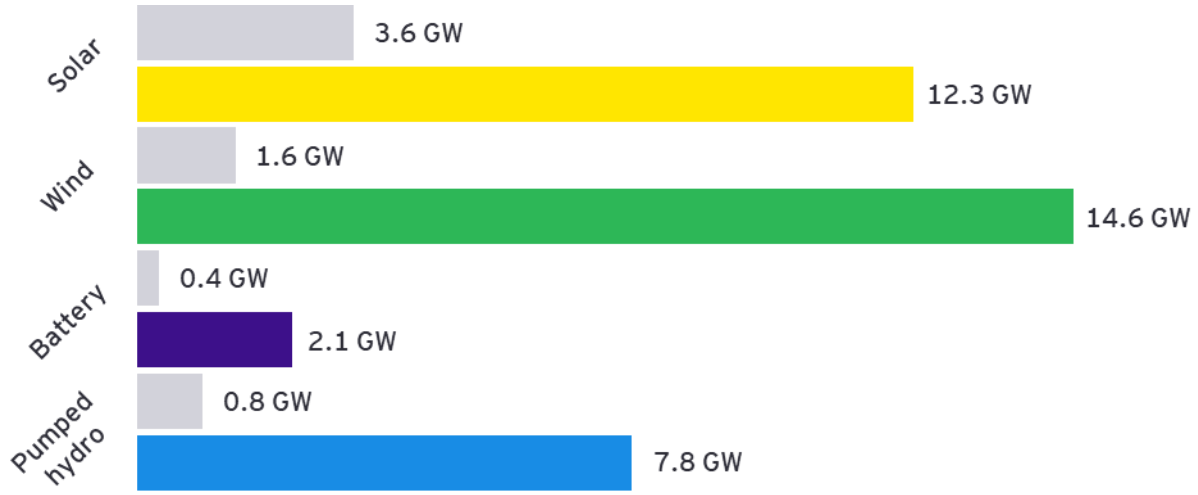
Renewable energy targets and Queensland's Energy Plan

The Queensland Government has targets to reach 50% renewable energy by 2030 and net zero emissions by 2050. These targets are in line with decarbonisation goals set in other economies around the world. To meet these targets, the Queensland Government has developed an Energy Plan, which sets out the Government's approach to reaching the renewable energy target and decarbonising the electricity grid.

The Energy Plan is a clear vision and investment blueprint for the clean transformation of Queensland's energy sector. The Energy Plan details key decisions on publicly owned assets as well as investment into wind and solar generation, pumped hydro storage, and expanding the transmission network. The Energy Plan is expected to deliver lower electricity prices, reduce Scope 2 emissions, and stimulate public and private investment into the state to uplift economic activity and create jobs.

The Energy Plan is a blueprint for investment into Queensland's energy sector, supporting the construction of renewable energy generation. It will significantly increase Queensland's renewable generation capacity, through the deployment of battery storage, pumped hydro, wind and solar generation. The figure below compares Queensland's current renewable energy assets with the project asset base in 2040 under the Energy Plan.

Figure 2: The Energy Plan rapidly increases Queensland's renewable generation capacity



Source: Client provided and EY analysis

This report examines the impact of this energy system transformation and its associated implications for current and emerging industries in Queensland. Two scenarios are examined:

- The Energy Plan – There is rapid investment in renewable generation and electricity network infrastructure over the next 20 years, ramping up to replace coal-fired generation, with Queensland achieving its 50% Renewable Energy Target ahead of the 2030 schedule.
- The Uncoordinated Outlook – There is continuation of the status quo, in which Queensland does not reach the 50% the Renewable Energy Target by 2030 and the energy transition is primarily left to market forces.

The Uncoordinated Outlook results in less investment into the state, higher electricity prices, and higher Scope 2 emissions compared to what could materialise from implementing the Energy Plan.

For example, implementation of the Energy Plan could provide $40.7 billion in total energy infrastructure investment into Queensland in NPV terms by 2040, or $76.2 billion in real terms. This compares with total investment under the Uncoordinated Outlook of around $22.3 billion in NPV terms, or $46.6 billion in real terms.

$40.7b
$22.3b

+$18.4b difference in overall investment made between the Energy Plan and Uncoordinated Outlook

The Energy Plan sets out a coordinated approach towards greening the state's electricity supply while ensuring prices remain stable. This will have a significant impact on industries within Queensland by providing the long-term certainty needed to make investment and operational decisions. Through the investment timeline outlined in the Energy Plan, Queensland is expected to reach its Renewable Energy Target of 50% before 2030. The implementation of the Plan is forecast to represent a 56% reduction in Scope 2 emissions by 2030 on 2005 levels compared to a 34% reduction if an Uncoordinated Outlook approach was taken.

Under the Energy Plan scenario, electricity prices are expected to be 15% lower on average than if no plan was implemented, which is expected to benefit electricity-intensive industries and households. Additionally, by decarbonising the electricity supply, electricity-intensive industries could reduce their Scope 2 emissions, creating economic opportunities in green markets.

This report will outline how established industries could benefit by these lower electricity prices, as well as assess their positioning to take advantage of any benefits associated with the reduction in emissions intensity of electricity generation. Furthermore, by implementing the Energy Plan, Queensland could capture opportunities in emerging industries such as green hydrogen and battery manufacturing. The Energy Plan could support these industries by delivering low-cost renewable energy and attracting investment.

About this report

This report analyses and quantifies the potential opportunities that the Energy Plan could achieve, as well as how it can help meet future challenges as the world transitions to a lower emissions pathway. The report structure is shown below.

Section 2: Overview of the technology, market, and policy drivers that are exerting pressure on Queensland's industrial base

Section 3: Summary of EY's electricity market modelling outcomes

Section 4: Economic outlook for established and emerging industries in Queensland under the Energy Plan

Section 5: The broader economic impacts of the Energy Plan

Section 6: Concluding messages

This analysis focuses on the impact of the Energy Plan on electricity prices and the emissions intensity of Queensland's electricity grid. It does not directly consider the industrial use of energy in other forms such as liquid fuels or bioenergy.

Our approach

Our approach analysed the impacts of the Energy Plan across three dimensions. The first dimension was the impact on Queensland's electricity market dynamics, including across electricity prices, emissions intensity, capacity mix, and others. These findings are summarised in Section 3. The electricity market modelling informed the industry and macroeconomic analysis.

The second dimension examined the impacts of the Energy Plan on established and emerging industries. Four industries were identified as heavily impacted by the Energy Plan due to their economic significance, energy intensity, export-exposure, and supply chain linkages. This analysis utilised industry-specific data and forecasts alongside electricity market modelling findings to foresight potential industry output. The projections of potential employment were estimated using industry-specific multipliers which were disaggregated into the Energy Plan's infrastructure investment profile and subsequent potential industry opportunities. The Energy Plan's infrastructure investment's impact on employment in Queensland was estimated based on the location, size, and timing of the infrastructure investment and utilised asset-specific job multipliers. Projections of output and employment should be considered as upper bound estimates of the Energy Plan's impacts.

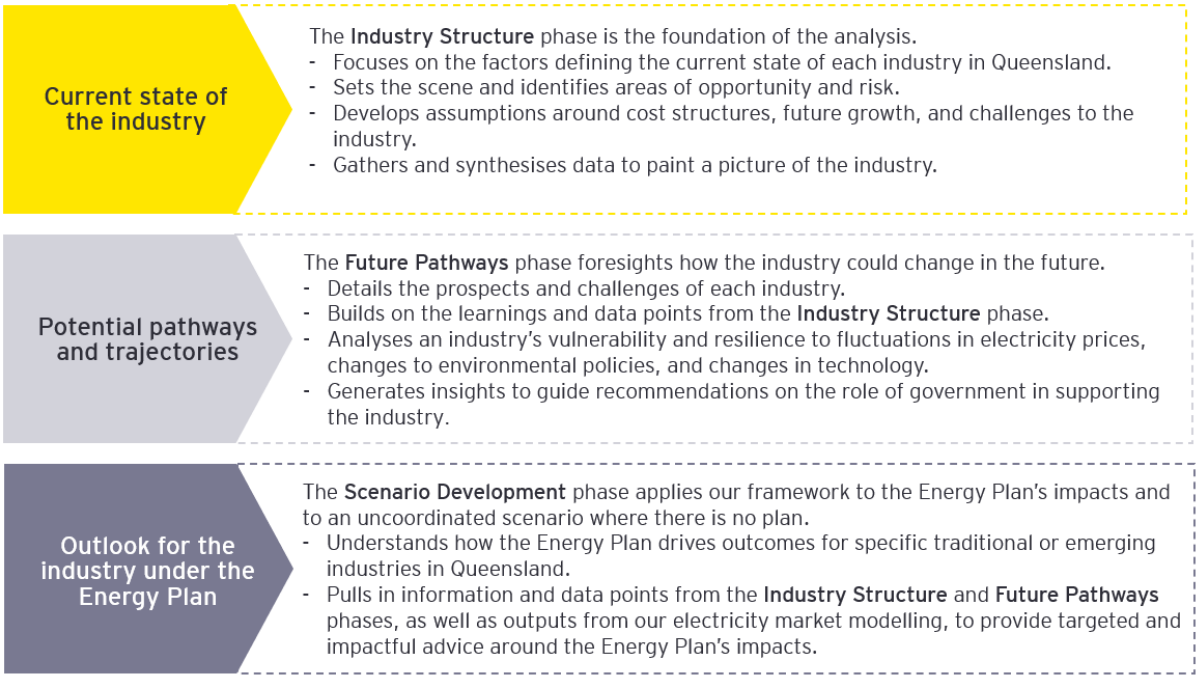
The final dimension analysed the potential impacts of implementing the Energy Plan on the Queensland's economy. This was modelled through EY's GEM computable general equilibrium model and leveraged the electricity market modelling outcomes to understand how lower electricity price and infrastructure investments could flow through the broader state economy. The whole-of-economy modelling primarily sought to quantify the impact of the Energy Plan on industry outcomes through electricity price effects and green premiums on investment. Assumptions on green premiums were consistent between the industry analysis and the whole-of-economy modelling,

which are detailed in the companion report, *The Queensland Energy and Jobs Plan: electricity market and economic modelling outcomes*.

Our analytical framework

This report applies an analytical framework to each of the identified industries to develop an economic outlook and assess the future opportunities under the Energy Plan. This framework has three key phases:

Figure 3: Our analytical framework



- The Industry Structure phase forms the foundation of the analysis by setting the scene, synthesising data, and investigating opportunities and risks.
- The Future Pathways phase outlines how the industry could change in the future and provides insights into industry vulnerabilities and global forces which are shaping the industry.
- The Scenario Development phase applies these factors to model potential industry output under the Energy Plan, compared with the no plan (Uncoordinated Outlook) scenario.

Global drivers: technology, market, and policy

2. Global drivers: technology, market, and policy

As countries around the world seek to decarbonise, there are a range of emerging forces that will influence Queensland's economy. These include new technologies and new industries, other government climate policies, and investment trends. Key trends are highlighted in this section – including other countries' environmental policies and carbon border adjustment mechanisms, electrification, the emergence of green markets, innovations in clean and energy efficient technologies, and increased demand for new economy minerals. The Energy Plan aims to uplift and capture the benefits of the global trends, while minimising or avoiding the potential negative impacts associated with higher emissions in the Uncoordinated Outlook.

Carbon pricing and carbon border adjustments

Queensland's exports are currently dominated by coal and manufactured metals, which have a high carbon-intensity. The high carbon-intensity of Queensland's exports make the state vulnerable to trends in global markets towards cleaner technologies and products, as well as carbon pricing. While many jurisdictions have implemented carbon pricing to decrease domestic carbon emissions, including the EU, UK, and Canada, these policies do not prevent carbon leakages. Carbon leakages occur when carbon-intensive economic activity is moved abroad to take advantage of lower carbon standards in other markets. Additionally, domestic carbon pricing policies are not applied to imported products, burdening domestic consumers with the cost of emissions created in other countries. To combat these issues, the EU has recently committed to implementing the Carbon Border Adjustment Mechanism (CBAM) which will apply a carbon price to imported products.

The CBAM is currently designed to only target Scope 1 emissions from the production process of imported goods. The CBAM could cover any emissions-intensive product or sector, however currently it is designed to only apply to iron, steel, aluminium, fertiliser, cement, and fuels for electricity generation including coal and natural gas, which tend to have high carbon emissions. These industries are significant contributors to Queensland's output, employment, and exports.

The CBAM is expected to be implemented from 2026, after a three-year transition period. From 2026, importers will be charged for emissions according to the EU's carbon price. In the first phase after the transition period, the CBAM will only cover Scope 1 emissions. It could possibly extend to Scope 2 and Scope 3 emissions in the future. Similar schemes are also under consideration in the US, UK, Japan, and Canada. [2,3,4]

Queensland is expected to be the most impacted state in Australia from the EU's CBAM, followed by New South Wales.[5] Queensland exports to Europe were valued at $4 billion in 2021, comprising $3 billion in coal and $35 million in aluminium. Queensland did not export significant quantities of iron, steel, fertiliser, or cement to the EU in 2021.[6] These exports will be subject to the CBAM when it is implemented in 2026 which could see a cost penalty applied to coal, natural gas, iron and steel. Alumina refining, aluminium smelting, fabricated metal products, basic chemicals, plastics, rubber and non-metallic building products will see a less dramatic price increase. Overall demand for Australian exports is not expected to fall for any of these industries by more than 1%, as the EU is not an important market for these Australian exports.[7] However, it is estimated that if some of

[2] ABC News, 2021
[3] Trading Economics, 2022
[4] Victoria University, 2021
[5] Climate Council of Australia, 2021
[6] Department of Foreign Affairs and Trade, 2022
[7] Victoria University, 2021

Australia's major trading partners such as Japan, South Korea, or the UK adopt a similar carbon adjustment to the EU, this would have a significant impact on these industries in Queensland.[8]

Scope 2 emissions from purchased electricity are currently excluded from the CBAM. Given the Energy Plan will have a limited impact on industry's Scope 1 emissions, CBAMs could still apply to Queensland's heavy industries. However, Scope 2 emissions could be included in the future, in which case, without a clear pathway forward Queensland's electricity and energy intensive industries would be at risk. The Energy Plan works to mitigate this risk for Queensland businesses.

The electrification of everything

As countries and major companies commit to emissions reduction targets, industries are moving from diesel, gas, and coal powered technologies towards renewable electrified technologies. For example, the transition from using coal-power in steelmaking towards electric furnaces, and the global shift from petrol-fuelled vehicles to electric vehicles (EVs). Electrification in a decarbonised grid allows industry and countries to utilise renewable energy in response to the growing importance of environmental credentials. As global markets begin to compete on environmental credentials, Queensland will need to move alongside its global trading partners. To do this, technologies and processes will need to be electrified, increasing the demand for electricity and requiring significant investment into electricity generation and transmission to meet demand.

In Queensland, 43% of energy consumption comprises diesel and auto fuel,[9] with the majority being consumed in transport, which is likely to be electrified over the next few decades as EV uptake increases and diesel generators are replaced with batteries and renewable electricity generation. This electrification, which is critical to reducing emissions in line with the state's emission reduction target, could put strain on the electricity grid and lead to higher prices during peak periods.[10]

By implementing the Energy Plan, significant investments would be made in Queensland's transmission network and firming requirements, including 1,550 kilometres of transmission lines.[11] This would boost Queensland's annual large-scale capacity mix to 40 gigawatts in 2035, compared to less than 25 gigawatts in the Uncoordinated Outlook. This extra large-scale capacity under the Energy Plan sets the preconditions needed to enable industries and consumers to electrify.

As technologies and processes are being electrified to reduce emissions in line with reduction targets, it is crucial to also reduce the emissions intensity of electricity produced in Queensland in order to avoid carbon costs. Currently, 76% of the state's electricity grid is supplied by coal, with a further 12% generated through natural gas,[12] and is producing almost 40 million tonnes of carbon emissions each year. If electricity demand grows and the emissions intensity of the grid remains the same, the reduction in emissions from electrifying Queensland's economy could be subdued. Therefore, to achieve the greatest emissions reduction through electrification, it is crucial to reduce the emissions intensity of the state's grid. Through the Energy Plan, the emissions produced by the grid could fall by almost 96% by 2040.[13] This will keep Queensland in lockstep with major trading partners and global trends in electrification.

Green premiums emerging in global markets

A green premium refers to the premium that consumers are willing to pay for a product that is produced in a low-carbon or zero-carbon process. While green premiums also tend to refer to low-carbon products that are more expensive to produce than more carbon-intensive products, this is not always the case. Many low-carbon products can be produced more cost-effectively, typically due

[8] Climate Council of Australia, 2021
[9] Australian Energy Update, 2021
[10] ABC News, 2022b
[11] Client provided
[12] AEMO, 2022c
[13] EY analysis

to the use of low-cost renewable energy. This is evident in the aluminium smelting industry, in which Rio Tinto facilities in Iceland and Canada utilise hydro power to produce low-cost and low-emissions aluminium, enabling them to benefit from green premiums.[14] Some industries in Queensland are already attracting green premiums. Sun Metals' zinc refinery in Townsville is seeking to be the first refinery in the world to produce zero-emissions green zinc by powering its facility through a combination of solar, wind, and hydrogen. Queensland's strong record on renewable investment has also attracted investment from battery manufacturer ESI, which chose to invest into the state due to its proximity to global markets and strong support for renewable technologies. More details on this investment are in Section 3.

Green premiums have become increasingly prominent as demand for low-carbon products has grown. As nations and companies adopt and strive towards emissions reduction targets, this trend is likely to continue affecting products across all supply chains. Green premiums are becoming more recognised, with S&P Global Platts now publishing prices for low-carbon and zero-carbon aluminium, with the view to expand to other green metals. Low-carbon aluminium attracts a premium of almost 15% and is expected to grow in the future as environmental sustainability becomes increasingly important to consumers.[15]

The emergence of green premiums is a significant opportunity for Queensland's heavy industries to attract higher market prices. For refined metals, green markets are emerging quickly. Some metal refining operations in Queensland such as Sun Metals' zinc refinery are already producing at a low-emissions level and are likely to be eligible for green premiums in the near-future regardless of whether Queensland implements the Energy Plan. However, for the Boyne Island aluminium smelter in Gladstone, the Energy Plan is crucial to reducing emissions and attracting green premiums.

Additionally, countries and companies which lag in reducing their emissions are beginning to face cost penalties for capital and financing. Investors and creditors are becoming more aware of environmental risks when lending to high emitting companies and are pricing this into their decisions. Green premiums also refer to the avoidance of this cost penalty by reducing emissions and tackling environmental risks.

Major trading partners moving towards hydrogen energy

A considerable portion of Queensland's current energy exports are to China, Japan, South Korea, United States, and India. However, countries are diversifying their energy mix and transitioning towards cleaner alternatives. As global demand for energy changes, hydrogen has emerged as an opportunity to diversify Queensland's energy export industry.

Governments around the world have announced intentions to use hydrogen as a key energy source, including China, Japan, and South Korea. Given these countries are already significant trading partners with Australia, the clean energy transition is an opportunity for Queensland to leverage existing energy production capabilities and infrastructure to become a major exporter of hydrogen to these countries.

By 2050, Australia could supply 14% of China's demand, 29% of Japan's, 14% of South Korea's and 3% of the rest of the world's demand.[16] The compounded annual growth rate for Australian hydrogen is around 15% for major trading partners and 20% for the rest of the world up until 2050. If Queensland can capture much of this growth, it could be one of the largest hydrogen producing states in Australia.

[14] Rio Tinto, 2021

[15] S&P Global Commodity Insights, 2022

[16] DISER, 2019

Demand for new economy technologies requires resources

In a global economy transforming to clean energy generation and technologies, demand for resources is set to increase as traditional capital and technologies are replaced with clean alternatives, which often require more resource-intensive components. For example, a typical electric car requires six times the mineral inputs of a conventional car, and an onshore wind plant requires nine times more mineral resources than a gas-fired power plant.[17]

New economy resources that Queensland produces such as aluminium, copper, zinc, and potentially vanadium are expected to face higher demand. Queensland could further benefit from this higher demand and from developing other resource industries such as cobalt and nickel which are also expected to be in high demand.

As the global economy moves towards net zero emissions, inaction could cost Queensland's economy billions in economic output and thousands of jobs. Whilst this transition present risks and challenges for the Queensland economy, it also provides opportunity for growth in new and existing industries. Queensland could capitalise on the global energy transition, as countries adopt more electrified technologies. The state is in a strong position to be a major global exporter of hydrogen as well as other new-economy resources.

[17] International Energy Agency, 2022

The Energy Plan's impact on the electricity market

3. The Energy Plan's impact on the electricity market

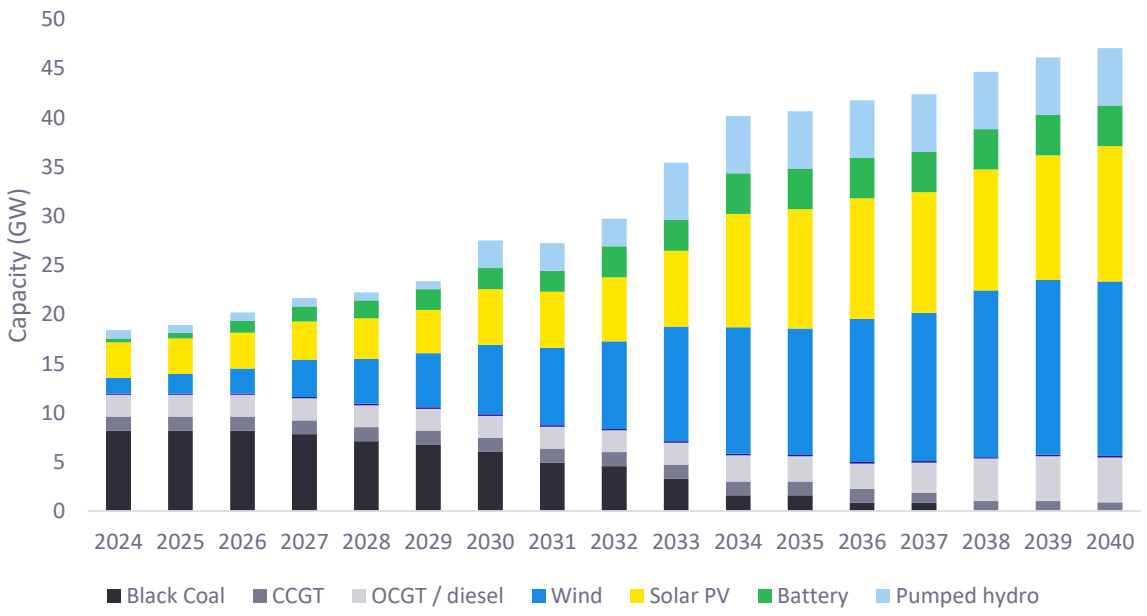
The Energy Plan is a large-scale investment blueprint which sets Queensland on a trajectory to meet its 2030 Renewable Energy Target of 50% and beyond. Electricity market modelling was undertaken to quantify the impacts of implementing the Energy Plan on the capacity mix, emissions produced, and cost of electricity in Queensland compared with an Uncoordinated Outlook in which no Energy Plan was implemented. This section summarises key outcomes of EY's report, *The Queensland Energy and Jobs Plan: electricity market and economic modelling outcomes*, which also contains additional detail on the input assumptions and methodology.

The two scenarios were modelled over a 17-year horizon from 2023-24 to 2039-40, as detailed below:

- **Uncoordinated Outlook**: this represents an uncoordinated outlook for the electricity sector and the flow-on effects to the Queensland economy. In this scenario, the Queensland Government does not make early investments in the electricity sector and there is no clear plan for the energy transformation.
- **Energy Plan**: this represents an outlook where there is a robust vision and infrastructure blueprint for the transformation of the Queensland energy sector including key decisions relating to publicly owned assets as well as proactive investment in wind and solar generation, pumped hydro storage and the transmission network.

The Energy Plan is a coordinated roadmap which aligns government and industry to accelerate renewable energy investment and transform the Queensland energy system. This includes the staged withdrawal of coal-fired generation from 2026, alongside government and private investment in large-solar, wind, battery, and pumped hydro capacity as well as new transmission. This results in the capacity mix falling from a forecast almost 50% coal-fired generation, to less than 2% in 2035-36 and 0% in 2039-40 as shown in Figure 4.

Figure 4: Forecast Queensland large-scale capacity mix, Energy Plan scenario

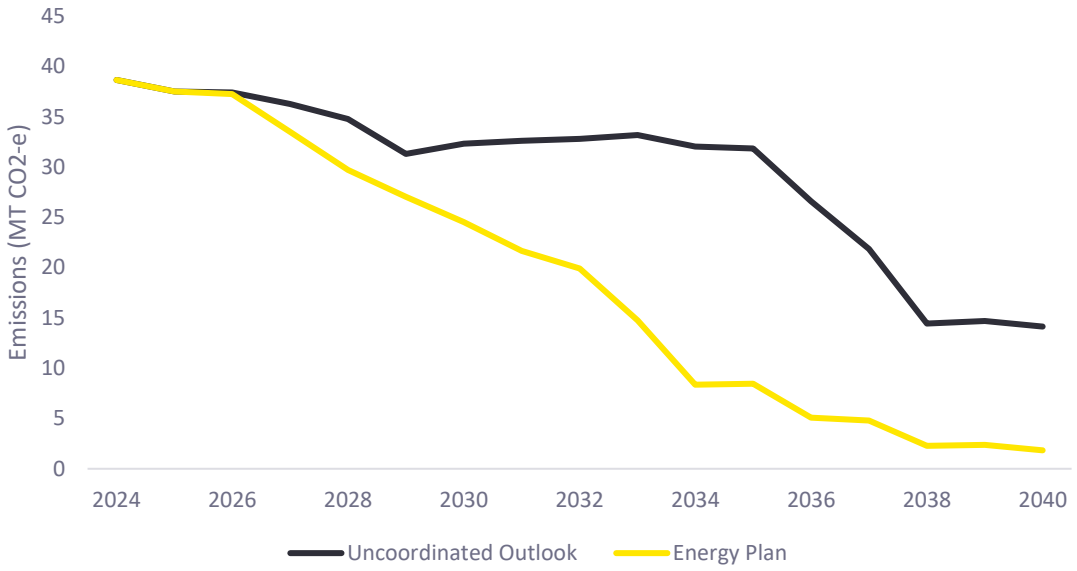


Source: EY analysis

This reduction in coal-fired electricity results in emissions declining at a faster rate in the Energy Plan scenario relative to the Uncoordinated Outlook scenario where withdrawal of coal-fired generation occurs later.

By 2030, the Energy Plan could deliver a 56% reduction in Queensland's emissions from electricity production relative to 2005 levels. For the Uncoordinated Outlook, emissions are expected to fall at a slower pace as there is greater coal-fired generation in the system, as shown in Figure 5: Queensland emissions comparison, both scenarios.

Figure 5: Queensland emissions comparison, both scenarios



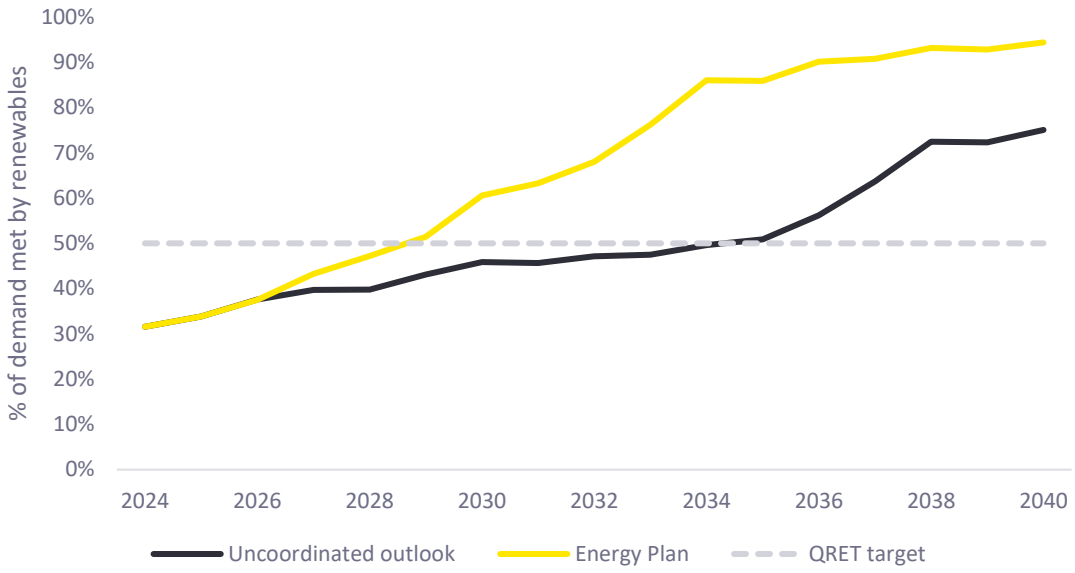
Source: EY analysis

As a result of later withdrawal of coal-fired power stations, Queensland is not expected to reach its Renewable Energy Target of 50% by 2030 in the Uncoordinated Outlook (Figure 6). By implementing the Energy Plan, this target is forecast to be reached before 2030, compared to the Uncoordinated Outlook where the 50% renewables target is not met until around 2033-34.

In the Uncoordinated Outlook, renewable energy investments are driven by the market, without coordination from government. This results in a slower uptake of renewables and a higher dependency on coal-fired electricity, which sets Queensland on a pathway to missing its 2030 target. It should be noted that while the Uncoordinated Outlook findings reflect a more uncertain pathway for Queensland's energy supply, there is the potential that the outlook could be less favourable. For example, Queensland could be exposed to energy supply and price disruptions which could become more acute, especially if the geopolitical environment becomes increasingly challenging.

With the Energy Plan, markets move to increase renewable capacity alongside Queensland Government funded renewable capacity investments in response to the strong long-term signal for investment provided by the Energy Plan's coal withdrawal schedule. Private investments increase as government and industry coordinate, including proactive investment by industry to demonstrate decarbonisation pathways and remain globally competitive. Additionally, the increased renewable investment (as well as investment in storage and transmission) allows for the earlier withdrawal of coal-fired generation which reduces emissions and helps in achieving this target in the Energy Plan scenario.

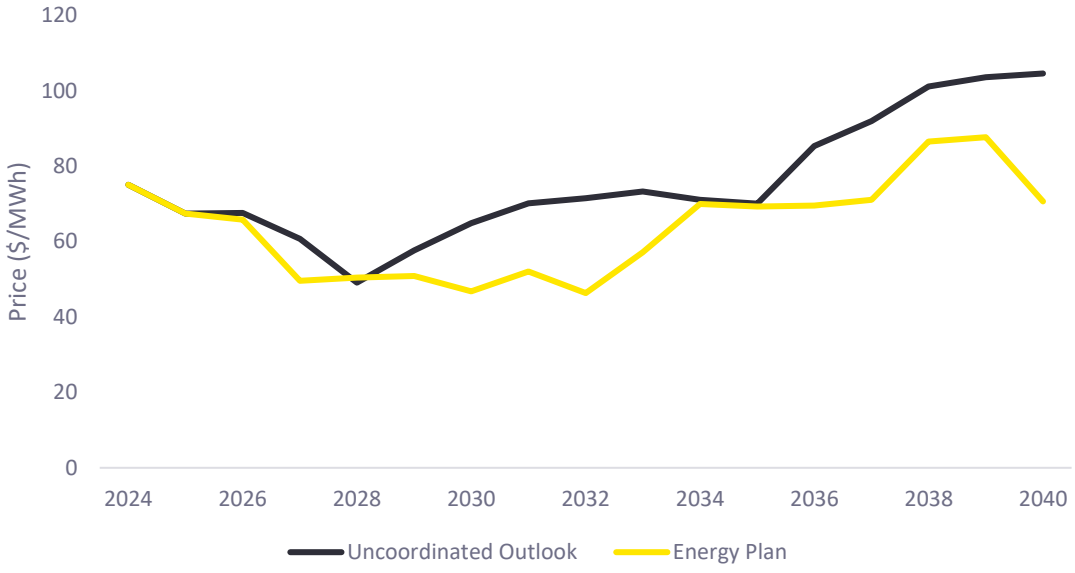
Figure 6: Renewable Energy Target comparison, both scenarios



Source: EY analysis

In addition to emissions being lower under the Energy Plan, electricity prices are also projected to be lower. As Queensland's electricity grid becomes less reliant on coal-fired power, proactive public and private investments into renewable electricity generation keep supply stable, which results in 15% lower expected electricity prices on average in the Energy Plan Scenario. This could result in average annual savings of $77 on a typical household electricity bill. Without the Energy Plan, investments into new renewable capacity are lower, and the grid remains reliant on coal-fired power, leading to higher electricity prices. Overall, the Energy Plan sets Queensland on a trajectory towards lower electricity prices and lower emissions by reducing the state's reliance on coal-fired electricity and boosting public and private investment into renewable electricity generation.

Figure 7: Annual average Queensland wholesale electricity prices, both scenarios



Source: EY analysis

The Energy Plan's impact on major identified industries

4. The Energy Plan's impact on major identified industries

This report focuses on identifying a series of established and emerging industries which could be most impacted by Queensland's Energy Plan and quantifying these potential impacts. Additionally, this report focuses on industries which are significant contributors, or could be significant contributors, to economic activity and employment in the state.

The analysis in this report focuses on the impact on the Energy Plan on growth opportunities for industry while acknowledging the limitation that EY's electricity market modelling does not consider the impact of these industries on electricity demand differentially between the Energy Plan and Uncoordinated Outlook scenarios.

Industries that are likely to be impacted by the Energy Plan are those that have a high electricity or energy consumption, as they will benefit from lower electricity prices and a reduction in Scope 2 emissions. Export-exposed industries are expected to benefit from the Energy Plan as they are most vulnerable to changes in global markets and can penetrate green markets. In addition to the Energy Plan's impact on these industries, this report focuses on significant or potentially significant industries in Queensland which make a meaningful contribution to the broader Queensland economy or specific regional economies within the state. Industries with strong domestic linkages to other industries are also identified as being relevant, as threats to one industry along a supply chain could have significant flow-on effects to other parts of the supply chain. To this end, we performed a high-level analysis of Queensland's economy to identify relevant industries across four key criteria:

- Energy or electricity-intensive industries which could benefit from lower electricity prices
- Large or potentially large industries which make a meaningful contribution to the Queensland economy or specific regional economies within the state
- Industries with linkages to other domestic industries, such as the aluminium refining value chain in Queensland
- Export-exposed industries which could be exposed to trends in global markets, creating opportunities and challenges for the industry

The starting point for the analysis was to examine the electricity and energy profiles of Queensland's industrial base. From Figure 8 below, two industries that stand out in terms of non-residential electricity consumption. Excluding residential electricity consumption:

- Mining, oil, and gas production consumes 45% of Queensland's electricity
- Manufacturing consumes 44% of Queensland's electricity

The majority of the remaining 11% of electricity consumption is from transport. Industries such as agriculture and commercial services consume an insignificant amount of electricity and a small portion of total energy, suggesting that they are unlikely to be significantly impacted by the Energy Plan and were thus excluded from this analysis.

Mining-related electricity consumption predominately comprises of oil and gas extraction. However, in terms of electricity intensity, metal mining such as copper and zinc is considerably more electricity intensive per unit of output. Despite making up a fraction of mining output, metal mining made up 20% of the industry's electricity consumption.

The Australian Energy Update provides limited data on the breakdown of electricity consumption within manufacturing. Just 30% of manufacturing's electricity consumption is reported, with key industries such as non-ferrous metal refining and metal manufacturing omitted. However, other

estimates suggest that the aluminium smelting industry in Queensland could consume 13% of the state's total electricity consumption[18]. The metal refining industry is highly electricity intensive across aluminium, zinc, copper, and alumina, and the industry has a strong presence throughout Queensland. Other manufacturing subsectors such as food products and chemical manufacturing consume just one-fifth of the electricity as the aluminium smelting industry. Thus, the metal refining subsector is likely to be the most impacted manufacturing sector.

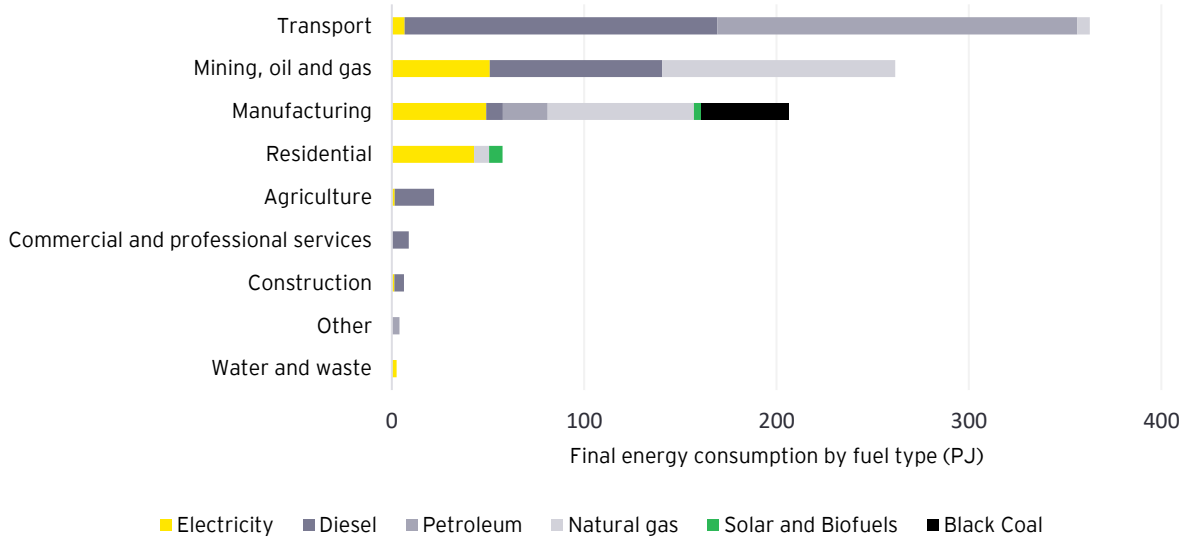
As these two industries make up almost 90% of Queensland's industrial electricity consumption, with scope to further electrify their processes, mining and metal refining manufacturing were identified as industries which are likely to be impacted by the Energy Plan.

In addition to an analysis of the current industrial base, emerging industries were also analysed for electricity intensity to understand how the Energy Plan could attract these emerging industries to Queensland. From this process, two emerging industries were identified as having high electricity intensity and consequentially high electricity costs:

- Green hydrogen production costs are made up of 72% electricity costs[19]
- Battery manufacturing production costs are made up of 15% electricity costs[20]

Additionally, AEMO estimates that Queensland's hydrogen production could consume more than 8,000 GW each year by 2040.[21] These emerging industries were thus included in our analysis. Further details of our criteria analysis in particular details of the economic significance and export-exposure of Queensland's industrial base can be found in Appendix A.

Figure 8: Energy consumption for Queensland sectors by fuel type



Source: Australian Energy Update, 2021

[18] Butler, 2020
[19] EY analysis
[20] Future Batteries Industries Cooperative Research Centre, 2021
[21] AEMO, 2022b

Opportunities to uplift established industries

Queensland's economy is primarily built upon the mining, agriculture, manufacturing and services industries, with services concentrated in urban centres, and other industries present throughout regional Queensland. These industries make up a significant portion of the Queensland's gross state product (GSP) and employment and have linkages with all parts of Queensland's economy. Some of these industries, including mining, agriculture, and manufacturing, are trade-exposed and face increasing pressure to decarbonise in line with major trading partners. For mining and manufacturing, in particular metal manufacturing, Scope 2 emissions generated from electricity consumption make up a large portion of total emissions. Additionally, electricity costs are a major cost component for industry. Implementing the Energy Plan could deliver low-cost renewable energy to these industries, reducing input costs and reducing the total emissions generated in these industries, allowing for these industries to penetrate global green markets. This section explores the potential impacts of the Energy Plan on established industries, with a focus on metal refining and manufacturing, and new economy resource mining.

Metal refining and manufacturing

Queensland's metal refining and manufacturing industry is dominated by three non-ferrous metals: aluminium (produced through refining bauxite and alumina), copper, and zinc. Non-ferrous metal manufacturing generated more than $13 billion in GSP in 2022, with strong linkages and value-added onto the non-ferrous mining operating in the Cape York Peninsula (bauxite) and Mount Isa (copper and zinc). Queensland's metal refining infrastructure is located across regional economies including Gladstone (alumina and aluminium), Mount Isa (copper), and Townsville (zinc and copper). The metal manufacturing industry in Queensland is being impacted by global trends, experiencing record-high metal prices and increasing demand for green metals. As electricity costs make up a significant portion of the total cost refining metals, implementing the Energy Plan could deliver low-cost renewable energy to these industries. Additionally, electricity consumption is responsible for up to 80% of the emissions generated by metal refining, and the Energy Plan could reduce these emissions, opening opportunities in green metal markets.

Market prices set to remain high

Copper, zinc, alumina and aluminium prices reached record highs in March and April 2022. Prices are expected to remain high going forward, reflecting supply shortages and increases in demand for the non-ferrous metals. High market prices provide producers with greater margins and reduce the risk of financial unsustainability, benefiting Queensland refineries of copper, zinc, and aluminium. Further, increased global demand for copper, zinc, and aluminium as economies move towards low-carbon futures present Queensland refineries with an opportunity to expand.

While copper, zinc, and alumina refineries in Queensland produce at a globally cost-competitive price, aluminium smelters in Australia are not as cost-competitive. Despite high aluminium prices, some refineries are still struggling to remain sustainable due to high electricity prices, and there are concerns about the financial and environmental sustainability of Australian aluminium refineries across Queensland, New South Wales, and Tasmania. Additionally, while aluminium prices may remain high in the medium-term, prices could normalise in the long-term, putting pressure on refineries in the future. Overall, Queensland refineries are expected to benefit from high aluminium market prices in the medium-term.

High exposure to electricity prices

Electricity costs make up between 10% to 30% of the total cost of producing non-ferrous metals, making producers vulnerable to increases in electricity prices. Metal refineries in Queensland make up a large amount of the total electricity demand of the state, with aluminium alone consuming 13% of the state's electricity.[22] To secure future growth in the industry, Queensland's electricity supply

[22] IEEFA, 2020

needs to be reliable, low-cost, and green. The Energy Plan sets out a coordinated approach towards greening the state's electricity supply while ensuring that prices remain stable, providing refineries the long-term certainty needed to make investment and operational decisions. Under the Energy Plan, electricity prices over the next two decades are expected to be lower than the Uncoordinated Outlook scenario, providing market certainty and improved profitability.

Major companies are greening their portfolios

Major companies with operations in Queensland such as Rio Tinto and BHP are actively greening their portfolios.[23] Since 2014, Rio Tinto has been proactive in selling off coal assets and greening their portfolio of mines and refineries. Currently, Rio Tinto's operations in Australia account for 60% of their total emissions, the majority of which are generated by aluminium refineries in Australia which use predominantly coal-fired electricity. Approximately 71% of Rio Tinto's global electricity usage is sourced from hydro, with aluminium refineries in Canada and Iceland benefiting from this low-cost renewable energy, allowing them to compete on both price and sustainability.

Australian aluminium refineries create more than four times the carbon emissions per tonne of aluminium as these hydro-powered refineries, while producing it at a cost of almost 20% higher. This places Australian aluminium refineries, including Queensland's Boyne Island smelter in Gladstone, at risk of downsizing. Delivering low-cost renewable electricity to the Boyne Island smelter through the Energy Plan is critical to its long-term financial and environmental sustainability.

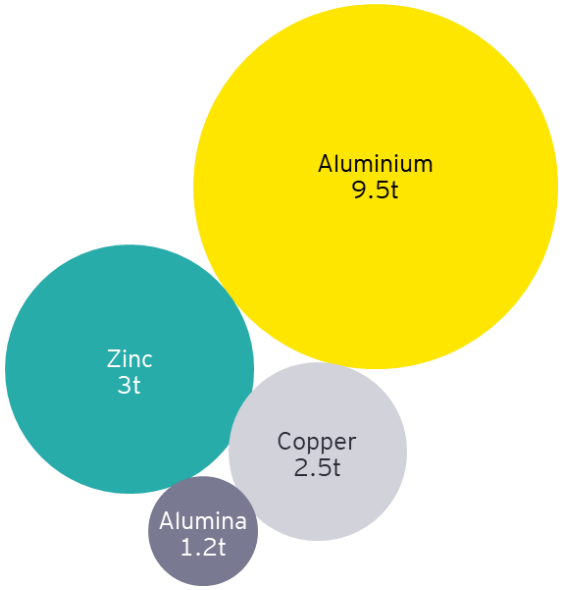
Copper, zinc, and alumina refineries also face this issue but to a lesser extent as they are less reliant on electricity in the production process. It is essential for Queensland producers to improve the financial and environmental sustainability of refineries going forward to remain competitive, and the Energy Plan directly addresses these issues. By delivering lower electricity costs and lower Scope 2 emissions in the metal refining industry, the Energy Plan could support the industry's ongoing financial and environmental sustainability.

The Energy Plan could reduce emissions by up to 80%

As countries move towards low-carbon and zero-carbon technologies such as electric vehicles, battery storage, and wind power generation, consumers and producers are becoming increasingly conscious of the carbon-intensity of the metals used to produce these technologies. The emissions produced from refining a tonne of various metals are shown in Figure 9. These figures relate to global industry averages for each metal which can vary significantly depending on the Scope 2 emissions generated from purchased electricity.

[23] IEA, 2021

Figure 9: Tonnes of carbon emissions produced from refining one tonne of metal



Source: EY analysis

Emissions can be generated from the reaction between anodes and reductants, heat generated during the process, diesel consumed during transporting of raw materials, and electricity use, as shown in Table 1. For each of these metals, with the exception of alumina, emissions from electricity use accounts for the majority of emissions created.

Table 1: Breakdown of carbon emissions by metal and source (%)

Metal	Electricity	Anodes & reductants	Process heat	Transport	Other
Aluminium	80%	17%	2%	-	1%
Copper	60%	-	5%	35%	-
Zinc	56%	-	-	-	44%
Alumina	25%	-	70%	2.5%	2.5%

Source: Rio Tinto, 2021 and Wood Mackenzie, 2021

By implementing the Energy Plan, the emissions created from electricity consumption in Queensland would fall around 70% by 2032-33 from 2005 levels, significantly reducing the amount of emissions produced by metal refineries in Queensland, and improving the long-run sustainability and commerciality of these refineries.

The Energy Plan will underpin decarbonisation of the Queensland electricity system and therefore provide a pathway for decarbonisation for grid connected energy intensive industries. Direct contracting with grid connected renewable development by heavy industry will also support further renewable development.

Low-carbon metals are attracting premiums of 15%

As demand for low- and zero-carbon metals grows, consumers are becoming more willing to pay a premium for green metals. This green premium is also becoming more institutionalised and recognised by financial institutions such as S&P. S&P as of January 2022 now produce daily prices for low- and zero-carbon aluminium. The price for low-carbon aluminium has grown from 11% higher

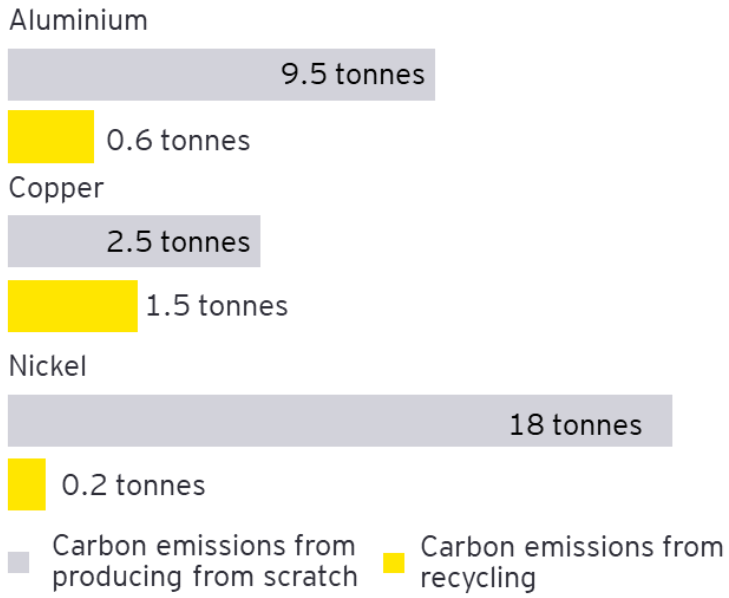
than the market price for aluminium in January 2022, to nearly 15% higher in April 2022. As demand for low-carbon aluminium grows further, this green premium is likely to continue growing.

Currently, to be eligible for the "low-carbon" aluminium premium, refineries must be able to demonstrate that the aluminium they produce has a carbon intensity of less than 4 tonnes of CO_2 per tonne of metal. Aluminium produced in Queensland is estimated to have a carbon intensity of 9.5 tonnes of CO_2, but if the Energy Plan was implemented, Queensland's aluminium could be eligible for this green premium by 2032. This could be further expedited if investments into reducing the emissions intensity of aluminium production such as Rio Tinto and Alcoa's ELYSIS technology were supported. Without a coordinated plan, Queensland's aluminium is unlikely to be eligible until 2038. Green premiums for other metals such as copper and zinc have not materialised in the same way as aluminium has, most likely due to aluminium being more emissions intensive. However, it is likely that secondary markets for green metals will emerge as demand rises. Queensland's copper and zinc production is already globally competitive in terms of emissions intensity, and thus could be eligible for green premiums in the near future or become eligible as the Energy Plan is implemented.

Improved recycling processes could provide a pathway to low-emissions production

The production of metals requires energy usage throughout the mining and manufacturing processes. Recycling these metals could provide a pathway to reduce the energy and emissions intensity of producing these metals. The energy used to recycle metals is significantly lower than the energy required to produce metals from primary sources as shown in Figure 10. Improving recycling rates could enable Queensland to produce low-carbon metals to target global markets willing to pay a premium for green recycled metals.

Figure 10: Carbon intensities per tonne of metal



Source: CSIRO, 2012 & Reuters, 2021

By moving towards low-carbon production methods such as recycling, Queensland could capture economic benefits in global green metal markets. Recycled aluminium has a carbon intensity of 0.6 CO_2 per tonne of metal, making it eligible for the low-carbon premium. As the global market evolves further, recycling metals is becoming significantly important to meet demand. Queensland increasing its recycling capacity could capture more of Australia's scrap metal production.[24] In 2020, Australia exported 119,000 tonnes of scrap aluminium for recycling, with the Boyne Island smelter recycling 2,340 tonnes per year.[25] Therefore, there is likely an opportunity to improve

[24] Soo VK et al., 2017

[25] Australian Aluminium Council, 2021

waste and recycling management to capture more low-hanging fruit in Australia's scrap metal production. This could be done by encouraging a low-cost disassembly design, increasing the use of recycled content in public infrastructure investments, and assist manufacturers to capture green premiums in the globally market.

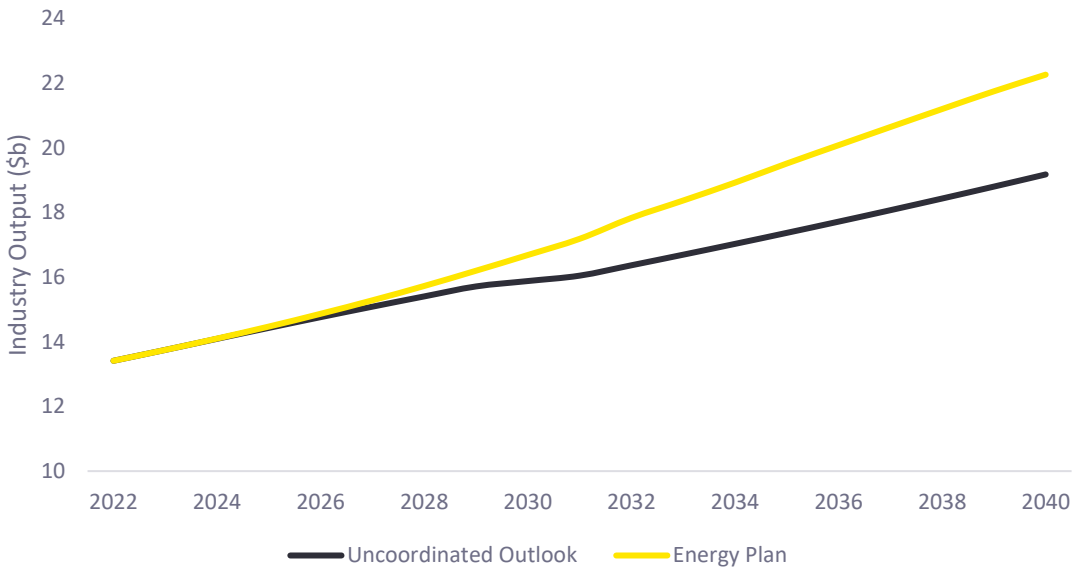
While recycling scrap metals can pose challenges around scaling up and 'downcycling' into lower-grade metals, there is scope for Queensland recycled metal manufacturers to capture green premiums to offset these challenges. As demand for aluminium is estimated to at least double by 2050, the demand for green metals could intensify, further mitigating these challenges.

The Energy Plan could secure a higher growth path for the industry

The future financial performance of Queensland's non-ferrous metal manufacturing industry is linked with the state's potential transformation to renewable energy. Currently, metal manufacturers, in particular aluminium, are facing high electricity costs. With electricity usage being responsible for up to 80% of the emissions created during the metal manufacturing process, the Energy Plan presents an opportunity to bolster the long-run sustainability of the industry in Queensland. Additionally, electricity prices are set to be lower under the Energy Plan than if the state did not implement the Energy Plan.

Overall, the industry could grow from around $14 billion in 2022 to $22 billion in 2040 if the Energy Plan was implemented as shown in Figure 11. This is $3 billion greater than if an uncoordinated approach was implemented, which would support 2,500 more jobs in 2040.

Figure 11: Output of Queensland's non-ferrous metal manufacturing industry under the Energy Plan



Source: EY analysis

This elevated potential output is attributable to:

- **Aluminium production attracting green premiums from 2032** – If the Energy Plan is implemented, the emissions intensity of aluminium would fall below 4 tonnes of CO_2 per tonne of aluminium by 2032. This would qualify the industry for green premiums in the global market.
- **Lower electricity prices improving profitability** – Electricity costs make up between 10% and 30% of the total cost of metal refining. By reducing electricity prices through the Energy Plan, input costs could fall, and profitability could improve.

- **State-wide green premiums attracting investment** – From implementing the Energy Plan and reducing Queensland's emissions, the state is seen as an attract destination for investment. This is reflected in the Energy Plan's increased private investment into renewable generation, with flow-on impacts to the metal refining industry.

- **Metal manufacturers capturing more market growth** - As countries move towards to low-carbon economies, demand for non-ferrous metals is expected to grow significantly. By implementing the Energy Plan, Queensland's metal refining industry could attract more market share and penetrate into green markets.

- **The avoidance of the Boyne Island smelter potentially downsizing in 2030** – The aluminium smelter is currently one of Rio Tinto's largest emitting assets[26] and faces acute cost pressures from global aluminium smelters which utilise low-cost renewable energy in their production process. The long-term feasibility of the smelter is becomingly increasingly tied to its environmental sustainability, and with 80% of the smelter's emissions coming from electricity use, implementing the Energy Plan is likely to have a significant positive impact on the smelter's long-term feasibility. To capture this, it was hypothesised assumed that once the current power purchase agreement expires in 2030, the asset could be downsized.

[26] Rio Tinto, 2021

Resource mining

The resource mining industry is a major component of the Queensland economy. The industry, made up of non-ferrous metal mining and exploration services, contributes almost $14 billion to Queensland's GSP. 80,000 jobs are supported by the resource industry, with 70% of these jobs in regional Queensland.

Queensland is one of the world's largest producers of lead, zinc, and bauxite, and is also a significant producer of silver and copper. 10.7% of global bauxite deposits and 8.4% of global zinc deposits are located in Australia, with Australia being the largest exporter of these metals. Queensland's major mining locations are near Mount Isa, Weipa, Mackay, Townsville, Gladstone, and Rockhampton. By implementing the Energy Plan, demand for non-ferrous metals could increase and growth in critical minerals such as vanadium could be supported. This growth builds on the current prospectivity of Queensland's North-West Minerals Province for resources such as copper, zinc, and potentially vanadium.

Demand for new economy resources set to grow

In a global economy transforming to clean energy generation and technologies, demand for resources is set to grow as traditional capital is replaced with clean capital. Demand for resources and minerals is expected to grow due to this capital replacement and the emergence of new technologies which require more components to produce. A typical electric car requires six times the mineral inputs of a conventional car, and an onshore wind plant requires nine times more mineral resources than a gas-fired power plant.[27] Resources Queensland produces, such as aluminium, copper, and zinc, are expected to benefit from higher demand.[28]

Due to increases in demand, there is potential for a global aluminium supply shortfall of almost 30%, and a copper supply shortfall of 85%, which poses significant challenges to the clean energy transition.[29] Supply shortfalls tend to be accompanied by increases in the market price for a commodity and increases in exploration spending to discover more reserves and boost supply. While the market has responded to supply shortfalls in the past, responses tend to lag behind the issue and create price volatility. Due to the consistent and unprecedented growth in demand for aluminium and copper, there is concern that once supply falls behind demand, it could be increasingly difficult to catch up.

Commodity prices are already at record highs for aluminium, zinc, and copper, and are forecast to remain high, which is reflective of the expected supply shortfalls in the industries. High aluminium and copper prices will negatively impact Australian manufacturing and in particular investments into grid transmissions, and higher prices could push out the cost of transmission investments significantly. Therefore, ensuring a domestic supply of these critical minerals will buffer Australian industries from price fluctuations.

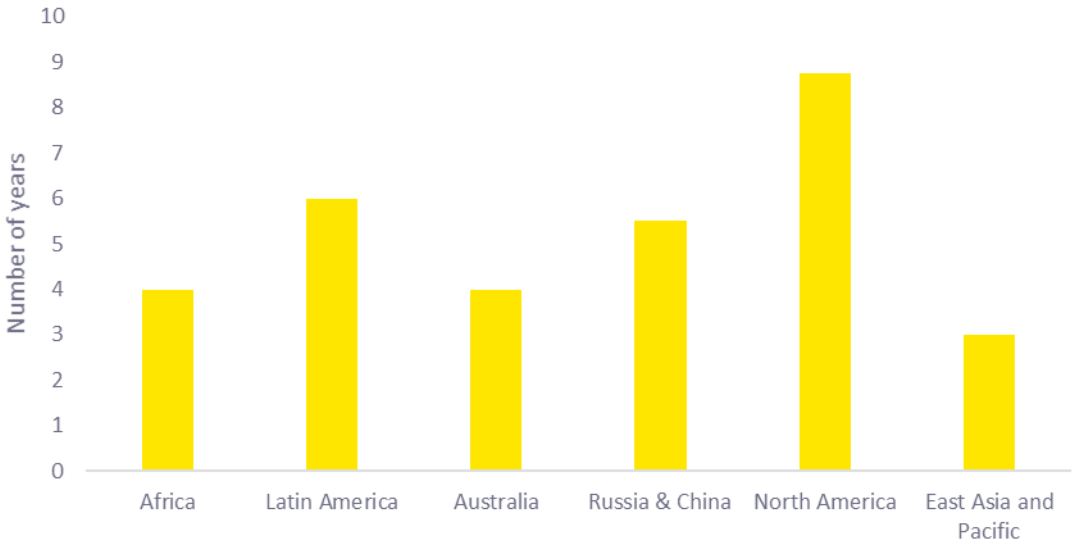
Australia's short mine lead times make it an attractive destination for investment

Since 2000, Australia has performed better than other nations in terms of lead times.[30] To remain competitive in the global minerals market, Australia must be an attractive destination for investment into the resources sector. Key to remaining attractive is providing certainty around mine lead times. Governments could play an important role in this by strengthening national geological surveys, streamlining regulatory burdens and red tape, providing financial support to de-risk important projects, and supporting the rehabilitation and reuse of abandoned mines and mine waste.

[27] International Energy Agency, 2022
[28] Department of Natural Resources and Mines, 2017
[29] Reuters, 2021
[30] World Bank, 2016

In recognition of their critical role in global decarbonisation, Australia and Queensland have made allowances for emerging minerals such as lithium and vanadium.[31] The Saint Elmo vanadium mine in Queensland was declared a prescribed project, allowing the Coordinator-General to streamline approvals and fast-track delivery.[32] Opportunities for streamlining approvals to attract investment should be investigated and supported by the Queensland Government.

Figure 12: Mine lead times across regions since 2000

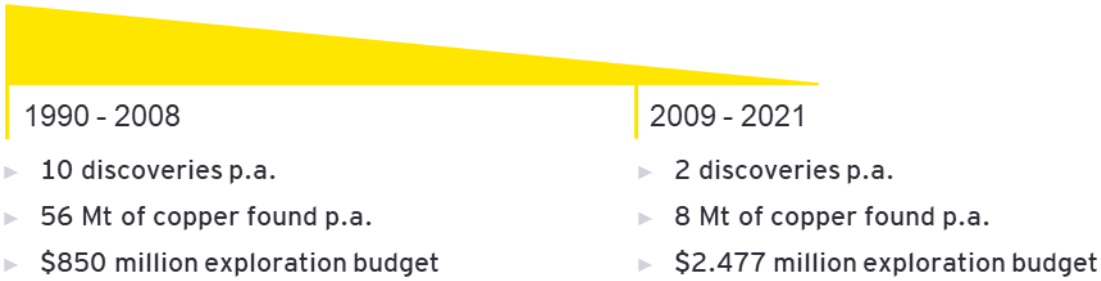


Source: World Bank, 2016

Declining ore discoveries are leading to an exploration boom

Globally, ore discoveries and ore grades have been declining. This creates concerns for supply and productivity at new and existing mines. Despite record exploration spending since 2008, the number of copper discoveries has fallen.

Figure 13: Copper discoveries and exploration budgets between 1990-2008 and 2009-2021



Source: S&P Global, 2022

As copper discoveries fall, the price of copper is pushed up, which sends signals to the market to expand exploration budgets in an attempt to boost supply. High exploration budgets and demand puts pressure on the exploration economy which is primarily made up of drillers that collect rock samples, and assay laboratories which assess those samples for the presence of minerals. The current and projected exploration boom has resulted in a shortage of drillers being available for hire, as well as backlogs at assay laboratories of up to six months.[33] This undersupply of exploration services is limiting potential ore discoveries and exacerbating poor discovery rates.[34]

[31] IEA, 2022
[32] Queensland Government, 2020a
[33] Financial Review, 2021
[34] ABC News, 2022a

The exploration industry is an important contributor to the Queensland regional economy, contributing 6% of gross value-added in the state's resource sector.[35] The exploration industry employs highly skilled workers with technical expertise, and successful discoveries have the power to transform regional economies. Considering the rise of new economy minerals, and the long lead times from discovery to mining, there is an opportunity to invest further into exploration programs to overcome high upfront costs and develop a pipeline of new economy minerals production. Furthermore, there is scope to increase the supply of exploration services such as drilling and laboratory testing to address backlogs and become a hub for exploration services, serving mining companies in other states and Pacific nations.

Most mines in Queensland operate off the electricity grid

Mining is the most electricity-intensive industry in Queensland, consuming 20% of the state's total electricity.[36] Electricity use in the resources sector depends on the type of resource being produced, but typically occurs during the crushing and ore extraction process for minerals such as copper and zinc. Regardless of the product, large amounts of energy are required across the entire resource sector value chain in the form of diesel, natural gas, and electricity. This means that the sector has a high level of exposure to energy price shocks.

Additionally, due to the remoteness of mines, there are large parts of the mining economy which outside of the state's electricity grid. One study has demonstrated that mines located more than 300 kilometres from a major substation tend to be off grid and are powered with on-site natural gas or diesel generators.[34] In Queensland, this represents a large part of the mining economy which is centred on Mount Isa and is powered by gas, as well as bauxite mines in Weipa which are powered by diesel generators. While these off-grid industries could benefit from the economic spill-overs created by the significant investment into renewable energy generation and transmission from the Energy Plan, they are unlikely to benefit from the direct reduction in emissions and electricity prices. Considering that the industry is the state's largest consumer of electricity, the mining industry could become an outlier in an otherwise low-carbon economy. The electrification of these mines and communities, either in local grids or connected to the state's electricity network through the CopperString project, is key to reducing emissions produced by the mining industry in line with the decarbonising of the electricity grid along the Queensland coast.

The CopperString project could unlock the benefits of the Energy Plan for mines in Queensland - CopperString 2.0 is a proposed 1,000km high-voltage overhead transmission line to connect the North West Minerals Province to the NEM. The proponents, CuString Pty Ltd have stated that the investment could unlock an estimated $740 billion worth of resources in the North West Minerals Province. The Queensland Government has fast-tracked the project by declaring it as a priority, and is working with key stakeholders to determine the best way to connect the Minerals Province with the NEM.

There are significant opportunities to support this electrification by using a combination of wind, solar, and battery storage solutions. This electrification can begin immediately, as is the case at Rio Tinto's Weipa bauxite mines which is transitioning from diesel generators to solar and battery. The existing diesel or gas generators at off-grid mines can be downsized over time and used as back-up stabilisers as renewable energy generators are installed. Government action could play an important role in supporting and incentivising this electrification to complement the Energy Plan's investment roadmap. This action could include financial support or setting an "off-grid renewable energy target" to converge off-grid industries with the rest of the state.

[35] Australian Bureau of Statistics, 2020
[36] DISER, 2021
[34] The University of Queensland, 2018

Improving discovery rates and exploration capabilities

To improve discovery rates, the Queensland Government has developed a series of funding programs designed to support the exploration and discovery of resources. The Strategic Resources Exploration Program (SREP) invested $27 million between 2017-21 to address this issue and boost exploration of resources in North West Queensland. Funding from this program contributed to finding potential high-value heavy rare earth elements in the Cloncurry region and the research for cobalt in copper mine waste.[37] SREP focused on the resource-heavy areas surrounding Mount Isa and funded the exploration of gas, new economy minerals, and geophysical data collection to improve exploration efforts in the future.

The $2.5 million Collaborative Exploration Initiative (CEI) offers grants of up to $200,000 to encourage exploration in greenfield areas, support innovative exploration techniques and technologies, and promote the discovery of new economy minerals. This program has just delivered its sixth round of funding and focuses on the whole of Queensland as opposed to the North West area, and was allocated a further $17.5 million over 4 years in the 2022-23 state budget. While the program does encourage the discovery of new economy minerals, it does not exclusively focus on it, with some rounds of the program funding the exploration for petroleum resources.

The North West Minerals Province Strategic Blueprint sets out a series of programs and investment including diversifying the region, supporting the exploration industry, and streamlining mine lead times. The Queensland Government's investments into the exploration industry have included supply-side policies such as improving and developing geological surveys and data, and demand-side policies including establishing collaborative exploration programs. As exploration spending is growing rapidly, supply shortages amongst drillers and assay laboratories are emerging. Further demand-side policies are likely to lead to crowding out and exacerbating these supply issues. The Queensland Government should continue to support the exploration industry through supply-side policies which include improving geological surveys and building capacity amongst drillers and assay laboratories.

Rehabilitating and reindustrialising decommissioned mines

As a state with a strong history of mining, Queensland is home to more than 15,000 abandoned mines, which consume a large geographic area throughout the state.[38] These mines present an opportunity for rehabilitation and reindustrialisation to turn large areas of unutilised land into agriculture, environmental, and industrial outputs. Land rehabilitation can restore ecological value to the broader mine area, however there are areas which cannot be rehabilitated for substantial environmental value. In some instances, these areas are equipped with key infrastructure including rail linkages, roads, housing, and electricity infrastructure and can be reindustrialised into green hydrogen and manufacturing precincts.

There is an opportunity to expand the planning and operation of mines to include post-mining production. This would include post-mine planning being factored into the construction process in order to build future-proof infrastructure with a view to service post-mine production. These efforts can be made through the Queensland Government's appointed Mine Rehabilitation Commissioner to drive the regeneration of land on old mine sites and create new jobs in regional communities.

The agriculture, environmental, and industrial opportunities in post-mine production

Mine land rehabilitation requires substantial capital expenditure but also provides significant economic and environmental long-term returns. Based on EY analysis, mines can be rehabilitated to provide agriculture, environmental, and industrial benefits.

Figure 14 shows that environmental outputs can utilise 55% of the total mine land, with agricultural outputs utilising 25% of the mine land, reflecting the land-intensive requirements of biodiversity and cattle grazing. Less than 1% of the mine land can be repurposed towards industrial outputs including

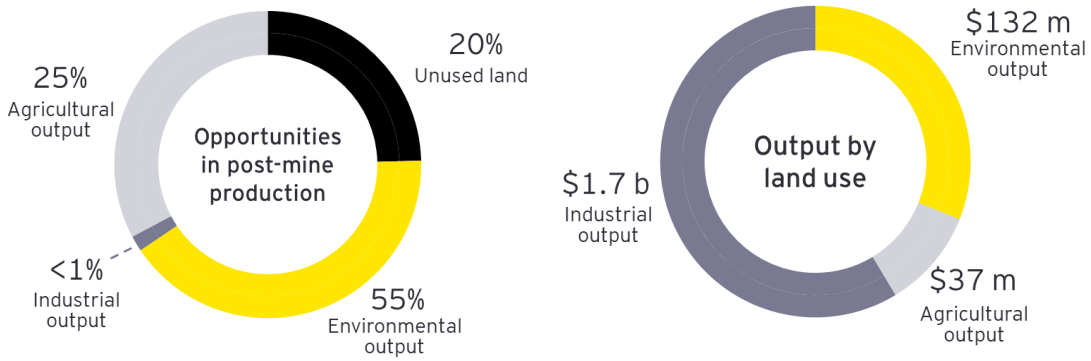
[37] Queensland Government, 2021b

[38] Lock the Gate, 2016

manufacturing, abattoirs, and hydrogen manufacturing. Approximately 20% is unused and is comprised of infrastructure such as roads and housing, and the final mine void which cannot be rehabilitated.

The Newlands mine which is one of the largest mines in Queensland and is expected to close in 2027, would free up more than 150,000 hectares of land for productive use. By applying this breakdown of land repurposing to the Newlands mine, industrial outputs could be $1.7 billion a year, agricultural outputs could create $37 million a year, and environmental outputs could generate $132 million a year.

Figure 14: Breakdown of how the Newlands mine can be rehabilitated and reindustrialised



Source: EY analysis

While this breakdown of land repurposing is based on NSW mines, Queensland's geography is more diverse and some mines may not be suitable for agriculture or environmental purposes. Assessments of abandoned mines will need to be undertaken to understand the potential use cases for mines, targeting low-hanging fruit which require minimal rehabilitation costs and provide strong productive opportunities. Mine rehabilitation is already occurring at mines around Australia and Queensland to turn them into renewable energy hubs or to utilise mine waste products to extract critical minerals.

Renewable energy hubs: Rehabilitated mine land can be reindustrialised into renewable energy hubs. This land is often well-placed for establishing renewable energy hubs due to its strong solar and wind resources. There have been a variety of renewable energy projects successfully established on rehabilitated mine land.

- The Kidston pumped hydro project is a 250MW pumped storage power plant being developed at the abandoned Kidston gold mine site in northern Queensland. The project forms an important part of the Kidston Clean Energy Hub which is an integrated solar, wind and hydroelectricity generation and storage hub. The hydro project takes advantage of existing dam and water pipe infrastructure, accommodations, road access, an airstrip, and the large open-cut mine pits from the former mine that act as upper and lower reservoirs.

- French renewable energy company Neoen has invested $350 million to build a green power hub in Bulgana at a rehabilitated gold mine in Victoria. The project commenced construction in 2019 and involved building 56 wind turbines and a 20MW battery.[39] The mine site was chosen due to the land's wind resources and proximity to transition lines. Construction finished in 2020, and now the hub produces over 750,000 MWh per year in renewable energy. The hub entirely powers the country's biggest agricultural glasshouse nearby.

[39] Bulgana Green Power Hub, 2021

- AGL is investigating the feasibility of redeveloping the Muswellbrook mine located inland from Newcastle, NSW into a pumped hydro renewable energy production and water storage facility, utilising on site infrastructure and the remaining mine void.[40]

- Anglo American are working to reindustrialise the Dawson Mine in Queensland into an integrated solar-powered green hydrogen production facility.[41]

Mining waste products and extracting critical minerals: After mines are decommissioned, critical and useful resources are often left behind. Minerals left behind offer substantial opportunity to collect critical minerals that can be used for battery and renewable manufacturing, such as cobalt, nickel, and zinc. Additionally, some mines are decommissioned during periods of low commodity prices and are recommissioned once prices return to normal levels. Mining waste at abandoned mines in the resource-rich Mount Isa area could have the potential for delivering economic benefits to the state.

New Century Resources reopened the Century mine near Mount Isa in 2018 after it was abandoned in 2016 by MMG. The mine was once the world's third largest zinc mine before it was closed due to the low price of zinc and low reserves affecting profitability. The reopening involved the processing of mine waste previously left at the mine site, recovering silver and zinc concentrate. This project will reportedly create $1.8 billion in cash flow, with further benefits from strategic continued mining and New Century's commitment to rehabilitation.

Opportunities to uplift growth in vanadium mining and processing

Vanadium is an emerging critical mineral that can be used effectively in large-scale redox batteries which could stabilise electricity grids and store power in remote communities. The future of vanadium is seen to be tied to the rapid increase in electricity demand both domestically and abroad, which will require large-scale batteries to store and stabilise electricity generation and distribution. The growth of this industry is from a very small starting base, which creates uncertainties over the growth path that vanadium mining and processing could take. Currently, global demand for vanadium was just above 100,000 tonnes in 2020, with the overwhelming majority consumed in the process of creating hardened steel. While the market for steel-hardening vanadium is projected to grow by just 3% a year until 2029, vanadium for battery production is forecast to grow by an average of almost 21% a year, signalling an opportunity for Queensland to capture growth in demand for high-purity battery-grade vanadium.[42]

A two-tiered vanadium market is developing; one for low-purity vanadium, and one for high-purity vanadium. Low-purity vanadium used in steel production, typically 80% purity, whereas battery-grade vanadium is high-purity at 98% vanadium. While the supply of low-purity vanadium is dominated by China and Russia and is expected to grow slowly, the market for high-purity vanadium is undersupplied and expected to grow rapidly. New vanadium demand from China alone represents an almost 30% increase in 2020 high-purity vanadium production, with countries like Japan, South Africa and Europe also expected to announce new vanadium battery projects in the near future. High-purity vanadium is expected to fetch premiums of 10 to 15% and rapid growth in demand for the mineral could create a supply deficit in 2030.[43]

Although vanadium batteries are considered to be safer, more durable, and more recyclable than lithium batteries, lithium batteries dominate the storage industry accounting for 98% of the global battery market. In order for vanadium batteries to compete with lithium ones, vanadium producers must offer end users with competitively priced vanadium batteries. Vanadium batteries are still an early-stage product that requires further development to be commercialised for large-scale grid

[40] PV Magazine, 2021

[41] Australian Renewable Energy Agency, 2020

[42] Office of Chief Scientist, 2021

[43] Corporate Connect, 2021

stabilising projects, however demand for these batteries as part of the Energy Plan could support commercialisation.

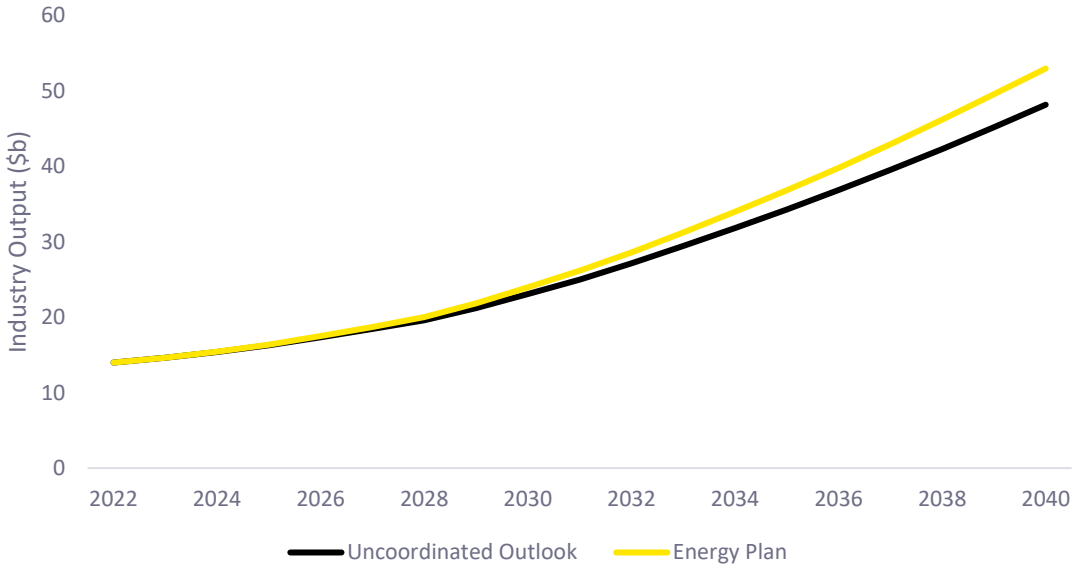
The Energy Plan signals to the market the need for greater storage technologies to support the increase in variable renewable energy technologies like wind and solar. This creates a pipeline of potential battery developments that could support growth in upstream inputs like vanadium to unlock mine to manufacturing opportunities in Queensland. Access to Queensland-based vanadium would ensure Queensland constraints on battery production could be minimised where the global market might be facing supply constraints for this input.

The Energy Plan is expected to have some benefits for the resource mining industry

The Energy Plan targets significant investment into renewable energy generation along the National Electricity Market grid in Queensland. With the majority of the mining industry in Queensland operating off the grid, there are limited benefits for the industry from lower electricity prices and a renewable electricity supply. However, with the right policy mix, the industry could capture some growth in vanadium mining, mine rehabilitation, and explorative services.

Figure 15 shows that the non-ferrous metal mining, non-metallic ore mining, and exploration and mining support services industries accounted for almost $14 billion in output in 2022, which could grow to $53 billion in 2040 under the Energy Plan. This is $5 billion more than industry output without the Energy Plan and could support 5,200 jobs.

Figure 15: Industry output for the mining industry excluding iron ore and coal mining



Source: EY analysis

This added growth could be attributable to:

- **Improved capacity for delivering explorative services** – By increasing the capacity for delivering explorative services in conjunction with increases in demand, Queensland could become a global hub for explorative services, improving discovery rates and boosting supply.
- **State-wide green premiums** - From implementing the Energy Plan and reducing Queensland's emissions, the state is seen as an attractive destination for investment.
- **Improved growth in the vanadium mining industry** – The Energy Plan is expected to boost demand for big batteries in Queensland, uplifting growth in the vanadium mining industry.

- **Improved mine rehabilitation and reindustrialisation** – By developing and delivering a range of policies outlined above to improve mine rehabilitation, Queensland could benefit from agriculture, industrial, and environmental opportunities that could leverage mine infrastructure to produce output.

Opportunities to capture growth in emerging industries

As economies increasingly electrify, install more renewables and storage, and adopt hydrogen power, there are emerging growth opportunities that Queensland can capture to create economic growth and jobs. Queensland is well-positioned to capture growth in the emerging green hydrogen production and battery manufacturing industries due to its abundance of renewable resources, existing supply chains, and its skilled labour force.

To attract these industries to the state, the right preconditions for growth must be set. For these emerging industries, this includes supplying reliable, low-cost, and green electricity to the state. Electricity costs make up a large portion of the total cost of green hydrogen production and battery manufacturing and ensuring that this electricity is renewable is key to attracting investments into the industry. Along with the right policy mix, there are considerable benefits to be gained from Queensland implementing the Energy Plan, supporting new growth and jobs in the state.

Green hydrogen

Green hydrogen is emerging as a key source of energy as countries around the world decarbonise. The production process uses electrolysis, powered by renewable energy, emitting no carbon dioxide. Green hydrogen production is at its early stages of development in Australia. However, there are several large-scale projects in the pipeline. Queensland has the potential to be a global leader in green hydrogen production, given its comparative advantage in renewable resources.

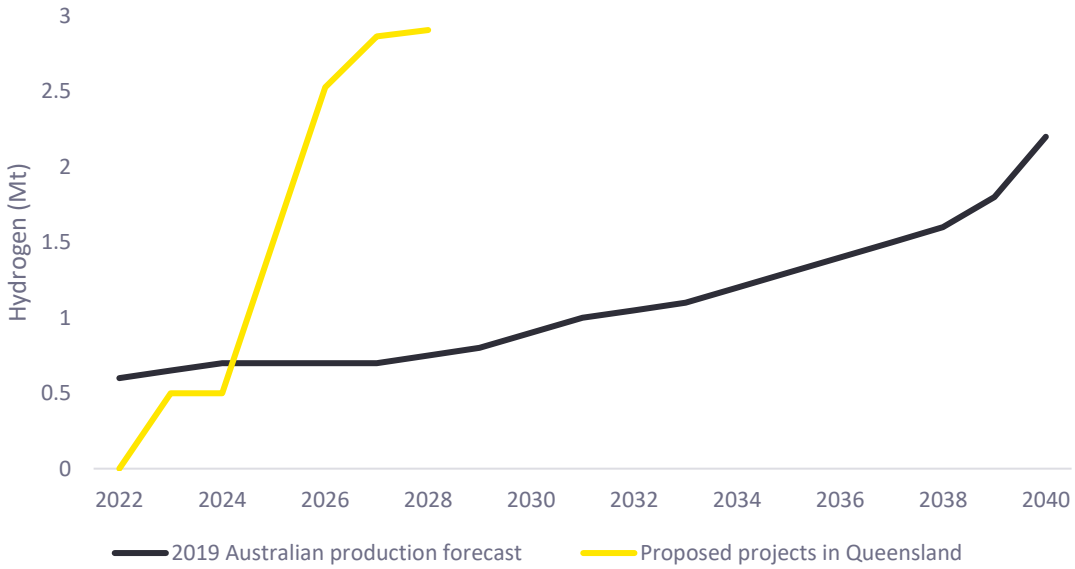
Green hydrogen is an emerging industry that Queensland could have a comparative advantage in

There is expected to be significant growth in the green hydrogen industry, with many countries investing now to capture growth in the future. Industry growth is already greatly outpacing forecasts made in 2019, which projected that Australia's hydrogen production could reach 1 million tonnes per annum in 2031 under an optimistic scenario.[44] However, Australia is likely to greatly outpace this forecast. There are several large green hydrogen projects in development in Queensland such as SunHQ Hydrogen Hub, expected to produce 0.5 million tonnes each year, the H2-HUB Gladstone, expected to produce 1.8 million tonnes each year, and the Central Queensland Hydrogen Project, expected to produce 0.3 million tonnes per annum. To capture growth in domestic and international markets, Queensland producers need access to low-cost renewable electricity, water supply, and industry infrastructure. Global demand for hydrogen is expected to grow from 90 million tonnes in 2020 to 210 million tonnes in 2040, with Queensland emerging as one of the lowest-cost regions in the world to potentially produce green hydrogen. Producers are continuing to optimise their electricity supply and may utilise a mix of on and off-grid electricity sources.

The below figure shows Australia's hydrogen production forecast as modelled in 2019 in the National Hydrogen Strategy compared to Queensland's actual proposed hydrogen projects. By 2025, Queensland's proposed projects will overtake Australia's projected hydrogen production. The proposed projects in Queensland are expected to produce 2.91 million tonnes of hydrogen per annum by 2028, more than 2 million tonnes higher than the forecasted national total, and 30% greater than the forecasted figure in 2040. This shows how rapidly the industry is growing beyond predictions made three years ago and demonstrates Queensland's ability to attract investment into the industry.

[44] Department of Industry, Science and Resources, 2019

Figure 16: 2019 Australian hydrogen production forecast compared to proposed projects in Queensland



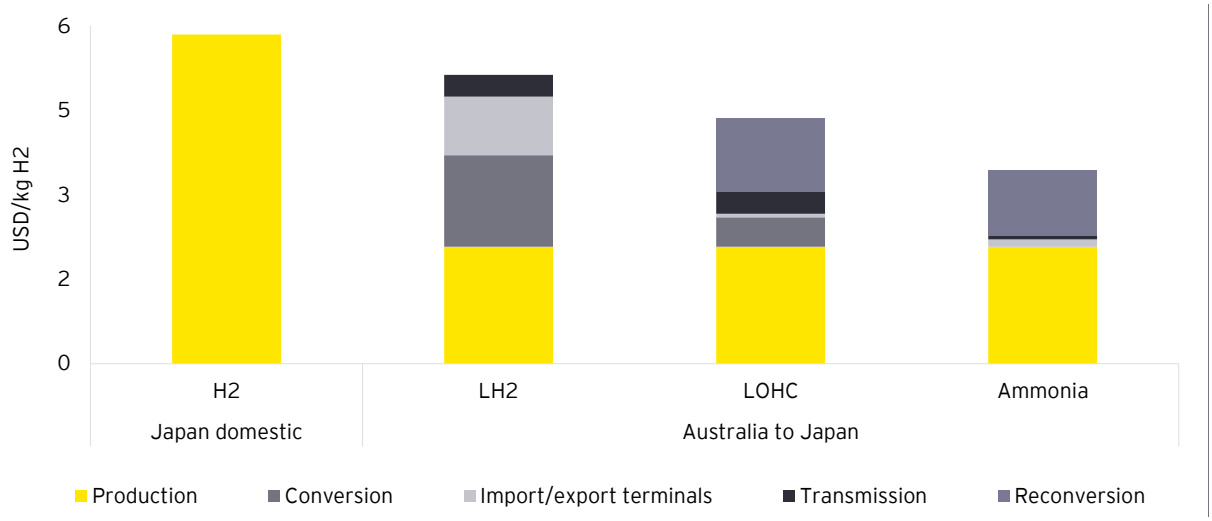
Source: EY analysis & DISER, 2019

The SunHQ Hydrogen Hub demonstrates a greener future for established industries in Queensland – Located at the Sun Metals Zinc Refinery in Townsville, the SunHQ Hydrogen Hub is set to be completed in December 2022. The project is owned by Ark Energy Corporation, which is the largest zinc, lead and silver producer globally. Leveraging off Queensland's abundance of renewable resources, the SunHQ Hydrogen Hub is expected to produce 0.5 million tonnes of green hydrogen a year. This hydrogen will be used to green the production and transport of manufactured zinc in Townsville. As Queensland is a low-cost region for producing green hydrogen, Ark Energy is expected to produce more hydrogen than they need on-site, allowing them to export excess green hydrogen to global markets.

Queensland has several advantages as a potential producer and exporter of green hydrogen. A key advantage is the state's access to a vast supply of cheap renewable energy resources to power electrolysis, including solar and wind. Queensland also has a skilled workforce and capabilities in manufacturing which will transfer well to the hydrogen industry. There is existing infrastructure for exporting, due to Queensland already being a major exporter of natural gas, that could be used or adapted for transport and exports of hydrogen. The state's proximity to Asian markets gives Queensland a transportation cost advantage compared to countries like the United States and Europe.

The IEA estimated the cost of producing hydrogen in Japan compared with delivering hydrogen from Australia in 2030 and found that it could be cheaper for Japanese consumers to import hydrogen from Australia than to produce it domestically. Three export strategies were costed, with each strategy being more cost-effective than Japan's domestic production, and ammonia being the cheapest delivery method. Globally, Australian hydrogen could be amongst the cheapest to produce, aligned with China and the United States by 2040. This is shown in Figure 17.

Figure 17: Cost of delivering hydrogen to Japan in 2030 – IEA projection



Source: IEA, 2021

Notes: LH2 = liquid hydrogen, LOHC = liquid organic hydrogen carrier

Electricity costs make up the majority of production costs

Queensland's comparative advantage is dependent on securing globally competitive electricity prices powered by renewables. Electricity is a major cost input into the production of hydrogen. At a cost of $60/MWh, electricity makes up 72% of the total cost of producing green hydrogen. By implementing the Energy Plan, electricity prices could be kept low, enabling for the rapid and early growth of hydrogen production in Queensland. Additionally, green hydrogen requires renewable energy, and with the Energy Plan's investment into renewable generation, the growth of the industry could be supported.

Access to water is crucial for production

Access to a reliable and plentiful water supply is integral to the production of hydrogen, highlighted by the recent abandonment of a hydrogen development project in South Australia due to water supply issues.[45] While water requirements are large, they are not significant compared to some other industrial uses. The CSIRO estimated that water consumption in 2050 in Australia may be equal to around one-third of the water currently used by the mining industry in Australia. Desalination plants and recycled water may be options to increase supply. While this is an important consideration for Queensland's hydrogen industry, the state's long coastline provides opportunities for desalination plants which can supply hydrogen production. This means that hydrogen production is likely to occur along coastlines with access to desalinated water.[46]

The Energy Plan could accelerate green hydrogen growth

Low-cost renewable energy is essential for green hydrogen production. Figure 18 shows the significant impact the Energy Plan could have on the output of green hydrogen. Under the Energy Plan, the Queensland green hydrogen industry could grow from $2.8 billion in 2024 to $33.4 billion in 2040. This is approximately $19 billion greater than in the Uncoordinated Outlook, supporting an additional 4,350 jobs. These projections are based on forecasts from Australia's National Hydrogen Strategy and updated forecasts from the IEA, and factors in projects that have already been announced in Queensland. [47,48]

[45] PV Magazine, 2022

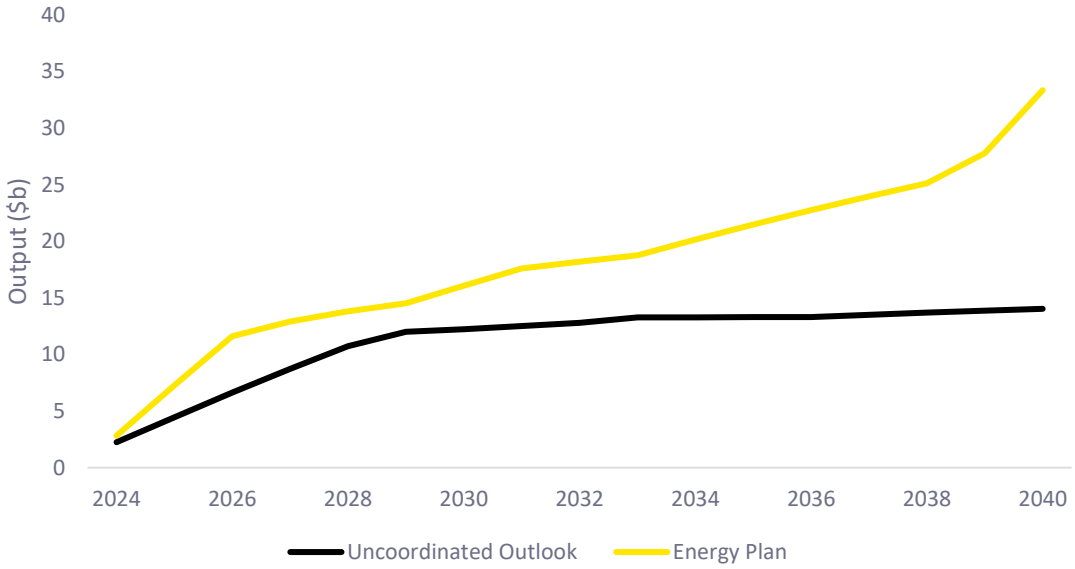
[46] CSIRO, 2019

[47] Department of Industry, Science and Resources, 2019

[48] International Energy Agency, 2021

The IEA predicts that in 2050, 61% of hydrogen will be green hydrogen and 39% will be blue hydrogen. Therefore, Queensland's green hydrogen could capitalise on green premiums, making it a more favourable import for trading partners.

Figure 18: Queensland's potential green hydrogen industry output under the Energy Plan



Source: EY analysis

The elevated growth rate could be driven by a number of factors:

- **Lower electricity prices de-risk hydrogen projects** – By implementing the Energy Plan, electricity prices are expected to be an average of 15% lower. As electricity costs make up more than 70% of the cost of producing hydrogen, this significantly de-risks hydrogen projects and enables for a stronger growth rate.
- **State-wide green premiums which attract invest** - From implementing the Energy Plan and reducing Queensland's emissions, the state is seen as an attractive destination for investment.
- **Earlier access and availability to renewable energy** – The Energy Plan accelerates Queensland's transformation to renewable energy which enables the green hydrogen industry to grow. Integrated planning and firming as part of the Energy Plan also unlocks future industry potential.
- **Projected output of proposed projects out to 2028** – There are a number of large hydrogen projects already proposed which could come online faster in the Energy Plan scenario. This strong starting point uplifts future growth.

Battery storage and manufacturing

The demand for batteries is expected to increase rapidly as countries decarbonise around the world. Batteries are important for energy storage technology as communities and businesses explore on-grid and off-grid energy storage solutions. Queensland has well-established upstream and downstream battery industries. This puts Queensland in a good position to manufacture batteries, with a focus on large-scale vanadium batteries. Furthermore, domestic demand for batteries is expected to grow significantly as the Energy Plan is implemented. High household solar penetration is expected to support demand for small-scale household batteries, and large mining companies seek to transition towards renewables through large-scale battery solutions.

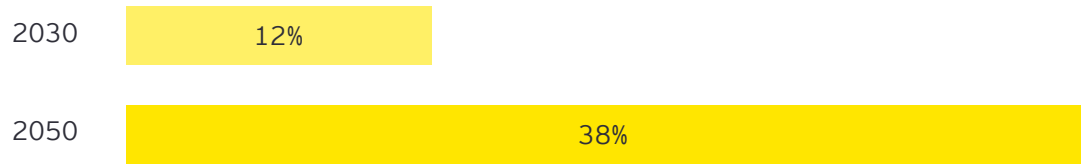
Battery industry could grow by 15% each year to 2030

The global battery industry is already significant, with the battery value chain being worth $185 billion in 2017. The industry is expected to grow by an average of 15% a year to 2030 as electric vehicle uptake sees battery demand increase, and countries move towards on-grid and off-grid battery storage solutions. There is considerable opportunity for Queensland to capture this growth by reducing electricity prices and reducing emissions through the Energy Plan, as well as developing a policy mix that attracts investment and builds on the state's strong position in upstream parts of the value chain.

Domestic demand for batteries could be significant

Australia's domestic demand for batteries is expected to be significant. Queensland has one of the highest uptakes of household solar generation in the world, which sell excess power back to the grid. Currently, the small battery storage market is relatively underdeveloped, with few households owning battery storage. Households are becoming more interested in battery storage options to capture excess power and reduce their power bills. Queensland's high solar uptake amongst households provides the battery manufacturing industry an opportunity to target the small battery storage market with lithium-ion battery production. The battery manufacturing industry will be able to capture the growing household battery market, with more than one-third of Queensland homes expected to have battery storage in 2050. The Energy Plan will play a crucial role in ensuring customer energy resources like household batteries can be effectively integrated into the grid, supporting more customer uptake.

Figure 19: Projected uptake of household battery storage under the AEMO's Step Change scenario, Queensland



Source: AEMO, 2022b

Additionally, Queensland has significant off-grid industries such as mining and metal refining that could move to renewable energy supplies in the future. Queensland's mining industry is the largest electricity consumer in the state, and primarily occurs off-grid. Electrifying these industries will require a mix of renewable energy generation and big batteries for storage. This provides a strong demand base which the state can leverage to propel its domestic battery manufacturing industry, with a focus on developing redox flow batteries which are most suitable for large-scale off-grid operations.

Queensland's position in the battery manufacturing value chain

Currently, Australia's position in the battery manufacturing value chain is concentrated to the mining part of the value chain, contributing 60% ($1.13 billion) of the global value add. To date,

Australia has captured limited market share in downstream parts of the value chain. Despite capturing 60% of value upfront, Australia captures just 0.5% of the total value chain. Significant investments have already been committed towards capturing more parts of the value chain, with $2.3 billion set to be invested into the refining and processing stage.[49]

Queensland's position in the battery value chain reflects Australia's broader position, with Queensland having a strong competitive advantage in the mining and production of battery materials such as vanadium, high-purity alumina, aluminium, and copper. This advantage is greatest in the big/off-grid battery manufacturing space due to Queensland's abundance of vanadium. Household and electric vehicle (EV) batteries require lithium which is not currently available for mining in Queensland, however these batteries still require a significant amount of copper, zinc, and aluminium.

There is potential to diversify and expand into chemical processing and cell manufacturing, with Queensland currently capturing 36% of Australia's value-add in chemical manufacturing. Queensland is positioned well in the battery integration and services industry for big and household batteries, as domestic demand for both is expected to be significant. This advantage does not exist for EV batteries as there is unlikely to be any significant EV manufacturing in Queensland. The state does have an advantage in the battery recycling and refurbishment industry as Queensland currently captures 50% of Australia's value-add in repair services, which could be leveraged to develop battery recycling capabilities.

Overall, Queensland's position in the big/off-grid and household battery manufacturing industry is the strongest due to the state's advantages in upstream industries and the significant demand for battery storage technology that could arise from efforts to electrify major off-grid communities and operations, and from the projected increase in demand for household batteries domestically. Queensland has already attracted funding towards high-purity alumina production and has committed funding towards vanadium processing. As major producers of copper, aluminium, and potentially vanadium, Queensland could vertically integrate the upstream materials mining and processing to target the big and small battery storage market. Queensland's opportunities in EV battery manufacturing are more subdued as the state currently lacks lithium resources and a domestic EV manufacturing industry, although could capture some benefits in the mining and refining of copper, zinc, and aluminium, and in the recycling industry.

A series of Queensland Government investments have signalled the state's intent to attract investment and innovation in the battery manufacturing industry, including $15 million into supporting the expansion of the National Battery Testing Centre in Brisbane. The Energy Plan is expected to further attract investment and uplift demand for battery manufacturing and storage, attracting investments into the state such as with battery manufacturer, ESI.

How the Energy Plan can attract investment – Energy Storage Industries (ESI)

The Energy Plan could support clean energy investments into Queensland by uplifting demand for renewable technologies and signalling to global markets the state's trajectory to low-emissions and low-cost renewable energy. In response to initial clean energy investments by the Queensland Government, large-scale battery manufacturer ESI have invested $70 million into a big battery manufacturing centre in regional Queensland. This investment is a result of the state's proactive approach to the energy transition and the proximity of Queensland to Asian markets.

By further stimulating public and private investments into renewable energy technologies, the Energy Plan could attract investment by signalling to global markets through a publicly available blueprint the state's trajectory to reach its renewable energy target. In addition to attracting investment, Queensland can also support and retain homegrown innovation.

[49] CSIRO, 2020

The Energy Plan could support upstream and downstream industries

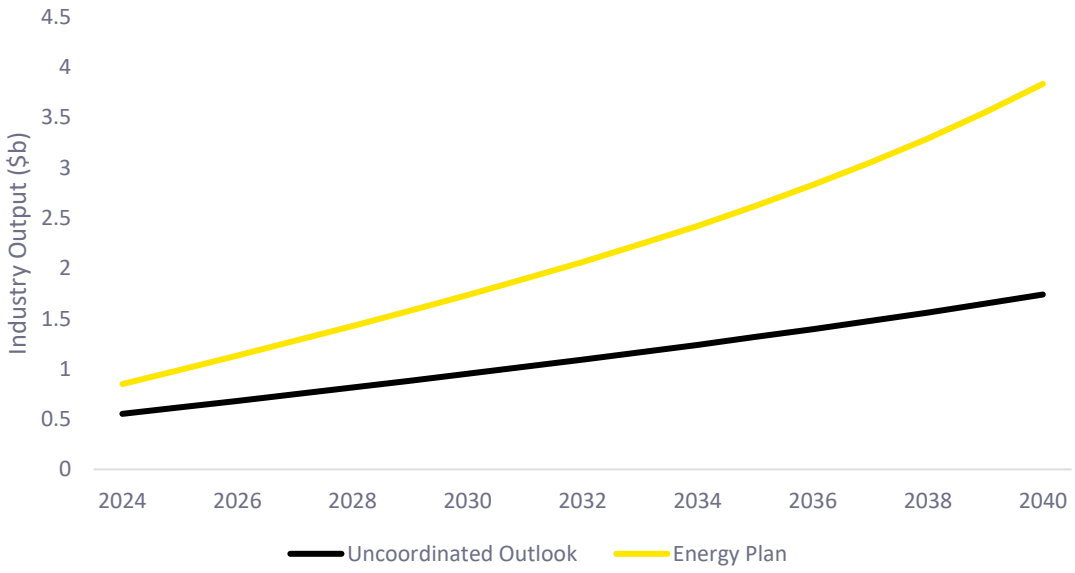
Upstream battery manufacturing industries such as mining and metal processing are very electricity intensive and investments are sensitive to electricity prices and emissions intensity. In order to support the future of aluminium, copper, and vanadium processing, the state should invest into delivering low-cost renewable energy to these industries. Without implementing the Energy Plan, the future of these industries, in particular aluminium refining, could be at risk, which would impact the state's ability to vertically integrate its battery manufacturing industry.

Alongside upstream industries, downstream battery manufacturing industries, such as the solar PV manufacturing industry could be captured to support battery demand. While Queensland has the highest uptake of solar panels in Australia, under the Energy Plan, it is expected that both the demand for solar panels and batteries to compliment them, would increase. This presents Queensland with an opportunity to expand the current solar PV manufacturing industry, with a focus on solar PV racking, as the barrier for entry is low and there is a strong opportunity to establish the supply chain. The solar PV manufacturing industry already has skilled workers and well-established manufacturing processes which could easily expand to capture the market growth under the Energy Plan. Consequently, this would allow for a greater supply of batteries so that households can maximise the benefits of renewable energy.

Opportunities for battery storage and manufacturing under the Energy Plan

The Energy Plan could support industry growth by securing low-cost and low-carbon electricity to support the upstream industries required to vertically integrate the battery manufacturing process. Without implementing the Energy Plan, metal refining industries such as aluminium could be at risk due to higher electricity prices and high Scope 2 emissions. Furthermore, with the right policy mix that supports upstream industries such as mining to reduce emissions, and downstream industries to support innovation, industry output could grow to almost $4 billion by 2040. This is $2 billion greater than if no plan was implemented, supporting a further 9,800 jobs. This is shown in Figure 20. These forecasts draw on the Future Batteries Industries Cooperative Research Centre's research.[50]

Figure 20: Battery manufacturing industry output with the Energy Plan and with the Uncoordinated Outlook



Source: EY analysis

[50] Future Batteries Industries Cooperative Research Centre, 2021

These outcomes reflect the impact of:

- **Lower electricity prices** – Under the Energy Plan, electricity prices are expected to be lower by an average of 15%, supporting early growth and profitability.

- **Growth in upstream industries and demand** – By implementing the Energy Plan and delivering reduced emissions and lower costs to upstream metal refining industries, while supporting the growth of battery demand, Queensland's battery manufacturing industries could secure a stronger foothold in the industrial base.

- **Support for off-grid battery solutions** – If support or incentives were provided to install off-grid big battery solutions and transform the energy mix of mining operations, this would further support growth in battery demand.

The Energy Plan's employment impact

The Energy Plan represents a significant infrastructure investment and requires the construction, manufacturing, and operation of new renewable energy assets in Queensland. This capital installation period is expected to create and support direct and indirect jobs in the state. In addition to the jobs created during the construction phase, the Energy Plan could capture opportunities in established and emerging industries to support industry growth and employment. This section disaggregates the Energy Plan's employment impacts across the initial infrastructure installation phase and the industry uplift which occurs as a result of the Energy Plan's implementation.

In total, the Energy Plan could support an average of 28,500 direct jobs each year during the initial infrastructure installation phase, with significant outcomes for regional Queensland. Furthermore, the Energy Plan's support for industry growth across the four identified industries, is expected to support 22,000 direct jobs from 2040.

The infrastructure installation phase could support 28,500 direct jobs each year

The Energy Plan is an investment blueprint which outlines the Queensland Government's approach to significantly increasing the state's renewable energy assets through public and private investment. This represents a significant infrastructure investment program over the next 17 years to install:

- 16.2 GW of wind
- 10.2 GW of solar
- 1.7 GW of battery storage
- 7 GW of pumped hydro
- 1,550 kilometres of transmission infrastructure.

Each of these renewable energy and electricity infrastructure requires construction, manufacturing, and operation, with significant employment opportunities for Queensland. Using jobs multipliers for specific renewable energy asset, the employment impacts of the Energy Plan's infrastructure installation phase were calculated in Table 2 below.

Table 2: Average annual job-years created across each energy investment

	Average annual job-years		
Energy investment	**Construction and manufacturing**	**Operation**	**Indirect**
Wind	5,021	2,921	10,039
Solar	1,078	515	2,073
Battery storage	674	409	1,405
Pumped hydro	17,035	563	21,557
Transmission infrastructure	274	-	-
Total	24,082	4,408	35,074

Source: EY analysis of client data, UTS 2020 & Infrastructure Australia 2021

For wind and solar energy assets, these are typically imported and then assembled, creating opportunities predominately in the construction and operation phase of the infrastructure investment, but limited opportunities in the manufacturing phase. Battery storage and pumped hydro require more significant onshore manufacturing and thus support a higher number of jobs during the installation period. While battery storage energy investments support more construction

jobs per GW of investment, Queensland is expected to target investment into pumped hydro and wind assets.

Pumped hydro investments support the greatest number of construction and manufacturing jobs due to the significant civil engineering and construction requirements of the asset. Compared with wind, solar, and battery storage, constructing pumped hydro capital demands significant civil and technical planning as well as concrete and piping infrastructure, supporting high value-add construction and onshore manufacturing jobs. The state's rollout of investment into 1,550 kilometres of transmission is expected to support an average of 274 construction jobs each year.

The Energy Plan's investment supports jobs across a range of occupations and skills, including labourers, technicians, and professionals. UTS (2020) analysis shows that across each of the energy assets, labourers, technicians, and professionals make up an even split of 75% of the total labour demand required to construction, manufacture, and operator these assets. The remaining 25% is made up of managers, machine operators, and administrative workers. The Energy Plan's investment boosts opportunities across a broad range of occupations and skillsets.

In addition to supporting an average of 28,500 direct jobs each year during the capital installation phase of the Energy Plan, this significant investment is expected to indirectly support more than 35,000 jobs. The significant construction and operation jobs created from investments into wind and pumped hydro lead to positive spill-overs into supporting industries and communities, predominately in regional Queensland where investment is being targeted.

Employment benefits peak in 2029-30 as pumped hydro assets are being installed and investment flows into the state. Investment tapers in later years as Queensland installs the capital necessary to withdraw coal-fired generation, however employment outcomes remain strong as energy assets create long-term operational jobs.

Table 3: Breakdown of the Energy Plan's employment impacts across select years

Energy investment	2029-30	2031-32	2034-35	2039-40
Jobs (FTEs)	76,258	52,806	11,364	13,647
Investment ($b)	12.0	4.9	0.5	0.8

Source: EY analysis of client-provided data

The Energy Plan could support jobs in the major identified industries, with positive impacts across regional Queensland

The Energy Plan provides industry and investors with a roadmap for reducing emissions and increase the state's renewable energy assets in line with the Queensland Government's 2030 Renewable Energy Target. The infrastructure installation phase targets investment into renewable energy assets across Queensland, with regional Queensland attracting 95% of all investments. Additionally, by transforming Queensland towards reliable and low-cost renewable energy, opportunities for growth in established and emerging industries are expected to materialise and support jobs in regional economies.

From the analysis of the economic output and employment outcomes that the Energy Plan could drive in the four identified industries, it is expected that there could be significant employment outcomes for regional Queensland as detailed in Table 4. The Energy Plan could support 22,000 direct jobs in 2040 by supporting growth in metal refining, resource mining, green hydrogen, and battery manufacturing, as well as 14,200 indirect jobs.

Table 4: The Energy Plan could support direct jobs in regional Queensland across the four identified industries

Dimension	Total direct	Direct regional	Indirect
Infrastructure construction and manufacturing (average annual jobs between 2022 and 2040)	24,082	16,857	28,071
Infrastructure operations (additional jobs in 2040)	4,408	3,085	6,104
Industry impacts (additional jobs in 2040)	22,031	13,452	14,208

Source: EY analysis and UTS, 2020

These industries and employment outcomes are typically located in regional areas. 70% of resource mining jobs are in regional Queensland,[51] and the metal refining industry is centred in Gladstone, Townsville, and Mount Isa. Additionally, of the committed hydrogen manufacturing projects in Queensland, all are set to be located in regional Queensland, including Gladstone, Townsville, and Bundaberg.[52] For these three industries, it was assumed that 70% of all direct FTE jobs created would be in regional Queensland, consistent with UTS's approach. For battery manufacturing, a 50% ratio was applied which reflects the current manufacturing employment ratio between regional and urban Queensland[53] and is also consistent with UTS's approach.[54]

In total, the Energy Plan could support almost 13,500 direct regional jobs in 2040 by creating industry uplift across the four identified industries. This is in addition to the annual average of nearly 20,000 direct regional jobs in construction, manufacturing, and operations for renewable energy assets that are expected to be built over the next 17 years.

[51] Queensland Government, 2021b
[52] DISER, 2021
[53] ABS, 2022
[54] UTS, 2020

The broader economic impact of the Energy Plan

5. The broader economic impact of the Energy Plan

The Queensland Energy Plan is a roadmap to drive significant investment electricity infrastructure in Queensland. However, it will also have other impacts on the economy, including reducing electricity prices – potentially increasing the competitiveness of heavy industry, reducing carbon emissions and resulting carbon offset requirements, and allowing for businesses in Queensland to attract a green premium for its offerings.

The Energy Plan could drive up to **$23.2 billion of investment into Queensland** and contribute up to **$25.7 billion in gross state product, $25.1 billion in gross state income** and could also contribute to an additional **$10,380 in income for households**. Most of the investment will occur in regional areas, providing local jobs and lifting economic activity in these regions. However, South East Queensland is also set to benefit from a greener grid and reduced electricity prices.

Estimating the impacts of the Queensland Energy Plan

The economic modelling in this report is based on the application of EY's General Equilibrium Model (EYGEM described in additional detail in Appendix B), our in-house Computable General Equilibrium (CGE) model. EYGEM is a large scale, dynamic, multi-region, multi-sector model of the global economy. CGE modelling measures the net impact of a change, such as a new policy, on an economy and is the modelling framework of choice for analysing the economic impacts of major project investments, including electricity infrastructure. EYGEM accounts for direct and indirect effects and allows consideration of a wide range of demand and supply side outcomes from the Energy Plan. The key mechanisms through which the Energy Plan may influence the economy are captured as economic 'shocks' to the model, and their flow on effects are identified. The modelling methodology is described in further detail in EY's report *The Queensland Energy and Jobs Plan: electricity market and economic modelling outcomes*.

A key strength of the EYGEM model for this project is the degree of flexibility in the level of regional specification. For this analysis we have decomposed Queensland into nine separate regions of interest, allowing for specific treatment investment, carbon emissions and financial flows (among other economic detail).

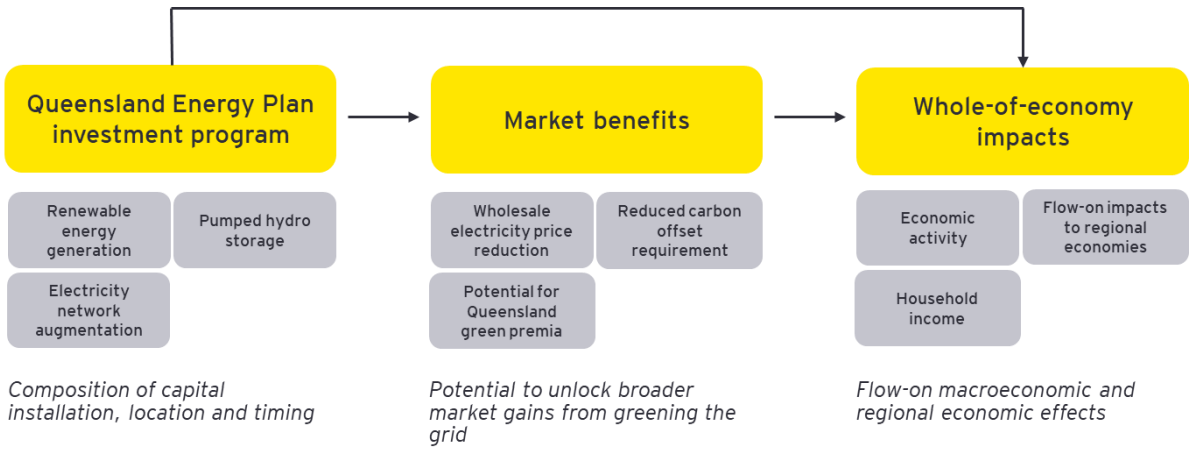
First and foremost, the Energy Plan is a policy to drive significant investment in electricity infrastructure, building new renewable generation, storage and transmission. The infrastructure program drives direct job creation in the regions that receive infrastructure investment, both in construction and through flow on benefits to the transport, accommodation and food services sectors.

In addition to the direct infrastructure investment, the Energy Plan is also expected to have broader effects on the Queensland economy. These include the following key market benefits, which influence the economy in different ways:

- **A reduction in electricity prices,** which lower the cost base for businesses and consumers and increases electricity consumption.
- **A decrease in the cost of carbon emissions** as a result of the low-emissions electricity grid, and a subsequent decrease in the level of carbon required to be offset.
- **A green premium on Queensland production** making Queensland a more attractive place to invest.

These economic drivers were considered in quantifying the overall impact of the Energy Plan. A summary of the flow of impacts from the Energy Plan is captured in Figure 21.

Figure 21: Framework for assessing the economic impact of the Queensland Energy Plan



Source: EY analysis

The following sections describe the impacts of the Energy Plan and the potential macroeconomic benefits that could occur. The outcomes represent an upper bound to the benefits, given considerations around funding of investments, operations and revenue changes of government assets have not been considered in the whole of economy modelling.

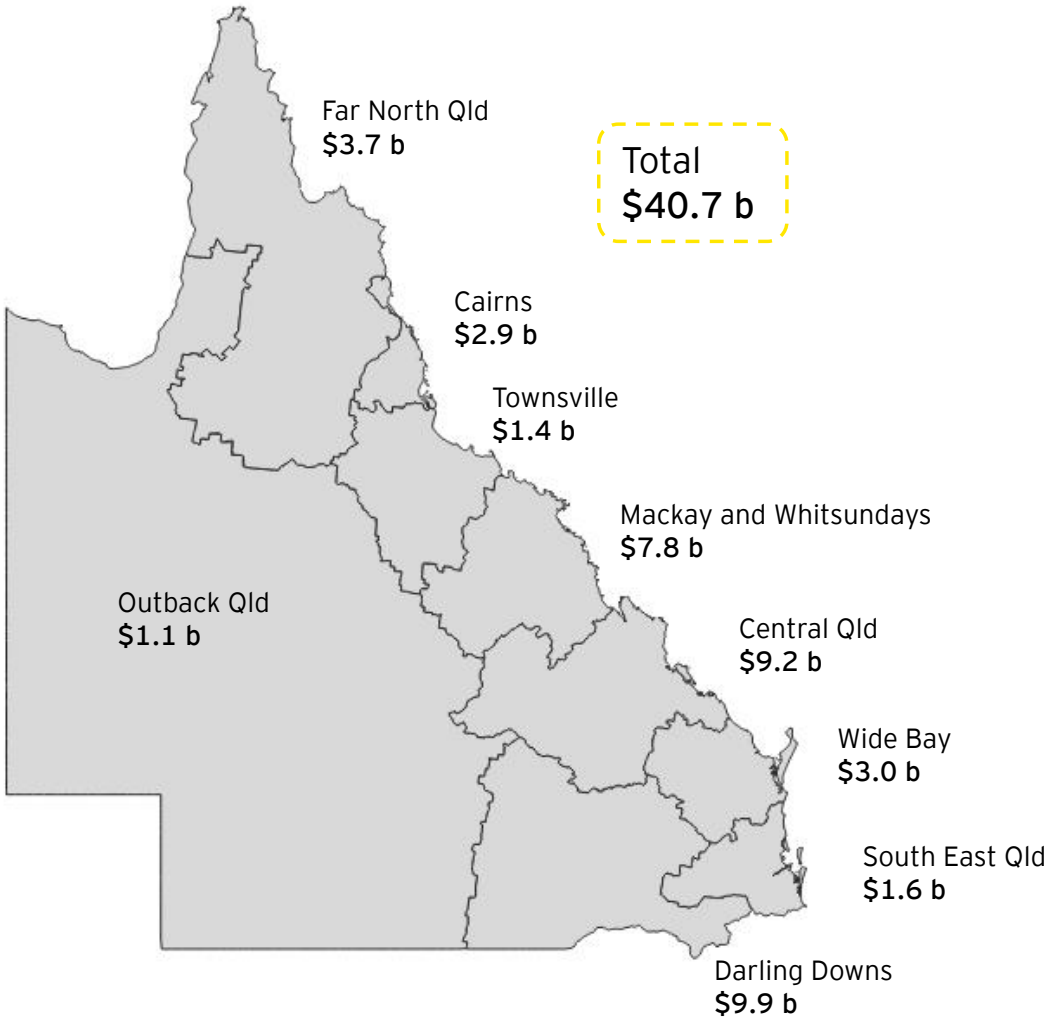
The following sections describe each of the economic drivers and provides macroeconomic insights into the effect of the Energy Plan.

Electricity infrastructure investment

The decarbonisation of the Queensland electricity grid under the Energy Plan is underpinned by a significant investment pipeline. This investment in renewable power sources, storage, and electricity transmission network upgrades leads to increased economic activity through demand side impacts including construction and demand for materials, which directly employs Queenslanders and stimulates local economies.

The location and nature of the infrastructure results in different forecast levels of investment across the subregions of Queensland from $9.9 billion in the Darling Downs to $1.1 billion in Outback Queensland, as shown in Figure 22. The differences in distribution of investment reflects each region's renewable energy resources, with Darling Downs attracting significant investment into its pumped hydro resources. Importantly, these represent estimates of the location of renewable energy development but will be subject to market conditions, project development and other policy outcomes.

Figure 22: Electricity infrastructure investment under the Energy Plan distributed across regions, in NPV terms

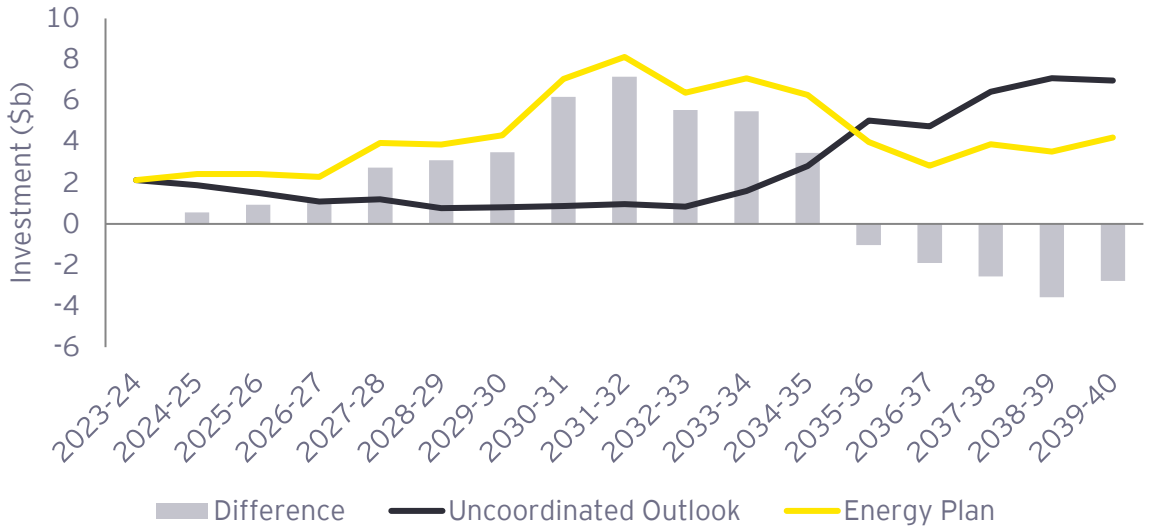


Source: Client provided & EY analysis

In addition to the geographical distribution of investment, Figure 23 shows how the investment is expected to be made over time. While investment between the Energy Plan and the Uncoordinated Outlook remains level until 2025-26 (based on projects already committed in the pipeline), the Energy Plan invests $18.4 billion more than the Uncoordinated Outlook scenario in NPV terms.[55] Most notably, peaks in investment activity reflect the development of significant pumped hydro projects and the renewable energy infrastructure that accompanies this.

[55] In 2022 real dollars.

Figure 23: Capital investment in generation, storage and transmission, under the Energy Plan and Uncoordinated Outlook scenarios



Source: EY analysis

The Energy Plan sees active investment in renewables, storage and transmission infrastructure over the next decade, while the Uncoordinated Outlook scenario sees minimal additional investment activity prior to 2035. After 2035, the Uncoordinated Outlook additional investment as some Queensland coal generators reach their end of life and investment in generation and battery storage is made to replace decommissioned coal generators. Regardless of the scenario, investment is required to transform the state's electricity supply towards renewable energy generation. By front loading this investment in the Energy Plan, Queensland boosts construction activity earlier, bringing forward the benefits of increased economic activity, lower electricity prices, and lower carbon emissions.

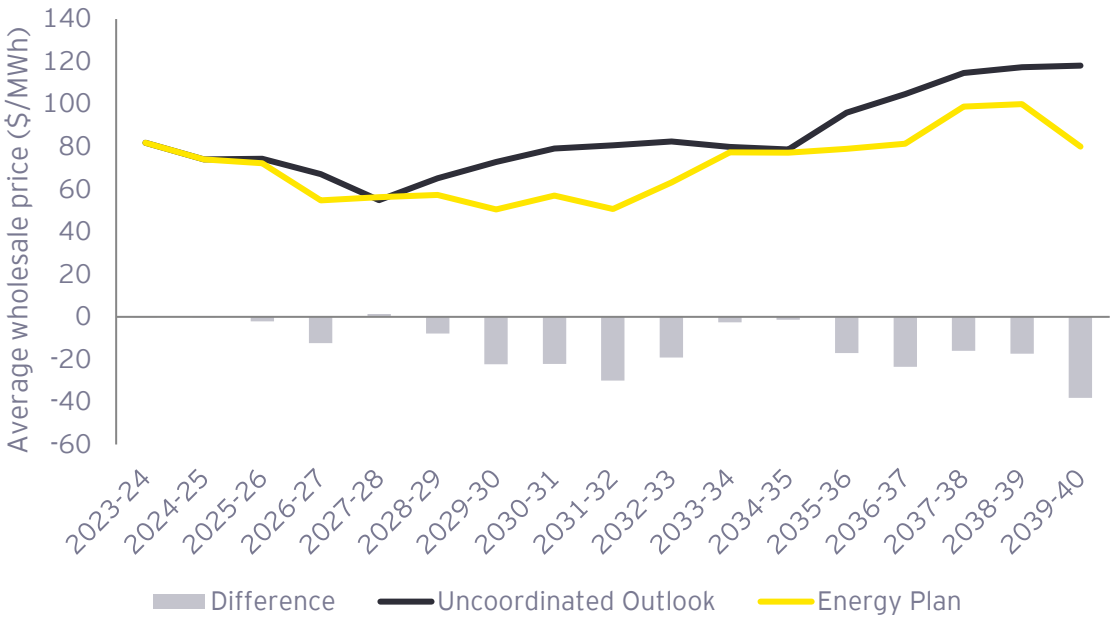
Reduced electricity prices

Electricity is a key element of both the industry and consumer cost base, in particular heavy industries. Excluding households, a handful of heavy industries in Queensland concentrated in the mining and metal refining sectors consume the majority of the state's electricity. Large consumers of electricity are most exposed to fluctuations in price.

By investing early into Queensland's renewable electricity supply, the Energy Plan results in a lower cost of electricity, which benefits both businesses and consumers. The reduction in price decreases the operating costs of almost all industries in the economy, but particularly in heavy industry such as aluminium production. This reduced input cost improves competitiveness on a global and domestic scale and can lead to an increase in exports, investment and consumption.

The anticipated reduction in electricity prices is demonstrated in the below figure, which shows the annual wholesale prices of electricity to Queensland electricity customers under both the Energy Plan and the Uncoordinated Outlook scenario. Electricity prices could be up to 38% lower under the Energy Plan, with prices being 15% lower on average each year.

Figure 24: Demand-weighted wholesale electricity prices, under the Energy Plan and Uncoordinated Outlook Scenarios



Source: EY analysis

Carbon offset costs

The Queensland Energy Plan will increase renewable electricity in the market and reduce emissions, relative to the Uncoordinated Outlook. The Energy Plan creates a reduction in electricity emissions compared to the Uncoordinated Outlook scenario, and results in an additional 37% reduction in electricity emissions by 2040 on 2005 levels.

The specifics of future carbon mitigation scheme design (and, in particular, any future carbon budgets for Queensland) are the subject of ongoing policy refinement at the national level, and the depth and maturity of international markets for carbon permit trading will continue to evolve over the period to 2040.

Notwithstanding these uncertainties, a reduction in emissions at the Queensland state level is likely to either lead to an increased ability for Queensland to sell excess permits (should state emissions be lower than an allocated carbon budget) or a reduced requirement for Queensland to purchase offsetting permits (should state emissions be higher than an allocated carbon budget), resulting in a change in the financial flows associated with the sale and purchase of carbon permits. This relative increase in net financial flows to the state will drive an increase in Gross State Income (GSI) and a flow on increase in both employment and GSP.

To calculate the value of these permit transfers, the adopted price path was designed to be consistent with the modelling recently undertaken by the Australian Government in Australia's Long-Term Emission Reduction Plan report[56], which assumes international carbon permit prices at a fixed level of $40/t CO_2-e in real terms across the modelling period.

Green premiums

The increasing focus on environmental concerns has in recent years led to the emergence of a "green premium", whereby capital markets are factoring in environmental (and in particular greenhouse gas) footprints into investment decisions. The decarbonisation of the electricity grid under the Energy Plan will mark Queensland as a green destination for investment, increasing the

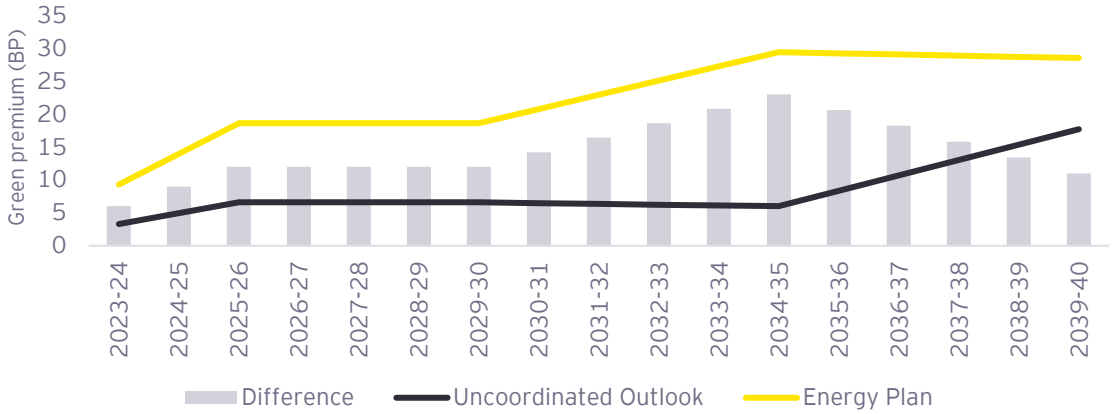
[56] Australian Government, 2021

green premium in the state and increasing the attractiveness of the state as a destination for investment.

To capture the potential green premium impacts in the state, assumptions were drawn from the Department and recent Commonwealth modelling assuming a 100 basis point (BP)[57] premium for decarbonisation. As the electricity system contributes to approximately 30% of Queensland's emissions today, it is assumed that 30 BP may be attributed to electricity sector emissions. Of these 30 BP it is assumed that only the incremental difference between the Energy Plan and Uncoordinated Outlook Scenario emissions may be considered when calculating the change in the green premium.

Finally, it is assumed that the change in premium may be forward looking in nature and may occur before any actual reduction in emissions. The following figure shows the potential annual green premium assumed in the modelling, developed with the Department to reflect the trajectory of emissions reductions, taking into account the above considerations. In the Uncoordinated Outlook, green premiums begin to increase slowly from 2035 as thermal generation exists the system.

Figure 25: Potential green premium in Queensland



Source: EY analysis

Modelled economic outcomes for the Queensland economy

The impact of implementing the Energy Plan on the broader Queensland economy was modelled through the EYGEM model. Specifically, the flow on effects of investment in renewables, and the associated impacts on electricity prices, carbon emissions and a green premium were modelled. The impact on key macroeconomic variables was examined: gross state product, gross state income, household income and investment.

- **Gross State Product (GSP)** is the measure of the total value of goods and services in the economy and is a key metric in tracking the overall progress of an economy and the effectiveness of policies. The model estimates the GSP as the sum of consumption, investment, government expenditure and net exports in real terms.

- **Gross State Income (GSI)** is used as a measure of the total income in a state economy and is used to track the wealth generated by a state economy both domestically and through overseas investment.

- **Household income** is the measure of the average income per household in Queensland.

[57] 100 basis points is equal to 1%.

- **Investment** is also referred to as Gross Fixed Capital Formation in the system of national accounts and comprises both direct electricity infrastructure investment (as per section 0) and other changes in investment induced by reduced electricity prices and green premiums.

The Energy Plan is expected to make a significant impact on the economy, compared to the Uncoordinated Outlook scenario. The following tables and graphs present results of the Energy Plan as compared to the Uncoordinated Outlook scenario.

Table 5: The additional value generated by the Energy Plan compared to the Uncoordinated Outlook across key variables

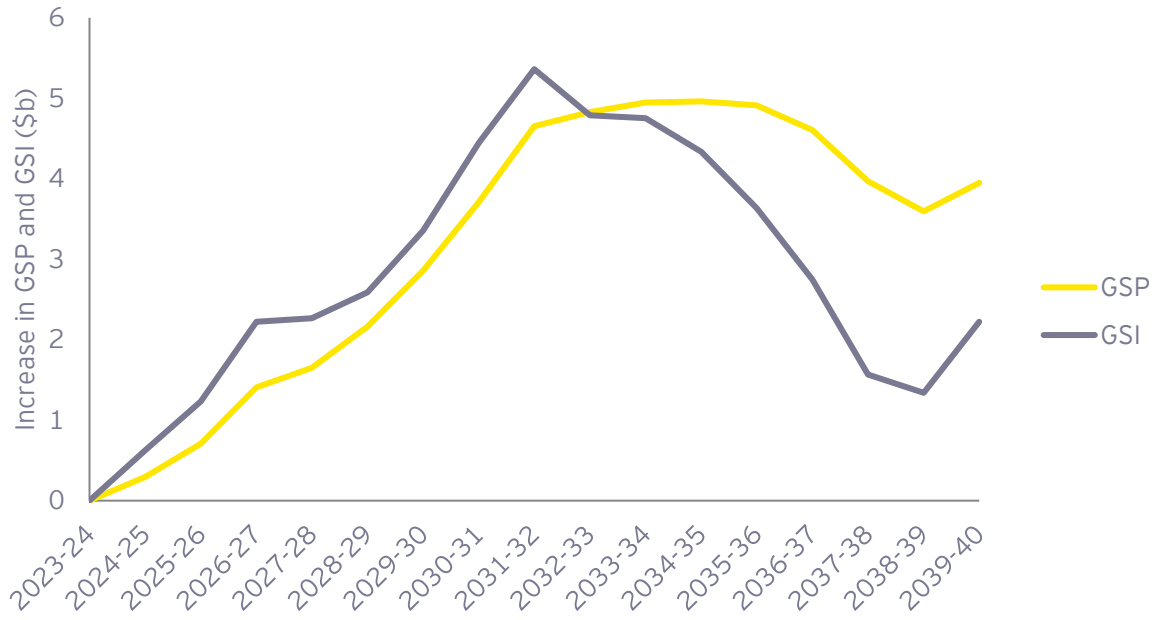
Economic variable	Additional value
Total economy-wide investment ($b NPV)	+23.2
GSP ($b NPV)	+25.7
GSI ($b NPV)	+25.1
Household income ($ NPV)	+10,380

Source: EY analysis

Gross state product and gross state income

The annual increase in GSP and GSI is presented in the below figure. The economy sees a significant boost in the first decade of the Energy Plan, created by the significant construction activity, increasing green premiums and positive carbon transfers. The peak difference in GSP is predicted to occur in 2034-35, at $5.0 billion higher than the Uncoordinated Outlook scenario. While GSI normalises after 2035-36, GSP remains high as the state builds long-run productive capacity through the Energy Plan's investments.

Figure 26: Annual increase in GSP and GSI, Energy Plan relative to the Uncoordinated Outlook scenario



Source: EY analysis

The overall uplift in GSP is driven by four key components of the Energy Plan:

- Additional investment into the state's electricity infrastructure, which creates economic stimulus and accounts for 27% of the GSP uplift.

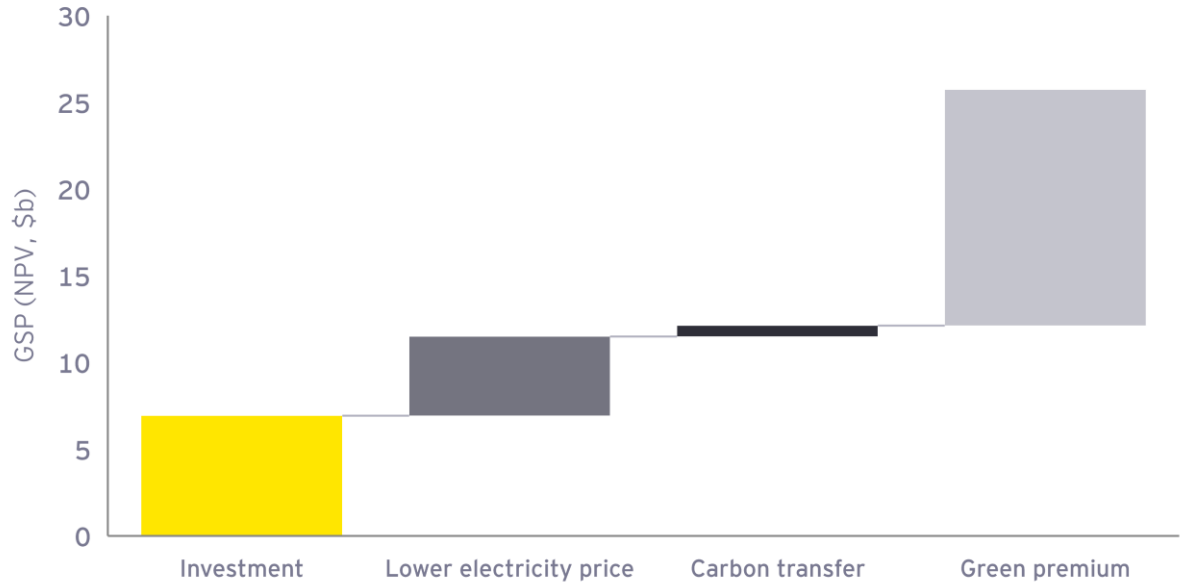
- Reduced electricity prices which reduce the cost base for industry and households, accounting for 18% of the GSP uplift.

- Positive carbon transfers as the cost of offsetting carbon emissions falls as emissions are reduced across the state, accounting for 2% of the GSP uplift.

- As the Queensland Government reaches its 2030 Renewable Energy Target, the state is seen as an attractive destination for investment and receives a green premium on economic activity, accounting for 53% of the GSP uplift.

These four components lead to a potential $25.7 billion increase in GSP, as shown in Figure 27. Green premiums emerge as the dominant driver of economic benefits, with these benefits primarily concentrated in SEQ as the largest economic centre in the state. SEQ is expected to attract green premium investments as the hub for innovation in the state, with regional areas also expected to attract investments into industries such as manufacturing, mining, and agriculture. Additional investment under the Energy Plan is expected to boost economic stimulus and employment particularly in regional areas which are set to receive approximately 95% of investment, creating almost $7 billion in additional GSP. Positive carbon transfers make up a small portion of the total GSP uplift. Carbon transfers are primarily income flows which benefit industries that reduce their emissions alongside the Energy Plan. These income flows allow for industries to produce at a lower cost base and increase production accordingly. This is similar to the benefits accrued from lower electricity prices, wherein consumers and industry are able to increase their consumption and production as input costs fall by implementing the Energy Plan.

Figure 27: Increase in GSP by driver, Energy Plan relative to the Uncoordinated Outlook scenario



Source: EY analysis
Note: Investment refers to the direct investment in electricity infrastructure as part of the Energy Plan.

Investment and household income

$23.2 billion
Additional investment (NPV)

The Energy Plan is expected to increase economy-wide investment by an additional $23.2 billion in NPV terms over the modelling period compared to the Uncoordinated Outlook. This includes both the direct electricity infrastructure investment from the Energy Plan and the flow-on increase in investment in other areas of the economy. The increase in investment is influenced by falling electricity prices and green premiums, as well as the attraction of private investment.

Increases to employment and income have a strong positive impact on Queensland household incomes. Benefits accrue to households from reduced electricity prices easing pressures on household budgets and from greater employment opportunities created by the Energy Plan's infrastructure investment. This is important as an increase in household income increases disposable incomes and assists household budgets, resulting in positive social outcomes. The average increase in household income is $10,380 over the modelling period, above the Uncoordinated Outlook scenario.

$10,380
Additional household income (NPV)

Regional analysis

The Energy Plan is a state-wide strategy that targets investment towards renewable generation, storage and transmission network upgrades into suitable regional locations. While the investment primarily occurs in the regions, benefits flow throughout the state to both urban and regional centres. The impacts on electricity prices and the impacts from carbon offsets and green premiums apply more broadly across the state.

The infrastructure installed as part of the Energy Plan (for example, renewable energy projects, transmission and pumped hydro) is predominantly targeted towards regions with strong renewable resources. As a result, there are different outcomes between regional Queensland and the metropolitan South East Queensland (SEQ).[58]

Table 6 below highlights the potential economic returns for each subregion from the Energy Plan. The impacts at the subregional level depend on the size and structure of the economy, its exposure to electricity prices and the amount of investment received. The spread of benefits among regions reflects the decentralised nature of the state.

As regional Queensland attracts more electricity infrastructure investment, these regions attract economic benefits from the construction activity. The increased economic activity in regional Queensland draws employees and investment into those regions as people move for jobs and businesses invest in areas with increased activity. The impacts depend on the type and location of the investment as well as the structure of the regional economies. Greater benefits flow for projects that involve greater domestic manufacturing, such as pumped hydro which requires significant concrete and piping infrastructure, compared to solar and wind infrastructure which can be imported and assembled.

While the Energy Plan's investment predominantly occurs in regional Queensland, the whole state benefits from a decarbonised electricity market, reduced electricity prices and the potential for a green premium. While investment is targeted towards areas outside of SEQ, SEQ attracts significant benefits as the largest economic centre in the state. This highlights potential for SEQ to attract investment into the state from domestic and international capital markets.

[58] Regional Queensland includes all regions excluding SEQ for the purpose of this report.

Table 6: Summary of economic results by subregion, Energy Plan relative to the Uncoordinated Outlook scenario

Region	Investment in electricity infrastructure ($m NPV)[1]	GSP ($m NPV)	GSI ($m NPV)
Central QLD	9,177	3,657	2,671
Darling Downs	9,923	1,333	1,071
Far North QLD	3,699	1,007	1,028
Mackay and Whitsundays	7,792	3,099	2,530
Outback QLD	1,128	598	632
SEQ	1,562	12,599	13,895
Townsville	1,447	1,263	1,253
Wide bay	3,042	1,462	1,237
Cairns	2,894	714	779
Total	**40,666**	**25,732**	**25,095**

Source: EY analysis
[1]Includes investment in generation, storage and transmission capital expenditure.

Conclusion

6. Conclusion

Global trends towards low-carbon products and technologies are accelerating and will continue to shape Queensland's industrial base. The Queensland Government has put forward an Energy Plan to provide clear guidance and investment into the state's electricity grid. The Energy Plan is expected to reduce the emissions-intensity of Queensland's electricity grid by 90% over the next 15 years and deliver electricity prices that are on average 15% lower each year, compared with an Uncoordinated Outlook in which there is no early investment into renewable energy and no clear plan for the energy transformation in Queensland available in the public domain.

Four key industries were identified as being impacted by the Energy Plan: metal refining, resource mining, green hydrogen production, and battery manufacturing. These established or emerging industries are large, electricity intensive, and are vulnerable to global trends towards low-carbon technologies and products.

For established industries such as metal refining and mining, there is growing evidence that the feasibility of these industries is at risk unless Queensland can reduce its Scope 2 emissions and deliver low-cost electricity. The Energy Plan mitigates challenges that established industries are facing and broadens opportunities to attract investment and secure green markets.

Additionally, implementing the Energy Plan is expected to increase demand for clean energy technologies such as green hydrogen and battery storage. Queensland could leverage its world-class renewable resources to attract investment into its green hydrogen industry, which is already outpacing production forecasts in the Australian National Hydrogen Strategy. The Energy Plan could secure the industry's supply of renewable electricity, setting the preconditions for growth.

The Energy Plan also sets the stage for increased demand for small and large-scale battery solutions in households and in off-grid communities. Queensland has one of the highest rates of household solar penetration in the world, which could be leveraged to grow the domestic battery manufacturing industry. Furthermore, Queensland's strong regional economies which operate off-grid are well-positioned to transition to renewable energy through a mix of wind, solar, and large-scale batteries. Queensland has strong upstream and downstream industries to support the manufacturing of battery packs and cells. The Energy Plan could create an economic uplift across each of these four industries, potentially supporting 22,000 jobs in these industries in 2040, and a further 14,200 indirect jobs.

The Energy Plan represents a significant capital investment to boost the state's renewable energy assets. This investment requires the construction, manufacture, and operation of renewable energy assets to transform Queensland's electricity grid. This capital installation is expected to directly create 28,500 jobs on average per year. As regional economies are expected to capture 95% of the Energy Plan's $40.7 billion of investment, almost 20,000 annual jobs are expected to be in regional Queensland, with 35,000 annual jobs indirectly supported by the investment.

The economic uplift will benefit Queensland's economy beyond the four identified industries. By delivering low-cost electricity to households, consumers could have an additional $10,380[59] to spend over the next 17 years.

The combined benefits of the Energy Plan's investment into renewable energy infrastructure, reduced electricity prices, and a greener electricity grid, could grow Queensland's economy by $25.7 billion to 2040.

[59] Real June 2022 dollars in present value terms discounted at a 7% discount rate selected by the Department

Appendix A Criteria analysis of Queensland's economy

The Energy Plan's investment roadmap is likely to impact Queensland's industries, both emerging and existing, to differing degrees. A high-level analysis of Queensland's industrial base was undertaken against a criterion to determine which industries to focus on. The criterion was developed to capture the potential impact the Energy Plan could have on established and emerging industries. This criterion includes:

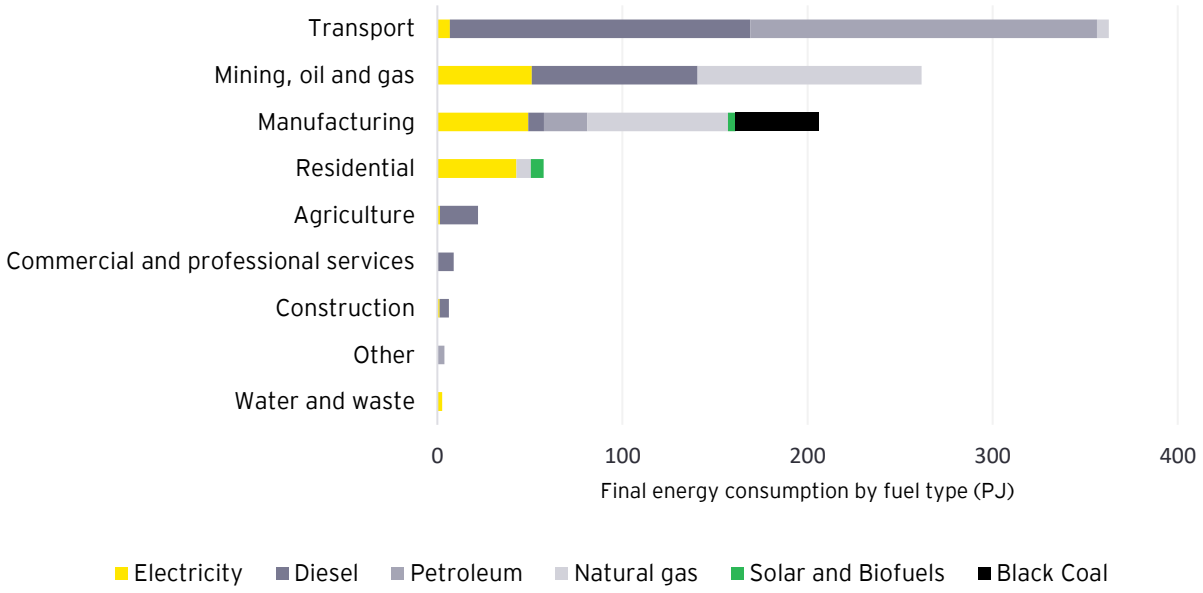
- Energy or electricity-intensive industries which could experience pressure from changing electricity prices
- Large or potentially large industries which make a meaningful contribution to the Queensland economy or specific regional economies within the state
- Industries with linkages to other domestic industries, such as the aluminium refining value chain in Queensland
- Export-exposed industries which could be impacted by trends in international trade and future global environmental policies

Electricity is a major cost component and source of emissions in certain industries

The analysis focuses on industries with the highest energy and electricity consumption. These industries are likely to be impacted by the Energy Plan's implementation as they stand to benefit from lower electricity prices and reduced Scope 2 emissions, especially as certain industries become further electrified in the future.

The figure below shows the sectors in Queensland with the highest energy consumption. Transport is the highest consumer of energy, followed by mining, oil and gas and manufacturing. Mining, oil and gas consume 45% of Queensland's electricity, and manufacturing consumes 44%. These industries are expected to greatly benefit from the Energy Plan should electricity prices be reduced. Whilst transport has a high energy consumption, it only accounts for a small percentage of Queensland's electricity consumption, so will not be heavily impacted by the Energy Plan.

Figure 28: Electricity is a major cost component and source of emission in these industries



Source: Australian Energy Update, 2021

The Australian Energy Update provides limited data on the breakdown of electricity consumption amongst industries within manufacturing. Just 30% of manufacturing's electricity consumption is reported, with key industries such as non-ferrous metal refining and metal manufacturing omitted. However, other estimates state that the aluminium smelting industry in Queensland could consume 13% of the state's total electricity consumption.[60] The metal refining industry is highly electricity intensive across aluminium, zinc, copper, and alumina, and the industry has a strong presence throughout Queensland. Other manufacturing subsectors such as food products and chemical manufacturing consume just one-fifth of the electricity as the aluminium smelting industry. Thus, the metal refining subsector is likely to be the most impacted manufacturing sector.

As these two industries make up almost 90% of Queensland's industrial electricity consumption, with scope to further electrify their processes, mining and metal refining manufacturing were identified as industries which are likely to be impacted by the Energy Plan.

In addition to analysing the energy intensity of established industries, we also considered the potential electricity demand for a series of emerging industries to understand how the Energy Plan could attract these emerging industries to Queensland. From this process, two emerging industries were identified as having high electricity intensities and consequentially, high electricity costs.

Currently, there is significant public and private investment going into producing green hydrogen in Queensland. Production costs are made up of 72% electricity costs, meaning the implementation of the Energy Plan is likely to have a significant impact on the growth and uptake of the industry in Queensland.[61] Additionally, green hydrogen production relies on a 100% renewable energy source, thus, the Energy Plan's impact on renewable energy could significantly support the growth of green hydrogen in Queensland.

Battery manufacturing is another emerging industry that has been considered. Electricity is a major cost component of battery manufacturing, comprising 15% of the total cost, therefore it could be significantly impacted by the Energy Plan. Additionally, the Energy Plan's significant public and private investment into renewable energy and transmission is expected to increase demand for big and small batteries in Queensland.[62]

Based on electricity consumption, resource mining, metal refining, green hydrogen and battery manufacturing will be further analysed. Sectors such as residential, agriculture, commercial and professional services, construction, and water and waste are not electricity intensive and will not be significantly impacted by the Energy Plan, but are still expected to benefit from lower electricity prices, emissions, and green premiums.

Significant industries with industry linkages support jobs and economic activity

The next step of the analysis was to identify industries with large contributions to Queensland's GSP. This also includes industries with linkages to other domestic industries. This is important as changes to the cost structure of large or potentially large industries can have significant positive or negative impacts on Queensland's economy, especially when they are linked to other industries.

Queensland's largest contributors to GSP are listed in Figure 29. In 2020-21, the health care and social assistance industry was the largest employer in the state and the most prominent contributor to GSP in Queensland. It is likely to continue to grow as the state's population ages and the demand for health services increases. Professional, scientific, and technical services and construction are also major industries in Queensland. However, despite their contribution to the economy, these industries are not expected to be impacted by the Energy Plan due to their low electricity consumption and have not been included as priority industries for this analysis.

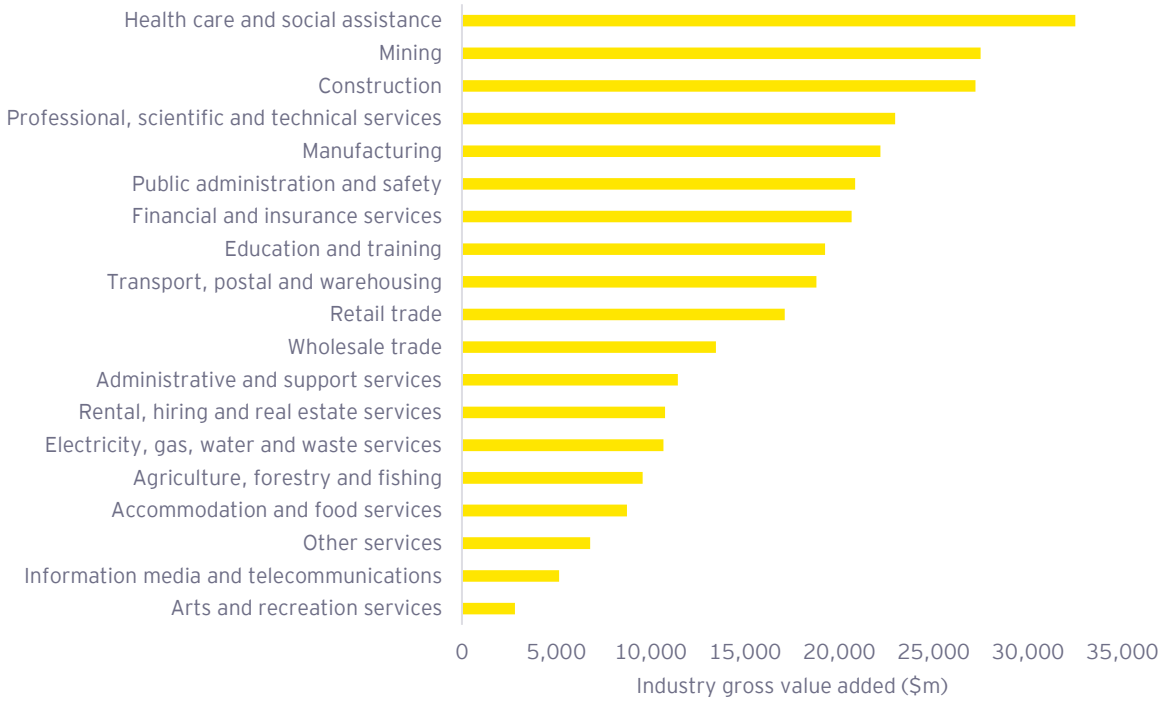
[60] Butler, 2020

[61] EY analysis

[62] Future Batteries Industries Cooperative Research Centre, 2021

Queensland's economy is also dominated by mining, manufacturing, and agriculture. Resource mining plays a major role in Queensland's economy as the second largest contributor to GSP. Resource mining supports over 80,000 jobs, with 70% of these jobs in regional Queensland.[63] The industry is expected to play a critical role in the transition to net zero as demand for resources, specifically as demand for non-ferrous metals increase. This presents a substantial opportunity for the resource mining industry to expand, creating more jobs and further supporting regional Queensland. Resource mining supports jobs throughout the state across a range of industries, through upstream and downstream supply chains. As a major export through Queensland's ports, the industry supports jobs in maritime and shipping. Non-ferrous metal mining in particular supports jobs as an upstream industry as it is a major input for metal refineries in Mount Isa, Townsville, and Gladstone. Any impacts on Queensland's mining industry are likely to flow through to metal refining jobs throughout the state's regions.

Figure 29: Industry contribution to gross state product, Queensland, 1-digit ANZSIC industries



Source: ABS cat. no. 5220.0, Table 4, June 2021.

Queensland has a well-established agricultural industry, supporting over 30,500 businesses and contributing over $10 billion annually, primarily in regional areas.[64] Queensland's beef industry is the largest in Australia, with almost 50% of the nation's 23.6 million cattle located in the state. Beef is also the most prominent exported good within the Queensland agriculture industry. The agriculture industry also supports the significant food processing and manufacturing industry in the state. While products such as cotton are not processed in Queensland, food products like beef, dairy, and sugarcane are processed in the state and support regional economies as a major export. However, the agriculture industry was not selected for further assessment due to its low electricity consumption, which was just 1% of the combined electricity consumption of the mining and manufacturing industries.[65]

The manufacturing industry was the fifth most prominent contributor to GSP in Queensland in 2020-21. The industry is comprised primarily of food product manufacturing, chemical

[63] Queensland Government, 2021b
[64] Queensland Government, 2017
[65] Department of Industry, Science, Energy and Resources, 2021

manufacturing, paper manufacturing, and primary metal manufacturing, and typically employs workers in regional Queensland.

Battery storage manufacturing has potential to see significant growth in Queensland. In 2017, the global battery value chain was worth $185 billion, with Queensland capturing some of the upstream resource mining components of the value chain. The demand for batteries will increase in the coming decade, expected to grow by an average of 15% annually to 2030. Queensland has one of the highest solar uptakes per household in the world and small household batteries are complimentary to rooftop solar. Therefore, there is a growth opportunity in the domestic small battery market in Queensland which could support industry growth. Additionally, Queensland is the most decentralised state in Australia, with some regional population centres that are off the state's electricity grid. This presents further opportunities in the big off-grid battery market which could service communities and mining operations. The battery manufacturing industry is also expected to support several industries in Queensland including mining, metal refining, and repair services.

Green hydrogen also has a promising growth trajectory. It is produced using electrolysis powered by renewable energy. Currently, many countries are investing in green hydrogen to capture future growth in the market. In 2020, 50GW worth of green hydrogen projects were announced globally, with many large-scale projects receiving government support. There are several high-profile green hydrogen projects in development in Queensland. In particular, the construction of the world's largest electrolyser manufacturing facility has begun in Gladstone. Based on committed projects, Queensland's hydrogen production is expected to grow by almost 100% each year until 2028.[66] Global demand for hydrogen is expected to grow from 90Mt per annum in 2020 to 210Mt in 2040, with Queensland emerging as one of the lowest-cost regions to potentially produce green hydrogen in the world.

Based on this analysis, significant industries that will be most impacted by the Energy Plan are resource mining, metal refining, green hydrogen and battery manufacturing.

Export-exposed industries face pressure from global trends

Export-exposed industries are most vulnerable to global trends towards environmental sustainability and the clean energy transition, and thus are expected to be most supported by the Energy Plan. The Energy Plan is expected to mitigate challenges presented by global trends by reducing industry emissions and create opportunities in new and existing industries. There are several global trends that are expected to impact export-exposed industries within Queensland, and which could be influenced by the state's Energy Plan.

- **Carbon pricing** - Carbon pricing is an emerging trend in developed nations. Carbon pricing puts a price on carbon emissions that emitters are required to pay. While this only affects domestic emitters, some countries are investigating the feasibility and merits of applying this carbon price to imports. The EU has committed to adopting this strategy to ensure that imports are charged for the greenhouse gas emissions that they produce. While the EU is not an important market for Queensland, if other nations such as Japan or South Korea take up similar policies, emission-intensive industries, such as metal refining, would face challenges.

- **Green premiums** - Green premiums refer to the extra cost that consumers are willing to pay for low-carbon goods. Green premiums are beginning to emerge in global markets for products that are typically emissions intensive but are required for clean technologies such as refined metals. By implementing the Energy Plan, Queensland's export-exposed industries could attract green premiums.

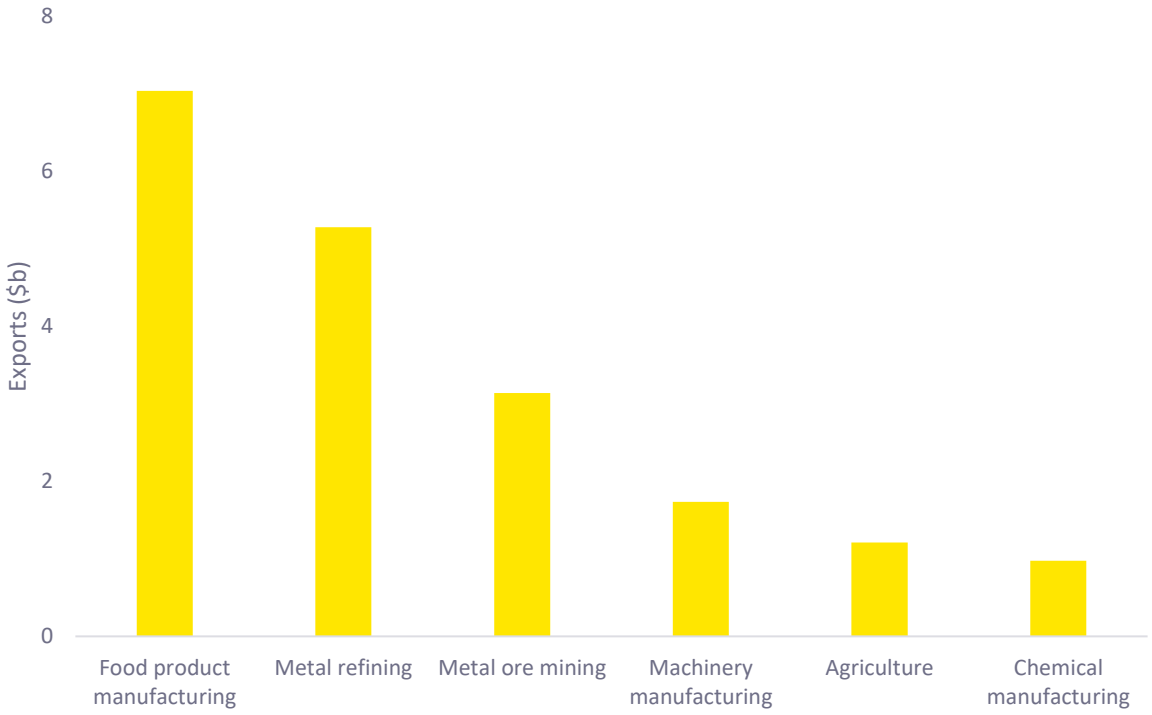
- **Demand for low-carbon technologies** - The demand for low-carbon technologies is set to increase as countries transition quickly to low-carbon futures. This is expected to lead to an

[66] Department of Industry, Science and Resources, 2021

increase in the demand for minerals and metals due to significant capital replacement requirements and increased investment in component production associated with new technologies.

Of this, key export-exposed sectors in Queensland include coal mining, food production manufacturing, metal refining and metal ore mining. Food production manufacturing was the second largest exporter by industry in 2020-21, exporting over $7 billion worth of goods.[67] The metal refining industry was also a significant exporter in 2020-21, exporting up to $5.3 billion in goods. Metal ore mining was another key export, with $3.1 billion worth of metals exported in 2020-21. This is showed in Figure 30.

Figure 30: Queensland exports by industry (2020-21)

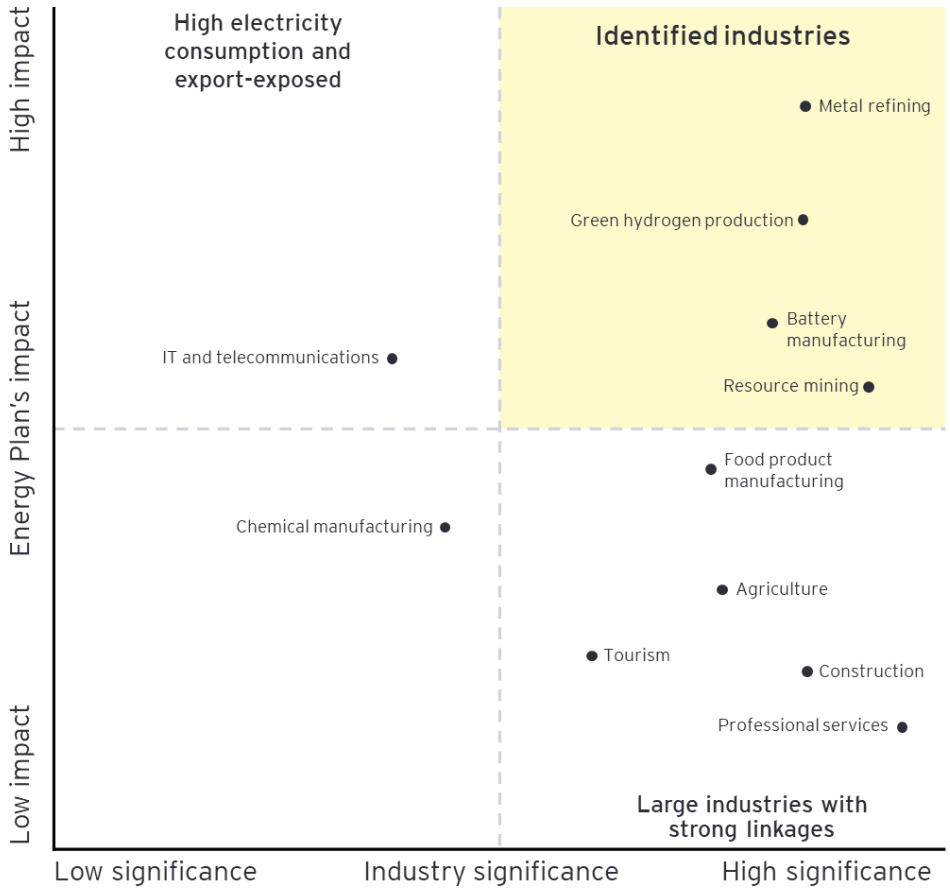


Source: Queensland Government, 2022

In addition to these export-exposed industries, established industries such as green hydrogen and battery manufacturing are also expected to be export-exposed in the future. These export-exposed industries are likely to be impacted by global trends towards carbon pricing and green premiums and could experience increased demand as countries transition to clean technologies. However, to capture opportunities and mitigate challenges, action must be taken to reduce the emissions intensity of Queensland's industries. The Energy Plan takes action to decarbonising the state's electricity grid, which will reduce the state's Scope 2 emissions significantly. These export-exposed industries stand to benefit the most from the Energy Plan's action, with the most electricity intensive industries also expected to gain from lower electricity prices and lower emissions. Figure 31 shows an overview of the results of the criteria, where metal refining, green hydrogen production, battery manufacturing and resource mining tick all four criterion.

[67] Department of Foreign Affairs and Trade, 2022

Figure 31: Overview of the results of the criteria analysis



Source: EY analysis

Table 7: Industry performance against criteria analysis

Industry	High electricity demand	Large industry	Export-exposed	Strong industry linkages
Metal refining	✓	✓	✓	✓
Green hydrogen production	✓	✓	✓	✓
Battery manufacturing	✓	✓	✓	✓
Resource mining	✓	✓	✓	✓
Food product manufacturing		✓	✓	✓
Agriculture		✓	✓	✓
Tourism		✓		✓
Construction		✓		✓
Professional services		✓		✓
IT/telecommunications	✓			✓
Chemical manufacturing			✓	

Source: EY analysis

Based on the above analysis, four industries were identified as being most likely to be impacted by the Energy Plan while being significant or potentially significant industries in Queensland: metal refining, resource mining, green hydrogen, and battery manufacturing. While these industries are expected to benefit the most from the Energy Plan, implementing the Energy Plan would reduce electricity costs and Scope 2 emissions for all industries, improving profitability and attracting green premiums and investment.

Appendix B Whole of economy modelling

The whole of economy takes various assumptions to inform the model inputs. Table 8 details the source of each assumption.

Table 8: Whole of economy model input assumptions

Assumption	Source
Electricity price	The electricity price is an output of the electricity market modelling.
Investment	The investment expenditure is an output of the electricity market modelling.
Carbon transfers	The carbon transfers take the carbon price assumed by the Commonwealth Government's report *Australia's Long-Term Emission Reduction Plan*[68], at $40 a tonne in real terms and the emission reductions that are an output of the electricity market modelling.
Green premia	The green premia assumptions are provided by analysis undertaken by the Queensland Treasury and are based on the Commonwealth Government's report *Australia's Long-Term Emission Reduction Plan*.

The EYGEM model

Economic impact analysis measures the net impact of changes on an economy. It is used to measure the net change in response to a given event (e.g., such as the loss of an activity, or increased expenditure in a particular sector). The key economic metrics are expressed in terms of changes to gross domestic product and other macro-economic indicators.

The EYGEM model is a large scale, dynamic, multi-region, multi-commodity CGE model of the world economy. The EYGEM model enjoys significant flexibility both at the regional and sectoral level, including the capability to individually identify sub-regions of Australia, including (but not limited to) at the SA4 or the LGA level as separate economic regions. This capability to identify subnational regions is also readily extended to other international regions.

EYGEM draws on the global CGE modelling framework developed by the Global Trade Analysis Project (GTAP) based at Purdue University in the United States. Their model is described in Hertel (1997), with its antecedent being the Industry Commission's Salter model (Jomini et al 1991). The GTAP model was greatly enhanced by the Australian Bureau of Agriculture and Resource Economics (ABARE) to incorporate dynamic capabilities. The MEGABARE model (ABARE 1996) and its successor, the Global Trade and Environment Model (Pant 2002), were the fruits of ABARE's efforts.

Our model is implemented in modern data science frameworks, including Python and Pandas, and has a user-friendly Excel interface. Our frameworks are specifically designed to improve auditing a paper trail in modelling exercises, reduce the risk of modelling error, and allow for (for example) systematic sensitivity analysis.

Overview of the modelling framework

EYGEM is based on a substantial body of accepted microeconomic theory. Key assumptions underpinning the model are:

- The model contains a 'regional consumer' that receives all income from factor payments (labour, capital, land and natural resources), taxes and net foreign income from borrowing (lending).

[68] Australian Government, 2021. *Australia's Long-term emissions reduction* plan. Available at: https://www.industry.gov.au/sites/default/files/October%202021/document/australias-long-term-emissions-reduction-plan.pdf

- Income is allocated across household consumption, government consumption and savings so as to maximise a Cobb-Douglas utility function.
- Household consumption for composite goods is determined by minimising expenditure via a CDE (Constant Differences of Elasticities) expenditure function. For most regions, households can source consumption goods only from domestic and imported sources. In the Australian regions, households can also source goods from interstate. In all cases, the choice of commodities by source is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption for composite goods, and goods from different sources (domestic, imported and interstate), is determined by maximising utility via a Cobb-Douglas utility function.
- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of creating capital.
- Producers supply goods by combining aggregate intermediate inputs and primary factors in fixed proportions (the Leontief assumption). Composite intermediate inputs are also combined in fixed proportions, whereas individual primary factors are combined using a CES production function.
- Producers are cost minimisers, and in doing so choose between domestic, imported and interstate intermediate inputs via a CRESH production function.
- Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. A global investor ranks countries as investment destinations based on two factors: global investment and rates of return in a given region compared with global rates of return.
- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.
- Prices are determined via market-clearing conditions that require sectoral output (supply) to equal the amount sold (demand) to final users (households and government), intermediate users (firms and investors), foreigners (international exports), and other Australian regions (interstate exports).
- For internationally-traded goods (imports and exports), the Armington assumption is applied whereby the same goods produced in different countries are treated as imperfect substitutes. But in relative terms imported goods from different regions are treated as closer substitutes than domestically-produced goods and imported composites. Goods traded interstate within the Australian regions are assumed to be closer substitutes again.
- The model accounts for greenhouse gas emissions from fossil fuel combustion. Taxes can be applied to emissions, which are converted to good-specific sales taxes that impact on demand. Emission quotas can be set by region and these can be traded, at a value equal to the carbon tax avoided, where a region's emissions fall below or exceed their quota.

Dynamics of EYGEM

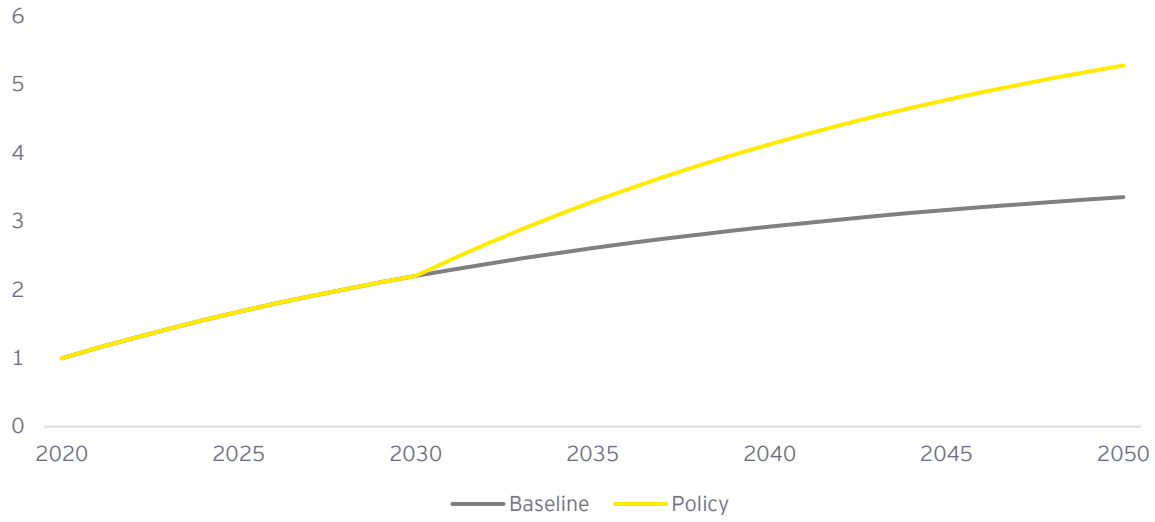
EYGEM is a recursive dynamic model that solves year-on-year over a specified timeframe. This has two main advantages. First, dynamics allows a richer specification of the model in that issues such as debt accumulation (which facilitates the ability to model international capital flows) and labour market dynamics are able to be modelled in a more sophisticated manner. Second, scenario analysis using a model such as EYGEM can be greatly enhanced by the ability to alter the baseline, or reference case, to account for key developments or uncertainties.

The model is then used to project the relationship between variables under different scenarios, or states, over a pre-defined period. This is illustrated in the figure below, where a reference case or 'baseline' forms the basis of the analysis undertaken using EYGEM. The model is solved year-by-year from time 0 which reflects the base year of the model (2020) to a predetermined end year (in this case 2050).

The 'Variable' represented in the figure could be one of the hundreds or thousands represented in the model ranging from macroeconomic indicators such as real GDP to sectoral variables such as the exports of iron and steel from Australia. In the figure, the percentage changed in the variables have been converted to an index (= 1.0 in 2020) and is projected to increase by 2050.

Set against this baseline is a 'Policy' scenario. This scenario represents the impacts of a policy change or different assumptions about economic development that results in a new projection of the path of the variable over the simulation time period. The impacts of the policy/assumption change are reflected in the differences in the variable at time T. It is important to note that the differences between the baseline and policy scenario are tracked over the entire timeframe of the simulation.

Figure 32: Dynamic simulation using EYGEM



Detailed interdependencies

The model is underpinned by a detailed, global database. The model's database is 'benchmarked' or 'calibrated' so that initial equilibrium solution exists that replicates actual sectoral production, consumption, trade and factor usage. It contains 141 regions and 64 sectors for a base year of 2007, and is the benchmark dataset for applied, global general equilibrium modelling. This database produced by the Global Trade Analysis Project (GTAP) at Purdue University is the most detailed and comprehensive database of its type in the world. Used by some 700 researchers globally, the database is a truly international, collaborative research effort that is fully documented and transparent.

The EYGEM model is primarily based on input-output or social accounting matrices, as a means of describing how economies are linked through production, consumption, trade and investment flows. For example, the model considers:

- direct linkages between industries and countries through purchases and sales of each other's goods and services; and
- indirect linkages through mechanisms such as the collective competition for available resources, such as labour, that operates in an economy-wide or global context.

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