



# Seizing Gladstone's low-carbon opportunity

A net zero  
industrial precinct  
approach

FEBRUARY  
2025

## ACKNOWLEDGEMENT OF COUNTRY

We acknowledge and pay respect to the Traditional Custodians and Elders – past and present – of the lands and waters of the people of the Kulin nation on which the Climateworks Centre office is located, and all of the Elders of lands across which Climateworks operates nationally. We acknowledge that sovereignty was never ceded and that this was and always will be Aboriginal land. [More information.](#)

## ACKNOWLEDGEMENTS

Climateworks Centre wishes to acknowledge the contributions of Mission Possible Partnership to the low-carbon product demand analysis in this report.

We thank Climateworks staff who contributed to the development of this report, in particular, Hannah McCaughey, Tommaso Mattia Pretto, Allison Courtin, Tyra Horngren, Anna Malos, Michael Li, Hugh Sheehan, Kylie Turner and Amrit Bhabra.

## ABOUT US

Climateworks Centre bridges the gap between research and climate action, operating as an independent not-for-profit within Monash University. Climateworks develops specialist knowledge to accelerate emissions reduction, in line with the global 1.5°C temperature goal, across Australia, Southeast Asia and the Pacific.

---

## AUTHORS

Dr Tessa Leach  
Dr Calvin Lee  
Carolina Dolan  
Tim Graham

---

Climateworks Centre, 2025, *Seizing Gladstone's low-carbon opportunity: A net zero industrial precinct approach*.

ISBN: 978-1-7637231-3-9

---

# Contents

<b>Executive summary</b>	<b>6</b>
<b>Introduction</b>	<b>9</b>
<b>1. Producing low-carbon products can maintain industrial regions' prosperity</b>	<b>13</b>
<b>1.1 Gladstone has numerous existing and natural advantages to produce low-carbon products</b>	<b>13</b>
<b>1.2 Gladstone's aluminium industry could take advantage of new sources of demand</b>	<b>14</b>
1.2.1 Global aluminium demand is projected to increase	14
1.2.2 Under a rapid decarbonisation scenario, demand for low-carbon aluminium will outstrip supply	15
1.2.3 Gladstone has competitive advantages in supporting a local low-carbon aluminium industry	16
<b>1.3 Gladstone can produce low-carbon ammonia for domestic and global customers</b>	<b>17</b>
1.3.1 Australian manufacturing will need low-carbon ammonia	17
1.3.2 Low-carbon ammonia demand will increase globally, and Gladstone is well-placed to meet demand	18
<b>2. A bottom-up modelling approach captures more precise region-specific energy demand</b>	<b>20</b>
<b>2.1 Producing low-carbon products will require a transformed energy system</b>	<b>21</b>
2.1.1 Gladstone could require 74 TWh/year for new and existing industries by 2040	22
2.1.1.1 By 2040, 94 per cent of fossil fuels could be displaced by electricity and hydrogen as industrial energy sources	24
2.1.1.2 By 2040, process heat could account for 89 per cent of the electricity used by existing industries due to electrification and hydrogen consumption	25
2.1.1.3 By 2040, the transformation of existing industries and new energy exports could demand 910,000 t/year of low-carbon hydrogen	25

2.2 Existing top-down modelling approaches may significantly underestimate regional energy demands	27
2.2.1 ISP scenarios may underestimate electricity demand for decarbonisation in Gladstone	27
2.2.2 Gladstone could require as much wind and solar capacity as there is currently planned for all 'renewable energy zones' in Queensland	29
<b>3. Key recommendations for a 'net zero industrial precinct' strategy for industrial decarbonisation</b>	<b>31</b>
3.1 A net zero industrial precincts approach in Australia could support Gladstone's existing and new industries	32
3.2 Net zero industrial precinct approaches consider people, land and investment	33
3.3 Recommendations for Gladstone and Australian industrial region transitions	34
<b>Appendix: Inputs and assumptions for Gladstone energy modelling</b>	<b>38</b>
Modelling methodology	38
Inputs and assumptions	39
Baseline assumptions	39
Industrial activity inputs	40
Existing industries	40
New industries and ammonia	41
Technology deployment timelines	42
Alumina	42
Aluminium	43
Ammonia for explosives	43
Cement and clinker	43
Explosives	43
Low-carbon energy exports	43
<b>References</b>	<b>44</b>
<b>Glossary</b>	<b>48</b>

# Executive summary

A coordinated and fast-paced transition of Australia's industrial regions will maintain prosperity in those communities and enable Australia to meet its obligations under the Paris Agreement.

Through the Australian Industry Energy Transitions Initiative (Australian Industry ETI), Climateworks Centre identified the emissions reduction potential for five of Australia's largest industrial regions and how the 'hard to abate' industries within these regions could decarbonise (Climateworks Centre and Climate-KIC Australia 2022). Building on this work, in 2024 Climateworks focused on one of these regions – Gladstone, in Central Queensland – to show how the region can abate virtually all emissions from heavy manufacturing. Gladstone was an ideal choice for our case study, as it has emissions-intensive manufacturing industries: 79 per cent of current energy use in heavy manufacturing comes from consumption of gas or coal, mostly for the heat that is needed for industrial processes. However, it also has many natural and economic assets that can provide globally competitive advantages in a net zero world. These include:

- + access to extensive renewable energy resources – the renewable energy zones (REZs) around Gladstone have the potential to generate over 47 GW of renewable energy (Edmonds et al. 2022)
- + existing infrastructure for heavy industry, particularly the Port of Gladstone, which has a total throughput of 120 million tonnes per annum (Gladstone Ports Corporation 2022)
- + a highly skilled workforce, with 14.4 per cent of the Gladstone region's jobs in the manufacturing sector (The Next Economy 2022).

To ensure the right actions are taken today, it is critical to understand what success looks like. This report presents our findings and recommended actions for Gladstone to remain competitive as the world decarbonises – findings on its future as a clean manufacturing hub.

The prosperity of the Gladstone region requires immediate action to maintain its heavy manufacturing industries and support Australia in meeting its obligations under the Paris Agreement. Gladstone's heavy manufacturing industries are critical to the local economy and supply products that the world will continue to need. Maintaining Gladstone's existing industries requires Australia

to look strategically at the global market and opportunities to capitalise on the demand for low-carbon products. Demand for low-carbon products is projected to increase, including in existing trading partners like Japan and South Korea, making Gladstone well-placed to seize the opportunity.

## Aluminium and ammonia could be produced in Gladstone with very low emissions and they are projected to increase in demand in key trading partners.

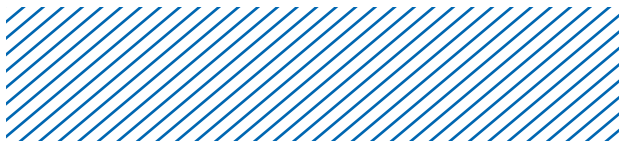
This is material to Australia's potential to become a low-carbon manufacturing powerhouse and helping to decarbonise some of the world's most emissions-intensive supply chains.

The transition will require low-cost, near-zero emissions electricity supply available to industry at a sufficiently rapid pace, as well as capital investment in industrial facilities so they can manufacture low-carbon products without too great a 'green premium'. Slow decarbonisation, high energy costs or uncertainty over timing could stand in the way of this opportunity. **The opportunity to produce low-carbon products is paired with a risk of losing market share if no action is taken, as well as the risk of missing corporate and government emissions reduction targets.**

Climateworks' work in heavy industry decarbonisation has shown that Gladstone, and regions like it, could benefit from adopting a 'net zero industrial precinct' (NZIP) approach. Collective industrial decarbonisation within an NZIP allows for coordinated investment and policy that promote regional prosperity and a more equitable transition to low-carbon operations. For an NZIP, industrial actors and government agencies come together to implement technological, economic and policy solutions that reduce investment costs and risks, aiming to secure firm renewable energy and produce competitive low-carbon products that will be in demand as the world transitions to net zero. Working to reduce emissions of a whole NZIP, rather than one company at a time, could set regions up for success.

For this project, we identified key gaps that restrict rapid decarbonisation, and that could benefit from an NZIP approach. **In the case of Gladstone, a key limiting factor is access to renewable energy generation at the scale needed to provide electricity, heat and alternative feedstock.**

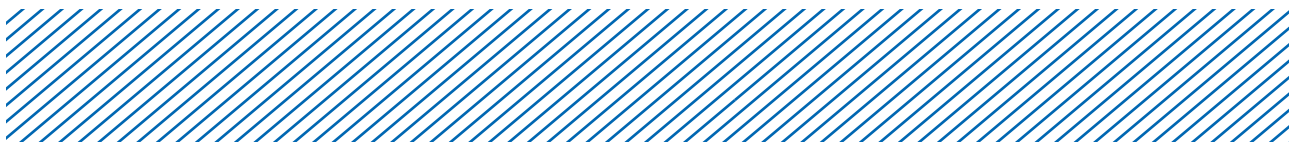
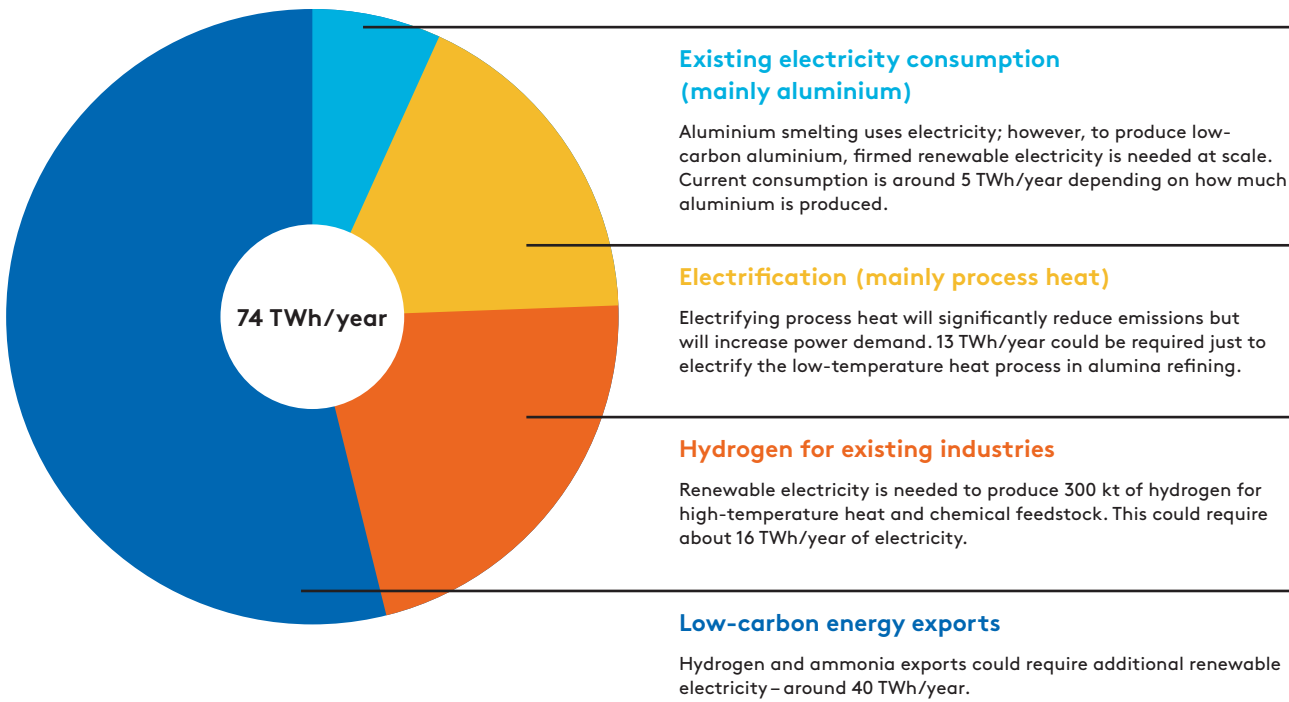
A combination of the closure of coal-fired power stations and a potentially dramatic increase in electricity consumption to meet early demand for low-carbon products would require significantly expanded renewable energy generation capacity. Facilities may access electricity via connection to the electricity grid or on-site renewable energy or energy storage. In this way, they can reduce both scope 1 and 2 energy emissions and make significant inroads into the emissions intensity of low-carbon products produced within the precinct.



Our analysis of future energy consumption and emissions – denoted as the ‘Climateworks Gladstone’ scenario – found that existing major manufacturing industries (aluminium, alumina, explosives, cement) and new low-carbon energy exports (using regional hydrogen assumptions) could require 74 TWh/year of renewable electricity by 2040.<sup>1</sup>

This results in a 93 per cent scope 1 energy emissions reduction across these industries by 2040. For perspective, the size of the National Electricity Market (NEM) today is 174 TWh/year.

**2040 ELECTRICITY CONSUMPTION BY INDUSTRIES IN SCOPE IN THE ‘CLIMATEWORKS GLADSTONE’ SCENARIO (TWH/YEAR)**



<sup>1</sup> Assumptions and inputs, including changes in production volumes, can be found in the Appendix.

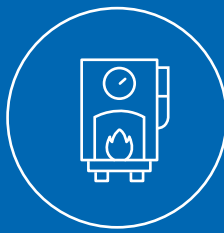
This report presents findings from our analysis of these issues in Gladstone and our recommendations for actions that can be implemented now. Gladstone is material to both Australia's economy and emissions, and the proposed actions position the region, and

Australia, to optimise the opportunity of the global low-carbon economy. These recommendations would enable the net zero transition in Gladstone as well as other Australian regions.

## We recommend that:



- + Energy planning authorities create 'regional Integrated System Plans' for Gladstone and other major industrial regions, building on the Australian Energy Market Operator (AEMO) 'Green energy exports' scenario, resulting in new electricity infrastructure being built at the scale required.



- + Governments develop policies to support low-carbon industrial heat at scale, including national and state-level industrial heat strategies, financing models and a coordinated funding response to support early-stage technologies and deployment of low-carbon heat technologies at scale.



- + Energy demand management policy and energy efficiency mechanisms for heavy industry be expanded, optimising infrastructure development and costs for all energy users.



- + Governments enact measures to support early hydrogen demand in existing industries, catalysing a low-carbon hydrogen market in industrial regions.



- + Governments and industry endorse high-quality standards for low-carbon products, ensuring consistency between Australia's emissions intensity standards and international standards.



---

## Introduction

The world is moving to a net zero economy to meet the goals set out in the 2015 Paris Agreement to limit global warming. Exports contributed around 22 per cent of Australian GDP in 2020–21, with approximately a fifth of this attributed to coal exports (Australian Bureau of Statistics 2023). Other important exports are from 'hard to abate' sectors, including mining and heavy manufacturing. A coordinated and fast-paced transition of Australia's industrial regions would maintain prosperity in those regional communities and enable Australia to produce and sell the low-carbon products that the world needs. The Central Queensland city of Gladstone is home to the fourth largest coal terminal in the world, as well as three liquified natural gas (LNG) terminals, but is also at the forefront of the Australian energy and low-carbon industrial transition.

Gladstone produces heavy manufacturing products such as alumina, aluminium, cement and explosives. In FY 2022, Australia exported over 16.5 million tonnes of alumina, with a value of roughly \$8.3 billion (DISR 2024). Roughly 5.6 million tonnes of alumina was exported via the Port of Gladstone alone (Gladstone Ports Corporation n.d.). Manufacturing contributes

significantly to Gladstone's local economy, representing roughly 4,520 out of a total 24,267 jobs (Central Queensland Regional Organisation of Councils n.d.). However, Gladstone's manufacturing sector is emissions-intensive and highly dependent on fossil fuels. The Australian Industry ETI found that potential greenhouse gas emissions reductions for existing alumina, aluminium and explosives production could be 13.1 MtCO<sub>2</sub>e per year, with LNG production representing an additional 8.1 MtCO<sub>2</sub>e per year (Climateworks Centre and Climate-KIC Australia 2022). This is close to the annual emissions of Queensland's entire transport sector in 2022, which was 21.5 MtCO<sub>2</sub>e (Department of Energy and Climate 2024).

Stakeholders from Gladstone's heavy industry, as well as state and federal government, have expressed support for creating a clean industry hub and making Central Queensland a renewable manufacturing powerhouse. Gladstone has attracted interest from companies pursuing new green export opportunities, including a potential new green iron project (Quinbrook 2024).

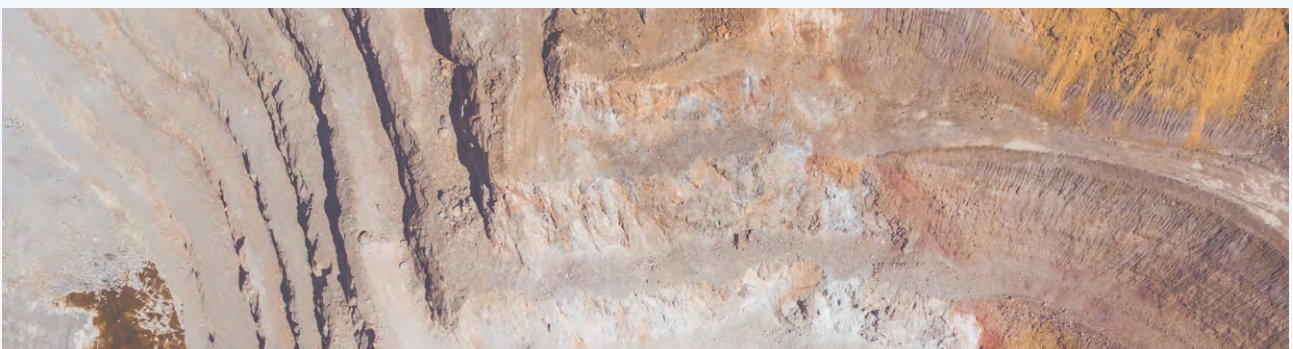
## BOX 1:

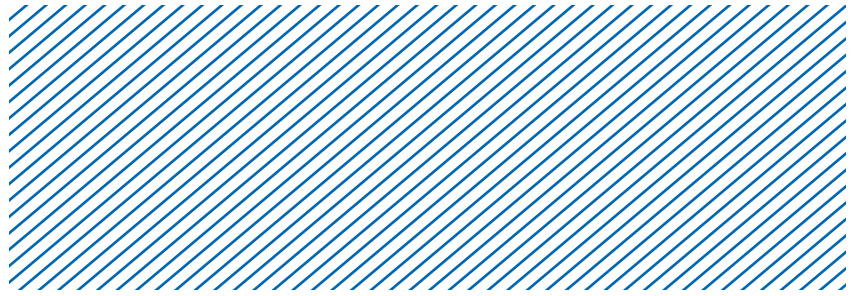
## Building on the Australian Industry ETI

The Australian Industry ETI, which was co-convened by Climateworks and Climate-KIC Australia, found opportunities for emissions reduction in Australian industry in line with 1.5 degrees Celsius of warming. Multi-year engagements with some of Australia's largest companies and evidence-based, independent analysis identified potential pathways across five industrial supply chains. Australia's industrial sectors account for roughly 44 per cent of its carbon emissions. However, the Australian Industry ETI found that a 1.5 degree-aligned scenario could see these emissions reduced by 92 per cent by 2050, from a 2020 baseline, while Australia maintains a strong industrial economy. Between 2020 and 2040, both the aluminium and chemicals (ammonia, fertiliser and explosives) supply chains reduced their emissions by 94 per cent (Climateworks Centre and Climate-KIC Australia 2023).

One of the key findings of the Australian Industry ETI was that regional planning is critical to Australia's industrial decarbonisation. In our work in Gladstone, Climateworks built on the work from Australian Industry ETI, investigating how Australia-wide recommendations for industrial decarbonisation can be adapted to model rapid decarbonisation in a specific Australian region.

This report is designed to provide decision-makers in government and industry with new data to support key decisions regarding shared infrastructure and other key enablers. The technology pathway that sits behind this report's analysis is adapted from analysis undertaken for the Australian Industry ETI Phase 3 report (Climateworks Centre and Climate-KIC Australia 2023), with slightly amended technology deployment timing that considers practical on-the-ground opportunities and constraints in Gladstone. Changes were made partly due to an update from the Australian Industry ETI's 2020 baseline year, as the Phase 3 report's 1.5°C-aligned scenario would have seen greater deployment of enablers such as electricity generation and low-carbon hydrogen by 2024 than has occurred so far. We also found that specific regional challenges and opportunities needed to be accounted for. Details on assumptions and methodology can be found in the Appendix. Differences between the scope of this report and the Australian Industry ETI include the addition of the cement supply chain (a significant energy user in Gladstone), greater consideration of low-carbon energy export industries, and the exclusion of LNG (also a significant energy user in Gladstone but which is currently not supplied by the electricity grid).





For this Gladstone study, Climateworks worked with global expert Mission Possible Partnership (MPP) to assess the potential demand for low-carbon products that Gladstone can produce and export (Mission Possible Partnership n.d.). We also developed an energy demand analysis, in which industrial technologies are deployed, and electricity supply decarbonises rapidly, with the goal of assessing the potential electricity, heat and hydrogen required to deploy new low-carbon technologies in Gladstone.

The study focused on some of Gladstone's most energy-intensive existing manufacturing industries (Figure 1). The scope of industries is derived from desktop research, geographical scoping and the availability of appropriate data.

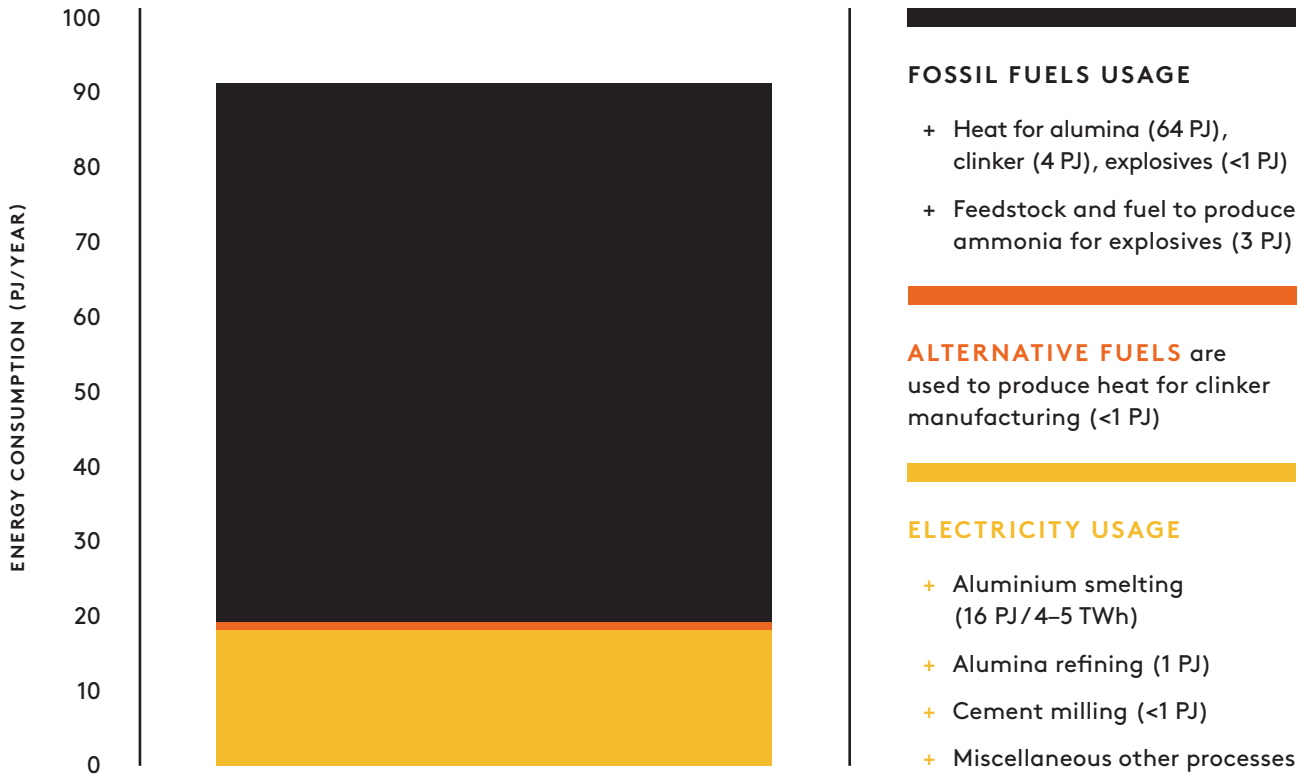
We have also modelled the development of new hydrogen-derived low-carbon energy export industries (namely liquified hydrogen and ammonia) predicated on published findings by the Queensland Department of Energy and Climate (2022) (see Appendix for details).

**FIGURE 1: Scope of industries included under Climateworks' Gladstone study**

EXISTING AND NEW INDUSTRIES IN SCOPE	OUT OF SCOPE
<ul style="list-style-type: none"> <li>+ Alumina</li> <li>+ Aluminium</li> <li>+ Cement</li> <li>+ Explosives</li> <li>+ Existing ammonia produced in Central Queensland</li> <li>+ Ammonia produced to replace currently imported ammonia</li> <li>+ Low-carbon energy exports (liquefied hydrogen and ammonia)</li> </ul>	<ul style="list-style-type: none"> <li>+ Electrification of LNG, coal mining or port facilities</li> <li>+ Electrification or hydrogen use in mining</li> <li>+ All other mineral refining</li> <li>+ Low-carbon energy exports other than liquefied hydrogen and ammonia</li> <li>+ Industry outside Central Queensland</li> <li>+ Residential</li> <li>+ Commercial</li> <li>+ Transport (except scope 1 emissions for industries in scope)</li> </ul>

Currently, most of Gladstone's heavy manufacturing considered in this report is carbon intensive and uses fossil fuels for 79 per cent of its energy needs, primarily to produce heat (Figure 2).

**FIGURE 2:** Current energy consumption of Gladstone’s industries in scope



We found that to effectively address the complexities of decarbonisation while ensuring the Gladstone regional economy continues to grow, a coordinated and strategic set of government and industry actions is essential. This will require a multidisciplinary approach, combining technical expertise, stakeholder engagement, policy advocacy and innovative thinking. The recommended next steps at the conclusion of this report aim to progress this approach and thus secure the future competitiveness of Central Queensland in a decarbonising world.





# 1. Producing low-carbon products can maintain industrial regions' prosperity

Australia currently produces many minerals, metals, chemicals and other industrial products that the world will require for decades to come.

Each industrial region has a unique pathway to grow, diversify and decarbonise local industries. These pathways can serve to both increase or maintain prosperity and support global decarbonisation. This chapter presents an evaluation of future opportunities for Gladstone, including an assessment of potential markets for low-carbon products based on the region's strengths.

## 1.1

### Gladstone has numerous existing and natural advantages to produce low-carbon products

Gladstone is well-positioned to be globally competitive in low-carbon commodities due to numerous existing and natural advantages. These include:

- + excellent renewable energy resources, including a high availability of land suitable for development
- + existing industry expertise and industry ecosystem
- + high quality preferential trade agreements with key export markets in North Asia and around the world
- + existing port facilities and geographical nearness of international markets
- + access to mineral reserves.

There are several industries in Gladstone that can significantly reduce emissions and take advantage of both regional efficiencies and market opportunities, such as the growing global demand for low-carbon products and resources. Climateworks' Gladstone analysis found that aluminium and ammonia are particularly promising commodities both from a technical feasibility perspective and a market demand perspective. The decarbonisation of the aluminium and ammonia supply chains would result in the transformation of existing industries and products; however, low-carbon ammonia also offers the potential for an entirely new export industry in the form of a low-carbon fuel product.

## 1.2 Gladstone's aluminium industry could take advantage of new sources of demand

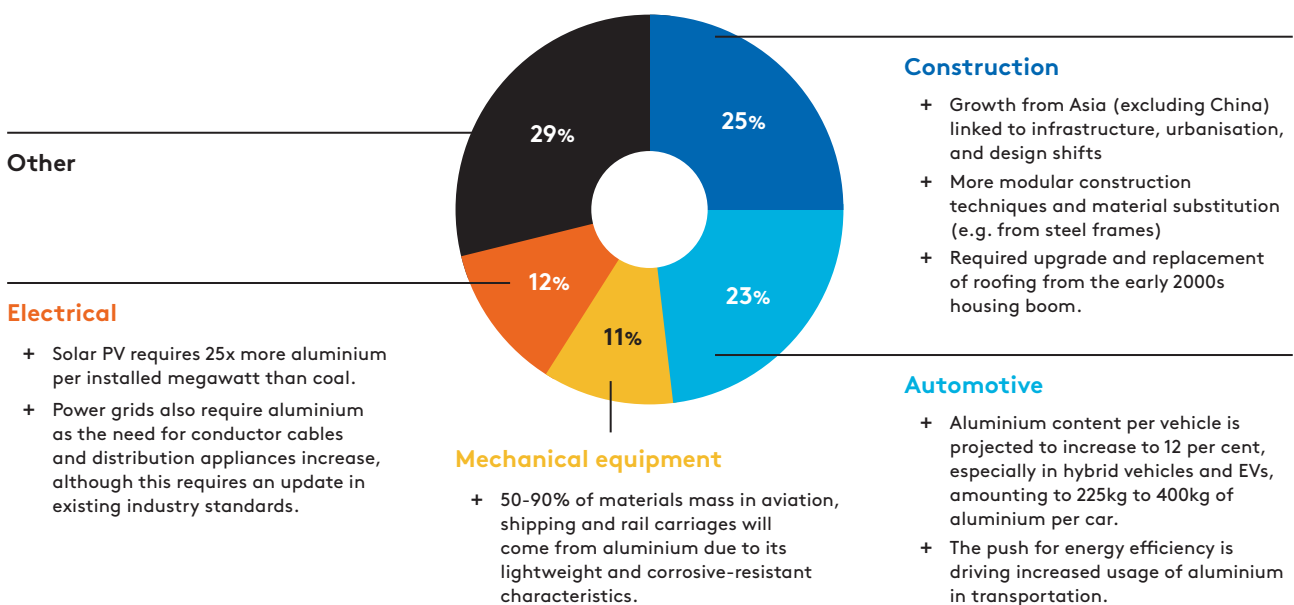
Globally, the aluminium supply chain is responsible for roughly 2 per cent of emissions. Without abatement, annual emissions could increase by 90 per cent by 2050 (Mission Possible Partnership 2023). Global aluminium demand is projected to increase significantly by mid-century, and decarbonising production with wind and solar energy would grow aluminium supply sustainably.

Australia is one of the few countries that possess an end-to-end integrated aluminium industry and is currently the seventh-largest exporter of aluminium in the world (Pistilli 2023). The Australian Industry ETI found that Australia's integrated aluminium supply chain could reduce emissions by 98 per cent by 2050, and the aluminium smelting process could reduce emissions by more than 99 per cent (based on a 2020 baseline) (Climateworks Centre and Climate-KIC Australia 2023). Reducing emissions from smelting requires efficiency improvements, increased use of scrap, inert anodes to abate emissions from chemical reactions and, most importantly, large-scale switching to renewable energy. Gladstone's renewable energy potential means it can be well-positioned to provide low-carbon aluminium to Australia and the world.

### 1.2.1 Global aluminium demand is projected to increase

In 2021, roughly 101 Mt of aluminium was produced globally. This demand is expected to increase significantly by 2050. The World Economic Forum projected a 50 per cent increase in global aluminium demand, relative to demand in 2020, mostly from the automotive (mostly electric vehicles), clean energy equipment and construction sectors (World Economic Forum 2020). Wood MacKenzie's (2022) global 1.5°C-aligned scenario forecasts an increase of 61 per cent relative to current demand. MPP analysis suggests that over the next decade, this demand for additional aluminium is expected to come from the construction, automotive, equipment manufacturing and power grid sectors. Their analysis projects that roughly 70 per cent of future demand, totalling 115 Mt, could come from these sectors by 2030 (Figure 3).

FIGURE 3: Projected end-user sources of demand for aluminium in 2030



Source: Mission Possible Partnership analysis.

Note: Sector shares are approximations, as exact numbers differ per year and sector definition. The 'Other' sector describes any other use that does not fall into any of the categories above, including packaging, foil stock and consumer goods.

## 1.2.2

### Under a rapid decarbonisation scenario, demand for low-carbon aluminium will outstrip supply

More low-carbon aluminium will be needed in the future if we are to both meet Paris Agreement goals and satisfy projected aluminium demand. MPP analysis, however, suggests that this demand will not be met if only current low-carbon production methods are utilised (Azevedo et al. 2022). This represents an opportunity for Gladstone to use its renewable energy resource advantage and capitalise on new low-carbon production methods.

Incumbent aluminium smelting processes produce direct emissions from chemical reactions in the smelter (scope 1 emissions). In Australia in 2022, smelting's indirect emissions from electricity were roughly 6.5 times higher than its scope 1 emissions (Australian Aluminium Council Ltd 2023). This suggests that reducing electricity consumption (e.g. through energy efficiency or demand management technologies) and switching to low-carbon electricity sources are key to decarbonising aluminium production.

#### BOX 2:

### What is low-carbon aluminium?

Low-carbon aluminium does not yet have a widely agreed-upon definition but is short-hand for aluminium that is below certain emissions thresholds. Low-carbon aluminium is typically defined as possessing embodied scope 1 and 2 emissions from the smelting process of less than 4.0 tCO<sub>2</sub>e/tonne of aluminium (tAl). Ultra-low aluminium has emissions of less than 0.5 tCO<sub>2</sub>e/tAl (International Aluminium Institute 2021; Aluminium Stewardship Initiative 2022; Azevedo et al. 2022). The production of ultra-low and low-carbon aluminium can be achieved through a combination of reduced or low-carbon electricity consumption and alternate anode composition to reduce smelting process emissions.

According to the Australian Government, the industry average emissions intensity is 1.94 tCO<sub>2</sub>e/tAl in Australia. This emissions intensity does not include emissions from electricity generation, only scope 1 emissions from facilities (DCCEEW 2024c). Australia has not yet defined a benchmark for low-carbon aluminium.

At the time of writing, the Australian Sustainable Finance Taxonomy was under development by the Australian Sustainable Finance Institute in partnership with the Commonwealth Treasury. A public consultation paper contains technical screening criteria for green aluminium smelting, which requires greenhouse gas emissions from smelting to be 3.1 tCO<sub>2</sub>e/tAl by 2030 (which would be below the low-carbon aluminium definition above) and 0.32 tCO<sub>2</sub>e/tAl by 2050 (below the ultra-low aluminium definition above) (Australian Sustainable Finance Institute 2024). This includes both scope 1 and 2. There is also an electricity consumption requirement.

As part of our Gladstone case study, Climateworks estimates that Gladstone's current aluminium smelting results in combined scope 1 and 2 emissions of roughly 15 tCO<sub>2</sub>e/tAl. Of this, roughly 2 tCO<sub>2</sub>e/tAl is scope 1 emissions, with the remainder being scope 2 emissions from electricity.

Globally, there are currently two primary methods of producing low-carbon aluminium. The first is producing aluminium through recycling, and the second is producing aluminium using hydropower as an electricity source. MPP analysis finds that roughly 40 Mt of the world's aluminium is currently produced through these two low-carbon production methods.

However, the potential to expand production through either method is limited. Hydropower is limited due to a finite number of suitable sites. Recycling is limited due to a finite amount of available feedstock, as aluminium is already recycled at a high rate, with a recycling efficiency rate of around 76 per cent (The Australian Aluminium Council 2020). MPP analysis forecasts low-carbon aluminium supply could potentially increase to 45 Mt by 2030 and 65 Mt by 2050.

McKinsey forecasts 62 Mt of global low-carbon demand by 2030 (Azevedo et al. 2022), meaning demand for low-carbon aluminium would outstrip supply from current low-carbon methods. There is an opportunity for renewable smelting, powered by wind or solar rather than hydropower, to fill the gap between demand and supply.

### 1.2.3

#### Gladstone has competitive advantages in supporting a local low-carbon aluminium industry

Australia, and Gladstone in particular, are well-placed to meet global demand that cannot be provided by current low-carbon production methods. Gladstone can do this through a combination of its high renewables potential and existing aluminium industry infrastructure, expertise and market access.

However, we find that rapid development of renewable energy infrastructure must occur to capitalise on Gladstone's abundant renewables potential and seize a first-mover advantage. Climateworks and CSIRO modelling for the Australian Industry ETI found that rapidly switching to renewable energy, Australia-wide, could lead to lower long-term electricity costs, including for large industrial flat-load customers. As such, the faster Gladstone's industries can access low-cost renewable energy, the greater the business case would be for low-carbon aluminium. The slow pace of deployment of wind and solar energy is a limiting factor on uptake by industry; Rio Tinto's 2024 power purchase agreements with renewable energy project developers to power its Gladstone assets suggest interest from industry in this solution (Rio Tinto 2024).

Climateworks' Gladstone energy and emissions analysis shows that, by switching to renewable electricity and decreasing process emissions, Gladstone could produce aluminium with an emissions intensity below 4 tCO<sub>2</sub>e/tAl by 2031 and below 0.5 tCO<sub>2</sub>e/tAl by 2040.

We also found that novel smelting technologies, such as inert anodes, could further lower these emissions intensities by dramatically reducing scope 1 emissions. Inert anode technology has been successfully demonstrated by ELYSIS in a partnership between Alcoa and Rio Tinto (ELYSIS n.d.). Inert anodes will require further development and capital investment for commercial-scale deployment.



## 1.3 Gladstone can produce low- carbon ammonia for domestic and global customers

Global demand for low-carbon ammonia is expected to increase under the International Energy Agency's 'Net zero emissions by 2050' scenario, characterised by global adoption of clean energy technologies, which Australia's industries have strategic advantages that set them up well to be pioneers. Under this scenario, demand for low-carbon ammonia is largely driven by new applications as a hydrogen carrier and marine fuel, as well as increased production of low-carbon fertilisers and explosives (for which ammonia is a key input) (IEA 2021a). Decarbonising ammonia production is critical as it is the single biggest carbon-emitting chemical process; the ammonia sector is responsible for roughly 1 per cent of global emissions (Mission Possible Partnership 2022).

The Australian Industry ETI found that more than 99 per cent of emissions from ammonia production could be abated by 2050, at which time 97 per cent of hydrogen feedstock is low-carbon electricity-based hydrogen (Climateworks Centre and Climate-KIC Australia 2023). We have found that the technologies required for producing low-carbon ammonia from this hydrogen feedstock are feasible to deploy in Gladstone, providing feedstock to the region's well-established explosives industry and potentially being a low-carbon energy export.

### 1.3.1 Australian manufacturing will need low-carbon ammonia

Globally, about 70 per cent of ammonia is used to manufacture fertiliser (Mission Possible Partnership 2022). Australia is different in that a little over half of the ammonia used domestically is used to produce explosives for the mining industry (IEEFA 2024). Gladstone both imports and produces ammonia to make explosives.

Today, Australia is a net importer of fossil ammonia. Climateworks' analysis shows that currently, in Gladstone, both the hydrogen feedstock and the heat used to convert it to ammonia are largely derived from fossil fuels. This reflects global trends – over 95 per cent of final energy consumption for global ammonia manufacturing came from fossil fuels in 2020 (IEA 2021b). Gladstone also imports ammonia in large quantities from other parts of Australia (roughly 180 thousand tonnes in 2023) and internationally (roughly 86 thousand tonnes from Indonesia and 9 thousand tonnes from China in 2023) (Gladstone Ports Corporation n.d.).

A local hydrogen supply coupled with renewable energy could provide the feedstock and heat required to produce low-carbon ammonia in Gladstone.

## BOX 3:

## What is low-carbon ammonia?

Ammonia production has two main sources of emissions: hydrogen feedstock production and heat for the Haber-Bosch process (which uses hydrogen and nitrogen to produce ammonia). These typically use fossil fuels, and the result is known as fossil or 'grey' ammonia. Low-carbon or 'green' ammonia would make use of 'green' hydrogen feedstock, which is produced through electrolysis powered by renewable electricity and an electrified Haber-Bosch process also powered by renewable electricity.

Emissions intensity criteria for 'green' ammonia, informed by several regional and industry standards, has been set at <math>0.3 \text{ tCO}\_2\text{e}</math> per tonne of ammonia ( $\text{tNH}_3$ ) (Green Hydrogen Organisation 2023). The bulk of Australian ammonia is produced through steam methane reforming using natural gas, which, globally, has an approximate emissions intensity of  $1.8 \text{ tCO}_2\text{e}/\text{tNH}_3$  (IEA 2021b). The Australian Government's default emissions intensity value, intended to represent an industry average, is  $1.87 \text{ tCO}_2\text{e}/\text{tNH}_3$  (DCCEE 2024c).

### 1.3.2

#### Low-carbon ammonia demand will increase globally, and Gladstone is well-placed to meet demand

Much like its aluminium industry, Gladstone has significant advantages for the production of low-carbon ammonia. It possesses the potential renewable energy resources required to produce low-carbon hydrogen feedstock for the ammonia production process, as well as existing ammonia production plants and expertise. It is also in proximity to growing markets, such as Japan and South Korea.

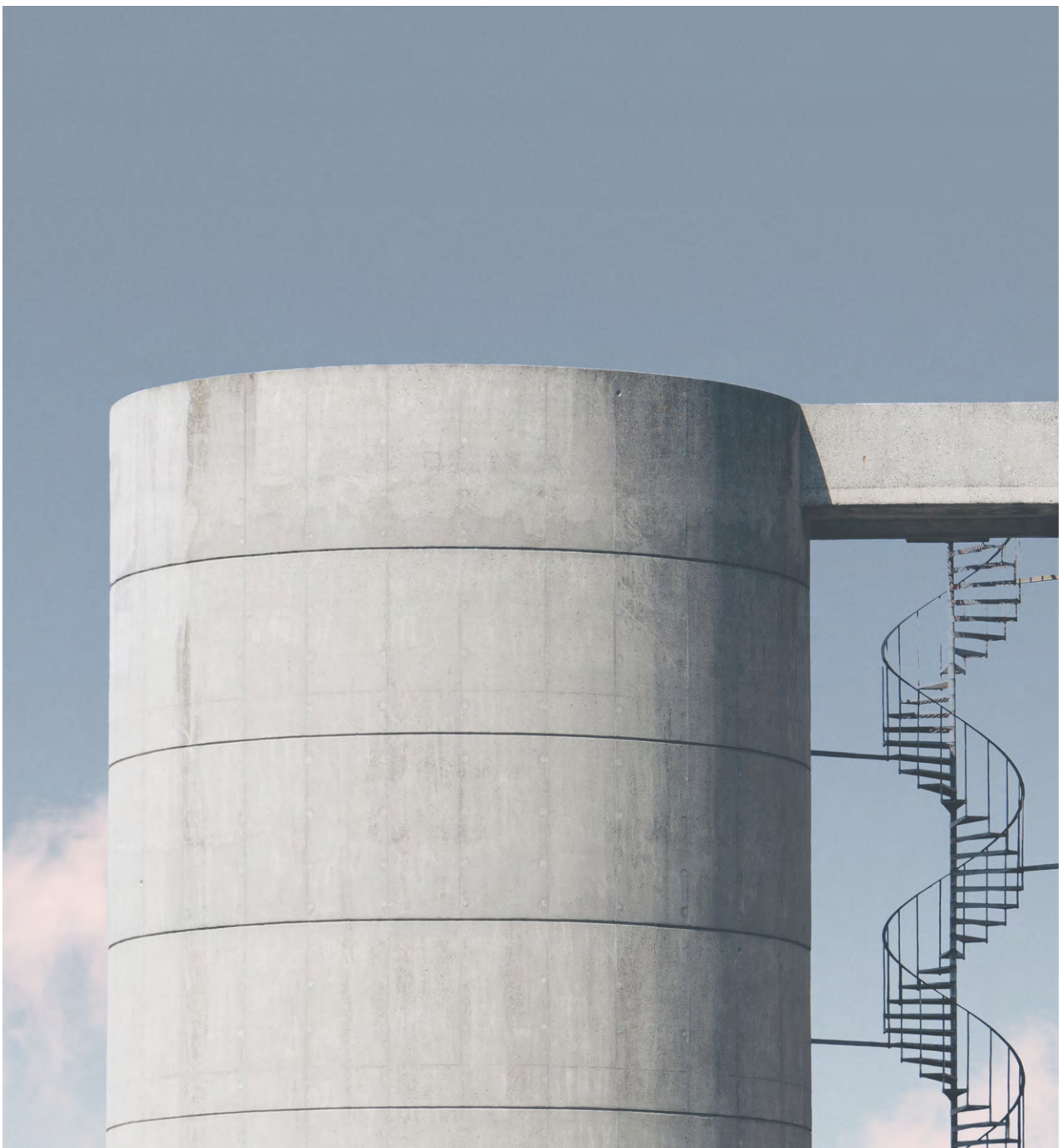
The International Energy Agency projects a compound annual growth rate of 3.6 per cent (2020–2050) for ammonia under their 'Net zero by 2050' scenario, partly driven by the need for low-carbon fuel for power generation in applications where direct electrification would be impractical (IEA 2021a). Shipping is a potentially large source of demand, with low-carbon ammonia expected to comprise 25 per cent of maritime fuel by mid-century (American Bureau of Shipping 2020). The first ammonia-powered ships are expected to be fully operational by 2026 (Yara 2023). A Memorandum of Understanding between Australia and Singapore shows support for a joint leadership role in green shipping, including trialling green solutions across shipping activities and port operations (Department of Infrastructure, Transport, Regional Development and Trade March 2024).

Due in part to this demand for low-carbon fuels, under the International Renewable Energy Agency's 1.5°C-aligned scenario, by 2050, 94 per cent of hydrogen and its derivatives—including ammonia— would be produced from low-carbon production methods utilising renewable energy (IRENA 2023).

Actions from some of Australia's most important trading partners point to future markets for low-carbon ammonia produced in Gladstone. For example, Japan aims for a supply of over 3 million tonnes of low-carbon ammonia for fuel by 2030 and anticipates demand for 30 million tonnes by 2050 (Ministry of Economy, Trade and Industry 2022). Similarly, South Korea anticipates 21 million tonnes of ammonia demand beyond 2030. Queensland-based Ark Energy has signed a Memorandum of

Understanding with South Korean entities to supply 1 million tonnes of low-carbon ammonia per year by 2032 (Ark Energy 2022). As such, Gladstone's existing trade with key partners in Asia, including Japan and Korea, could be an advantage, with multiple major export opportunities for low-carbon ammonia on the horizon.

Demand could also grow from existing applications in Australia, with explosives (ammonium nitrate) currently produced from ammonia in Gladstone. Explosives are widely used in the mining industry. IEEFA has found that reducing emissions from explosives production is an opportunity for mining companies to reduce emissions with a relatively low increase in their operating costs (<0.4 per cent increase in costs for a 100 per cent switch to green ammonia by 2030) (IEEFA 2024). CSIRO's modelling for the National Hydrogen Strategy found that in their central scenario, ammonia could be the largest single source of hydrogen demand in Australia in 2030 (DCCEW 2024a).



## 2. A bottom-up modelling approach captures more precise region-specific energy demand

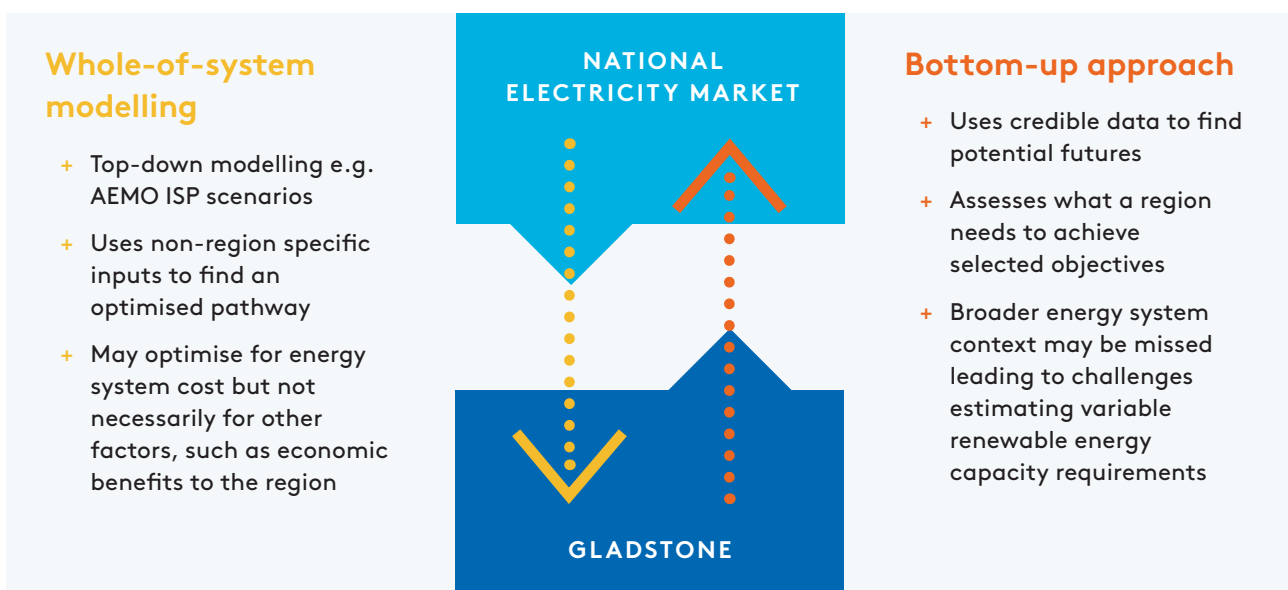
The decarbonisation of industrial regions will require a significant amount of renewable energy. Energy consumption and demand assessments can help decision-makers assist companies in the region in transitioning to low-carbon production of goods cost-competitively.

The assessment in this chapter provides a deeper analysis of Gladstone's future energy consumption to sustain existing industries and grow proposed new industries. We have compared these findings to AEMO's central 'Step change' scenario to establish how current plans support low-carbon manufacturing in Gladstone.

Climateworks' Gladstone study uses a 'bottom-up' approach to determine the energy needed for industrial decarbonisation. This study and associated modelling aims to show the energy requirements of a single region – and of individual industries within that region. This is distinct from the economy-wide and sector-specific decarbonisation pathways that Climateworks develops. For this study, we have combined Gladstone-specific industry-level data with existing Climateworks industrial scenarios and datasets. Such granularity provides an important guidepost for those planning state, territory and national energy systems. This 'bottom-up' approach complements the 'top-down' whole-of-system modelling by AEMO as part of the Integrated System Plan (ISP) scenarios (see Figure 4).

We aimed to understand how the region's energy requirements fit within the current broader work on energy planning for the transition. Climateworks would propose iterating this bottom-up approach alongside a 1.5°C-aligned least-cost whole-of-system scenario. It is important to note that AEMO's 'Step change' scenario is not 1.5°C-aligned.

**FIGURE 4:** Bottom-up approach to an energy and emissions assessment



The bottom-up approach quantifies and models each industry's potential and ambitions for decarbonisation at the regional level, based on region-specific inputs, as opposed to using whole-of-industry assumptions that do not consider local contexts. Examples of Gladstone-specific, industry-level inputs utilised in our modelling include:

- + technology deployment dates
- + fuel-switching assumptions
- + industrial activity (i.e. amount of production).

By using region-specific and technology-specific inputs, we are able to show long-term energy demand scenarios for Gladstone's industries, which can, in turn, be used to provide more detailed evidence to develop the energy system required for existing and new industries. The design of the future energy system considers the supply of variable renewable energy (VRE) generation and firming through energy storage or demand management.

## 2.1 Producing low-carbon products will require a transformed energy system

Gladstone has natural advantages and is well-positioned to produce low-carbon products that the world needs. However, making the most of that market opportunity depends on an energy system that can provide sufficient low-cost, low-carbon energy. Climateworks performed a high-level energy and emissions assessment of existing and new industries within the Gladstone region to understand the scale of energy required and the opportunities and challenges associated with Gladstone's transition to a net zero industrial precinct.<sup>2</sup>

Climateworks' modelling incorporated Gladstone's existing industries, including the alumina, aluminium, clinker, cement, ammonia and explosives industrial sectors, as well as new low-carbon energy export industries. Considering global demand for low-carbon aluminium and ammonia (see Section 1), Gladstone could establish itself as an engine of low-carbon production and manufacturing in Queensland.

This section includes our modelled findings for Gladstone's future energy demand. While our modelling focuses on industries within Gladstone, many of our findings are relevant for all of Central Queensland.

### BOX 4:

## Process emissions

While this report focuses on Gladstone's energy demand, we note that measures are also required to reduce process (non-energy) emissions from Gladstone's existing industry. For example, inert anodes for aluminium smelting and tertiary abatement catalysts in nitric acid production could address scope 1 emissions. Process emissions from clinker production account for 60 per cent of emissions from cement manufacturing (Cement Industry Foundation n.d.).

<sup>2</sup> In addition to additional generation capacity, such as solar and wind farms, the transformed energy system will require firming. This could take the form of energy storage and/or demand management to ensure energy is available when it is needed. This is an area of potential future analysis.



### 2.1.1

#### **Gladstone could require 74 TWh/year for new and existing industries by 2040**

Our analysis found that electricity consumption from Gladstone's new and existing industries in scope (see Figure 1) could increase 14-fold by 2040 from the 5 TWh/year they consume today. Under the 'Climateworks Gladstone' scenario, decarbonising existing industries and establishing new low-carbon energy export industries could require 74 TWh/year by 2040 (Figure 5). The electricity demand associated with decarbonising Gladstone's existing industries is comprised of electrification (13 TWh/year) and the production of low-carbon hydrogen for use as a fuel (16 TWh/year).

---

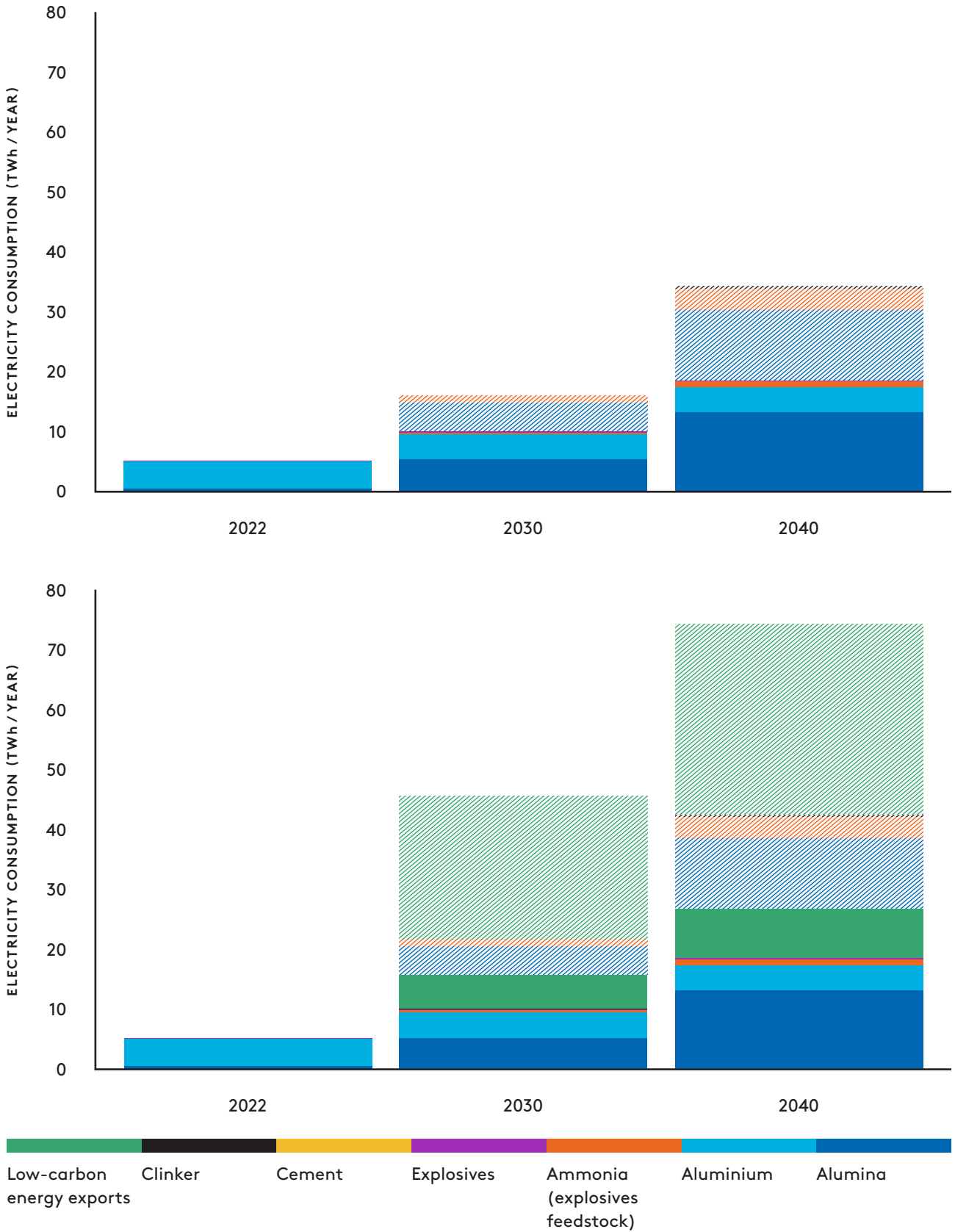
#### **BOX 5:**

### **Gigawatts and gigawatt-hours**

One gigawatt-hour (GWh) could be produced by a 1-gigawatt (GW) electricity generator operating at full capacity for one hour. For context, the nameplate capacity of Gladstone Power Station is 1.68 GW. A terawatt-hour (TWh) is a unit of energy equivalent to 1000 gigawatt-hours. In 2022–23, Australia's total electricity generation was around 274 TWh (DCCEE 2024b).

Notably, by 2040, the alumina sector alone could consume up to 25 TWh/year, while low-carbon energy exports (liquified hydrogen and ammonia) could be responsible for the largest increase in electricity demand, requiring up to 40 TWh/year.

**FIGURE 5:** Electricity consumption in the 'Climateworks Gladstone' scenario represented as industrial direct electricity consumption and electricity for hydrogen for a) only existing industries (top) and b) both existing industries and low-carbon energy exports (bottom).



**FULL COLOUR:** Industrial direct electricity consumption **PATTERNED:** Electricity for hydrogen production

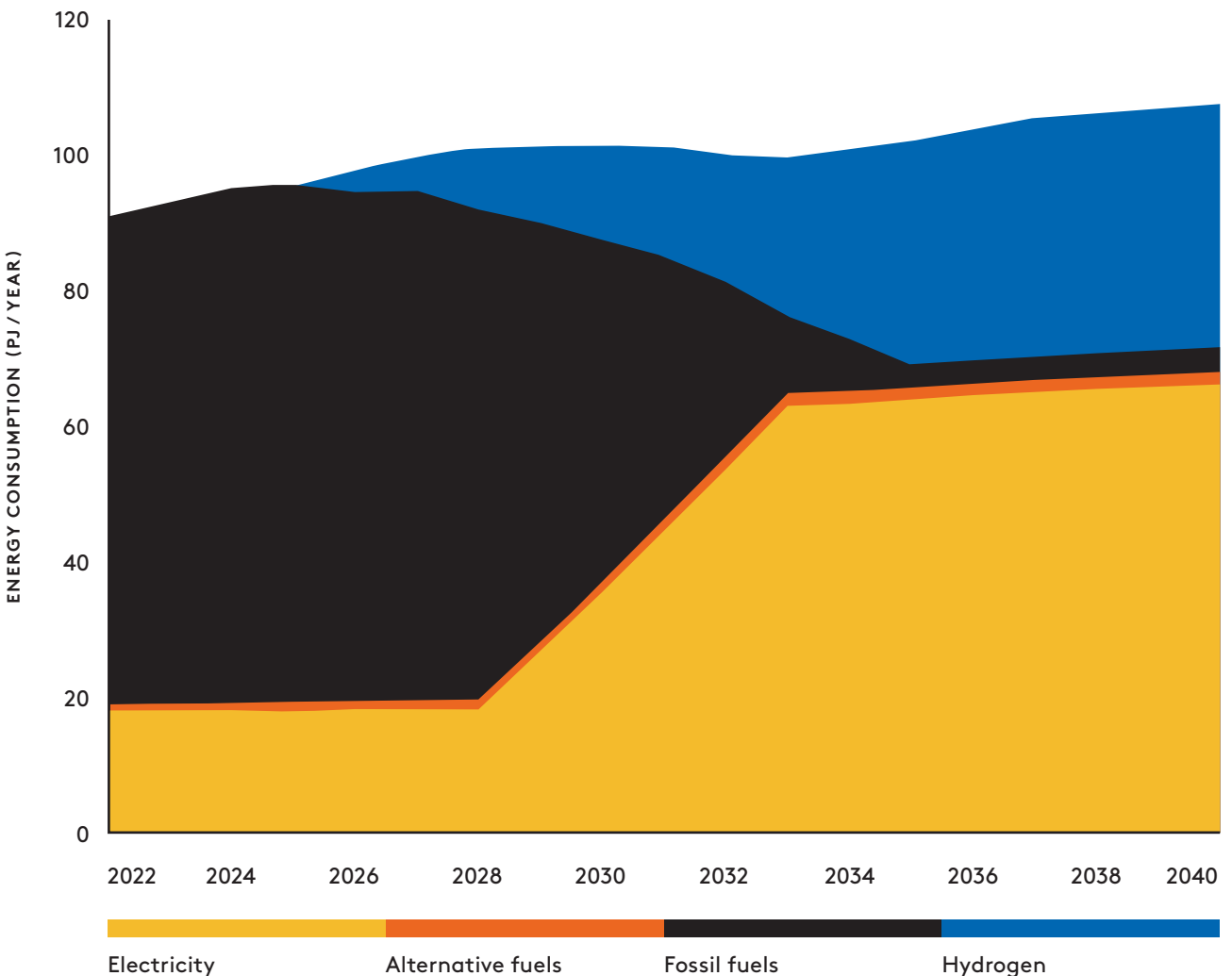
2.1.1.1

**BY 2040, 94 PER CENT OF FOSSIL FUELS COULD BE DISPLACED BY ELECTRICITY AND HYDROGEN AS INDUSTRIAL ENERGY SOURCES**

In our analysis of Gladstone’s selected industries, we found that fossil fuels were the predominant energy source in the baseline year 2022, see Figure 6 (quantified in petajoules (PJ) rather than terawatt-hours to account for the varied mix of fuel types). Of the total 91 PJ energy demand, 79 per cent was derived from fossil fuels, a further 20 per cent derived from electricity and the remainder from alternative fuels such as waste oil. Of this overall energy demand, 88 per cent was used in the alumina and aluminium sectors, while the ammonia and clinker sectors consumed 4 per cent each.

Climateworks’ modelling found that although the total energy demand of Gladstone’s existing industries undergoes only a steady increase from 2022–2040 (108 PJ in 2040, representing an 18 per cent rise from the 2022 baseline), the composition of this energy undergoes a dramatic shift. In the ‘Climateworks Gladstone’ scenario, fossil fuel consumption is mostly displaced by electricity and hydrogen, which would result in a 270 per cent increase in electricity consumption between 2022 and 2040 and a 160 per cent increase in hydrogen consumption between 2030 and 2040. The electricity consumption in Figure 6 is only a portion of the consumption in Figure 5B as it does not account for energy demand by new low-carbon energy export industries, nor does it include the electricity required to produce hydrogen.

**FIGURE 6:** Energy consumption in existing industries over time in the ‘Climateworks Gladstone’ scenario

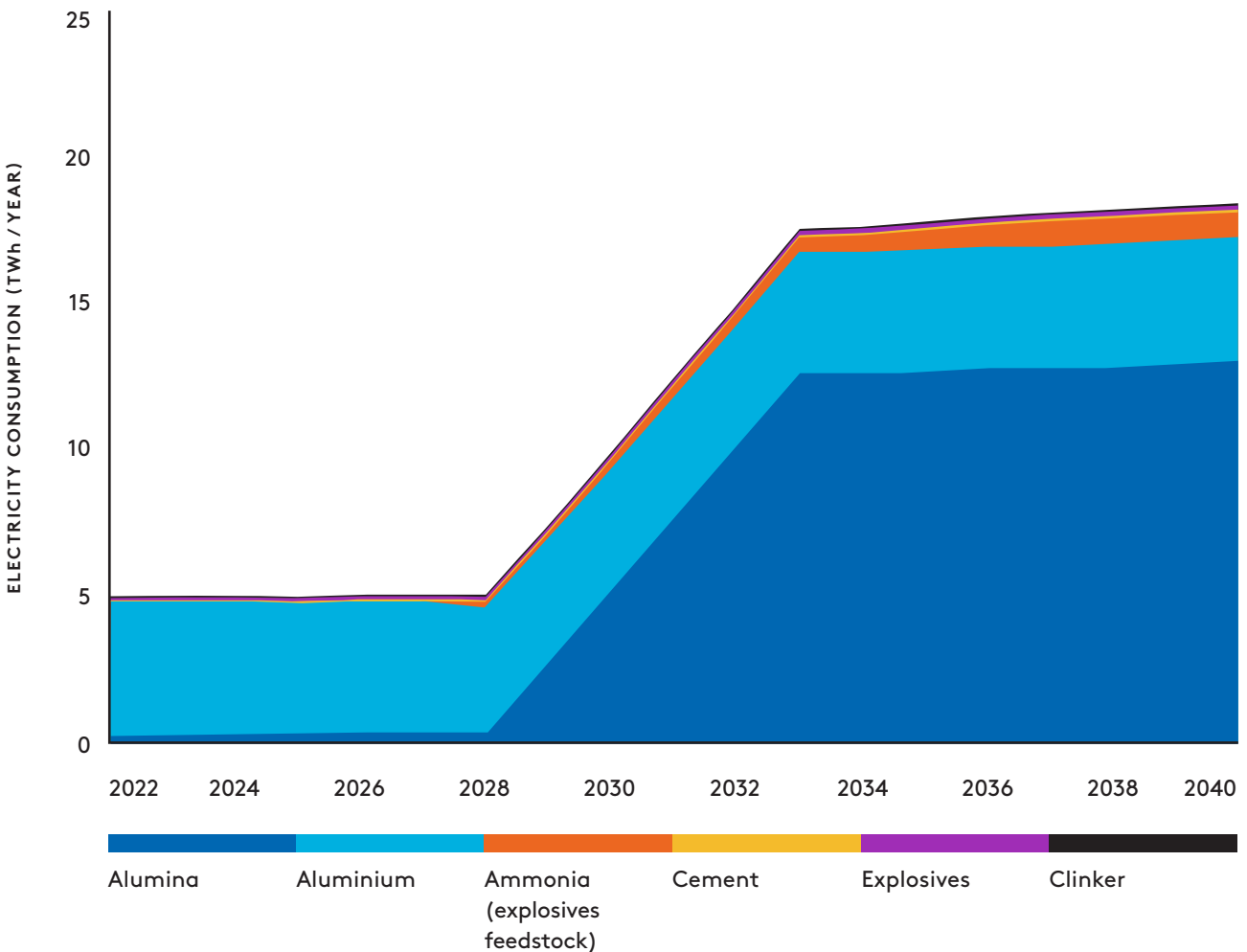


2.1.1.2

**BY 2040, PROCESS HEAT COULD ACCOUNT FOR 89 PER CENT OF THE ELECTRICITY USED BY EXISTING INDUSTRIES DUE TO ELECTRIFICATION AND HYDROGEN CONSUMPTION**

Direct electricity consumption by Gladstone’s existing industries reach 18 TWh/year by 2040 (Figure 7). The main contributor to the increase is the electrification of industrial heat. Climateworks’ modelling sees a significant increase in electricity consumption from 2028 onwards for the region’s existing industries. This is driven largely by the electrification of heat for the digestion process in alumina production. Electrifying industrial processes in the clinker, ammonia<sup>3</sup> and explosives sectors also increases energy demand by 2040.

**FIGURE 7:** Electricity consumption in existing industries over time in the ‘Climateworks Gladstone’ scenario



2.1.1.3

**BY 2040, THE TRANSFORMATION OF EXISTING INDUSTRIES AND NEW ENERGY EXPORTS COULD DEMAND 910,000 T/YEAR OF LOW-CARBON HYDROGEN**

By 2040, low-carbon hydrogen production in Gladstone could be 910,000 tonnes per year, see Figure 8.

Though direct electrification of industrial facilities will be a vital component in the region’s industrial transformation, so too will the use of low-carbon hydrogen. As seen in Figures 6 and 8, by 2040, Gladstone’s existing industries could require up to 300,000 tonnes of low-carbon hydrogen per year to serve as both feedstock and fuel, displacing the fossil fuels currently being used. Figure 5 shows that the annual electricity demand to produce this quantity of hydrogen would not be trivial – at 16 TWh. This would be half the total electricity demand from Gladstone’s industries.

<sup>3</sup> Ammonia in this chart is only ammonia for the production of explosives. Green ammonia for export or other purposes is captured under low-carbon energy exports. See Appendix for further detail.

Our research shows that three of Gladstone’s existing industries with promising future uses of hydrogen are:

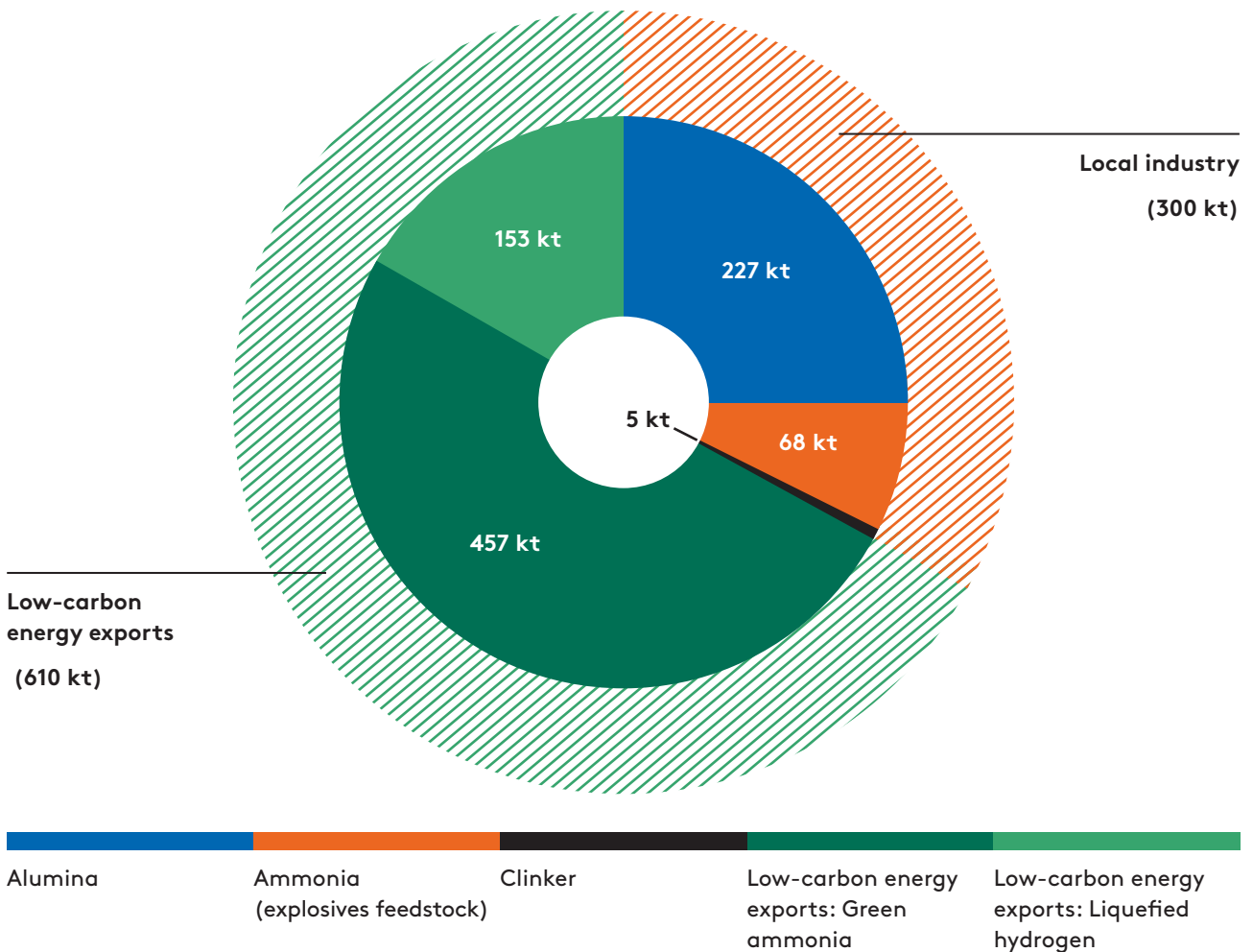
- + alumina (for combustion in the calcination process)
- + ammonia (as a feedstock to replace natural gas)
- + cement (for combustion as a 10 per cent fuel additive in the kilning process).

The alumina industry could consume the largest share of hydrogen out of the three existing industries (Figure 8). Climateworks’ modelling assumes that Gladstone-produced low-carbon ammonia, produced with green hydrogen, will displace both domestic grey ammonia and imported grey ammonia.

In addition, we assume 610,000 tonnes of hydrogen is produced each year for export – based on Queensland government findings (Queensland Government 2022) (see Appendix for details).

The modelling assumes that 25 per cent of the exported hydrogen would be converted to liquefied hydrogen, with 75 per cent converted to ammonia (see Figure 8 and Appendix). The power required to convert hydrogen for export into liquefied hydrogen and ammonia is included in Figure 5B (8 TWh/year). In the ‘Climateworks Gladstone’ scenario, including the electricity needed to produce hydrogen and prepare it for transport, new low-carbon energy export industries will require more electricity (40 TWh/year) than existing industries by 2040.

**FIGURE 8:** Hydrogen production in 2040 in the ‘Climateworks Gladstone’ scenario



## 2.2

### Existing top-down modelling approaches may significantly underestimate regional energy demands

Whole-of-economy and sector-based modelling can help inform the strategic direction of national decarbonisation and sector planning. It can find least-cost pathways to decarbonise all sectors and is used in various ways across government to support planning. For example, AEMO uses it to inform electricity consumption forecasts included in their ISP and applies this to the NEM (AEMO 2024a). The ISP process includes modelling of all parts of the economy, including residential buildings and transport. Climateworks' economy-wide decarbonisation scenarios similarly show how the entire Australian energy system can achieve emissions reduction targets for the least cost (Climateworks Centre 2023b). Whole-of-economy modelling can help to show how sectors should respond to ensure that resources are deployed efficiently across all regions and sectors.

However, AEMO's reporting of its high-level modelling does not include granular details of industrial and regional operations, such as energy demand aligned to industrial decarbonisation ambitions, energy that is required for industrial heat, and regional opportunities and challenges for the energy transition. Whole-of-economy modelling inputs tend to assume relatively uniform, whole-of-sector costs for some emissions-reducing technologies. These assumptions may fail to capture regional contexts that would provide opportunities to lower decarbonisation costs. Whole-of-economy modelling may not preferentially select the electrification of industrial loads in a given region under a least-cost decarbonisation trajectory. Therefore, this approach may fail to consider some of the potential benefits of industrial technology deployment unique to a given location – in this case, Gladstone's energy system and economy.

A complementary approach – modelling at a more granular scale – is an important part of understanding the whole picture for industrial and energy decarbonisation. The ISP underpins infrastructure planning and identifying investment opportunities to meet future energy needs across Australia's eastern states. It coordinates across and is used as a basis for state planning efforts to prioritise transmission projects in the NEM. Regional, bottom-up modelling, such as the energy demand assessment in this report, can be used to inform and refine the insights from whole-of-economy modelling, ensuring that regional requirements and opportunities are considered.

#### 2.2.1

### ISP scenarios may underestimate electricity demand for decarbonisation in Gladstone

The results from Climateworks' bottom-up energy modelling suggest that AEMO's ISP 2024 scenarios underestimate the electricity required to decarbonise existing industries in Gladstone. The ISP's forecasted energy demand for Central Queensland is sized to supply existing electrical loads in anticipation of the closure of Queensland's coal-fired power plants and to meet some additional electricity demand. This planning does not account for renewable energy in the quantities required for decarbonising Gladstone's heat, hydrogen and electricity demand and it is too delayed to enable Gladstone to take full advantage of the potential opportunities for low-carbon production.

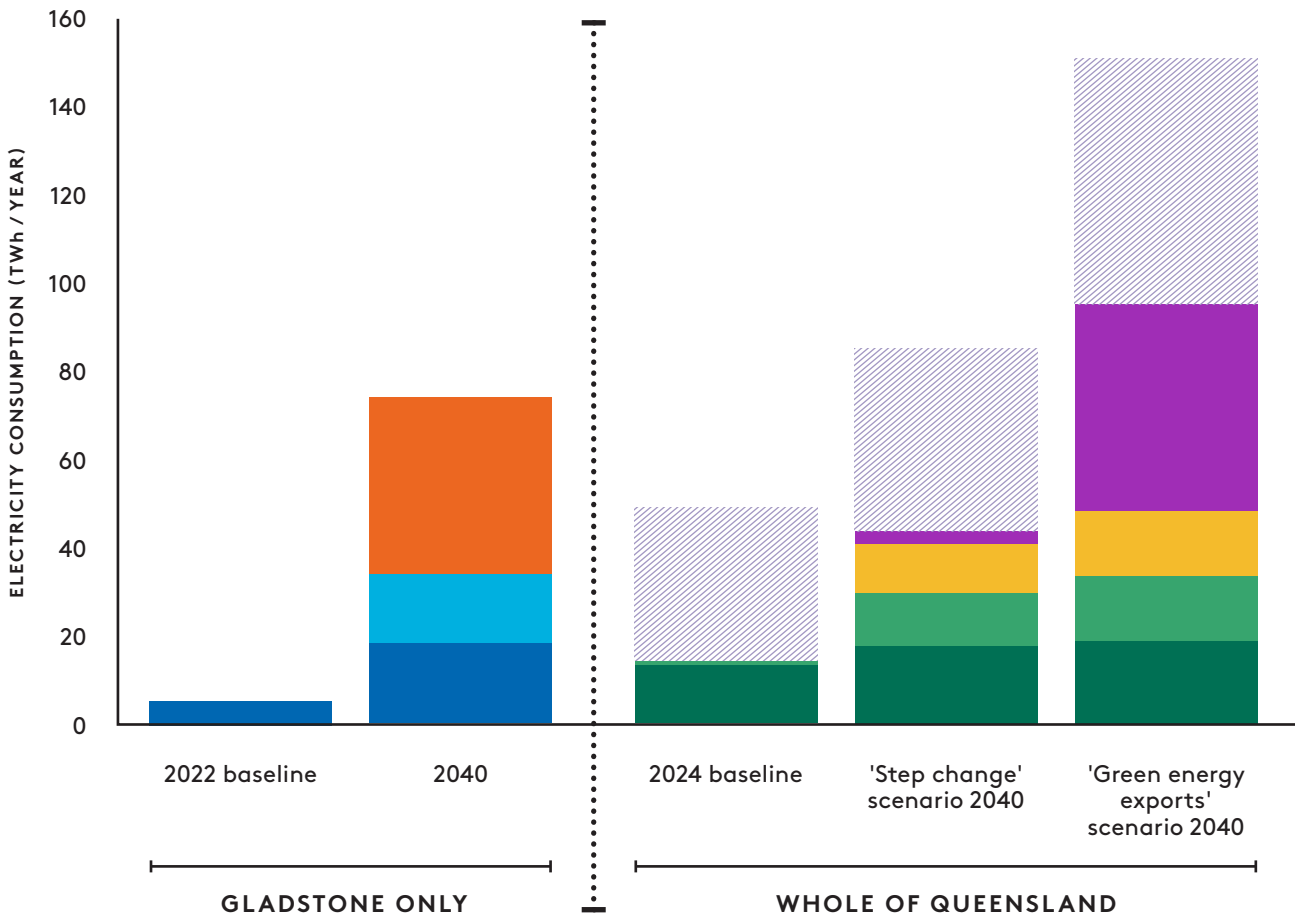
Figure 9 compares our Gladstone energy modelling and AEMO's energy modelling for all of Queensland. Here, we separate electricity demand from our modelling into three categories:

- + direct electricity for existing industries – all electricity-based industrial processes for existing Gladstone industries, excluding hydrogen production
- + electricity for hydrogen for existing industries – electricity used to produce hydrogen for existing industries

- + electricity for low-carbon energy exports – electricity used to produce liquefied hydrogen and ammonia for export.

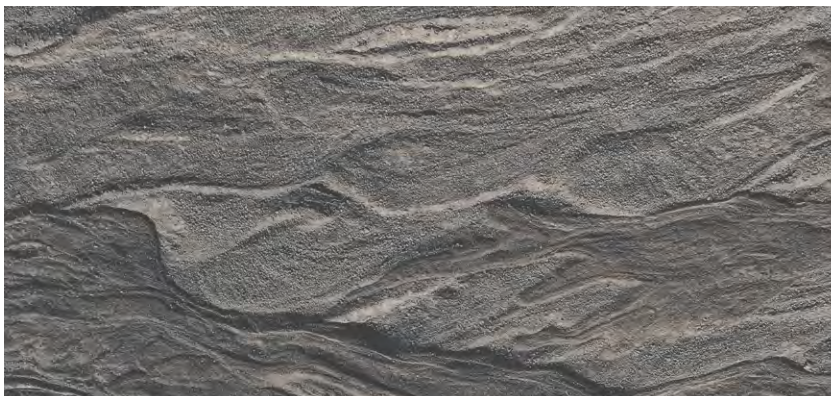
In Figure 9, we compare the categories from our bottom-up modelling with the AEMO electricity demand categories that are most analogous. The ISP categories are likely to have a larger scope than in our Gladstone modelling (e.g. 'Electrification (business)' could include electrification across both the industrial and commercial sectors). Assumptions are likely to vary (e.g. levels of energy efficiency improvements). We further note that while our assessment covers only certain industries in Gladstone, the energy consumption forecasts for the ISP cover all sectors of the main grid across the whole of Queensland. The ISP scenarios include the expected energy demand of other major industrial centres beyond Gladstone (e.g. Townsville, Brisbane) that may have their own plans for a low-carbon industry.

**FIGURE 9:** Electricity consumption by the industries in scope under the 'Climateworks Gladstone' scenario (left) compared with the selected sectors from two ISP scenarios for the whole of Queensland (right)



'Climateworks Gladstone' scenario	Direct electricity for existing industries	Electricity for hydrogen for existing industries	Electricity for low-carbon energy exports		
AEMO ISP scenarios	Large industrial loads	Electrification (business)	Domestic hydrogen	Hydrogen exports	Other categories e.g. Residential (operational)

Note: For details of AEMO's ISP electricity consumption categories, see the 2023 Inputs, Assumptions and Scenarios Report (AEMO 2023).



Climateworks' finding of 74 TWh/year of electricity consumption by 2040 for Gladstone contrasts strongly with the ISP's analogous 44 TWh/year forecast for all of Queensland under a 'Step change' scenario for the same year. In other words, all of Queensland's electricity consumption under a 'Step change' scenario is about 60 per cent of Gladstone's electricity consumption when calculated from the bottom-up. Even AEMO's more ambitious 'Green energy exports' scenario – which assumes a large quantity of hydrogen exports – shows an analogous electricity use across Queensland that is only slightly higher (96 TWh/year) than Climateworks' finding for Gladstone (74 TWh/year).

The key difference for the industry sector between the 'Step change' scenario and the 'Green energy exports' scenario is the difference in hydrogen production for export. However, compared with the 'Climateworks Gladstone' scenario there is little difference in demand for industrial electrification between the ISP scenarios. The 'Climateworks Gladstone' scenario finds an increase of 13 TWh/year for electrification by 2040. The 'Step change' and 'Green energy exports' scenarios find 15 TWh/year and 19 TWh/year respectively for increase in industrial loads and business electrification across all of Queensland.

## 2.2.2

### **Gladstone could require as much wind and solar capacity as there is currently planned for all 'renewable energy zones' in Queensland**

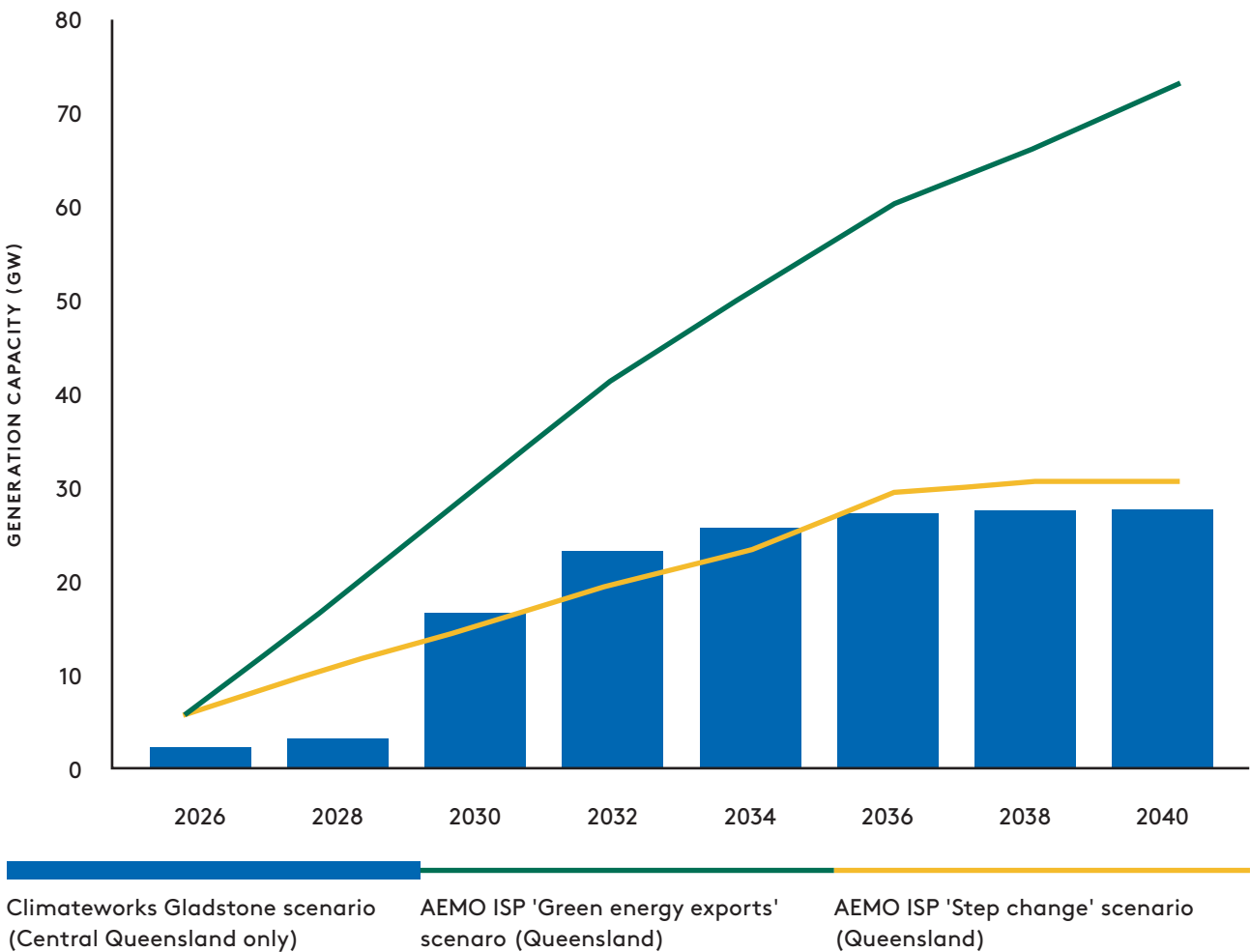
Queensland has a high potential for renewable energy. Up to 92 GW of solar and wind capacity is available across all candidate REZs in the 2024 ISP (AEMO 2024b).<sup>4</sup> However, Climateworks' analysis suggests that current ISP planning may not deliver capacity in time to provide for both the decarbonisation targets of Gladstone's existing industries and the establishment of new low-carbon energy export industries. Our work suggests that decarbonisation would need more rapid and greater deployment of solar and wind, storage, transmission and grid infrastructure.

Climateworks' post-modelling analysis of our Gladstone scenario found that meeting demand for 74 TWh/year could necessitate the installation of 28 GW of solar and wind generation by 2040.<sup>5</sup> In Figure 10, we compare our VRE capacity findings for Gladstone to REZ development plans under AEMO's 'Step change' and 'Green energy exports' scenarios for all of Queensland. In line with our earlier findings, planned VRE capacity under the 'Step change' scenario will be insufficient to meet Gladstone's needs (Figure 10). Gladstone's capacity requirements would take up most of the 31 GW of total planned capacity in 2040, leaving approximately 10 per cent for uses in the rest of the state.

<sup>4</sup> This is an aggregation of REZ allocations, which are areas that have been assessed to have abundant renewable energy potential on land that is appropriate for development from a land-use and environmental perspective.

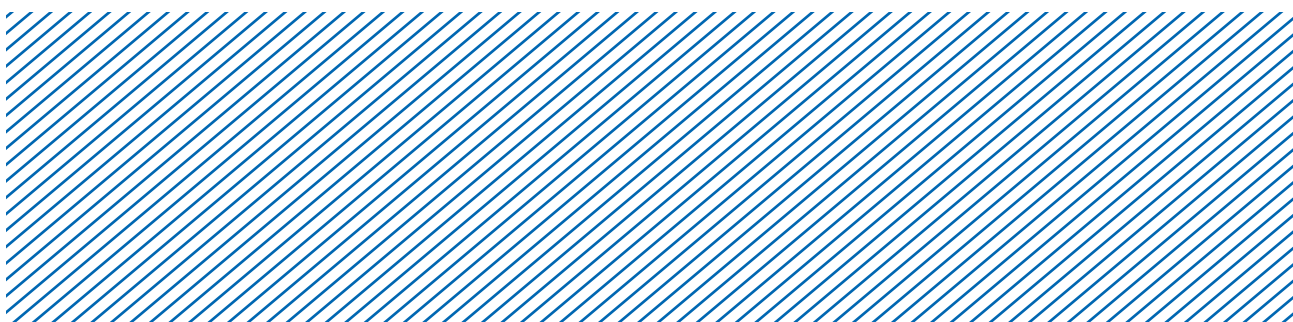
<sup>5</sup> See Appendix for details of post-modelling analysis methodology.

**FIGURE 10:** Wind and solar capacity requirements based on the 'Climateworks Gladstone' scenario for Central Queensland compared to the ISP's wind and solar generation capacity for all of Queensland



Note: Details of AEMO's REZ generation outlooks can be obtained from the 2024 ISP generation and storage outlook (AEMO 2024a).

Ensuring sufficient renewable energy is available on time will require decisions to accelerate planning and investment for REZs in line with AEMO's 'Green energy exports' scenario, along with supporting grid transmission infrastructure necessary to connect industrial facilities to a VRE-heavy grid. There are already projects proposed by the ISP that would be good candidates for accelerated development, such as the Queensland SuperGrid North and Facilitating Power to Central Queensland projects, which would increase transmission capacity to Gladstone from North Queensland as well as expedite the Barcaldine and Isaac REZs (AEMO 2024a).





---

### 3. Key recommendations for a 'net zero industrial precinct' strategy for industrial decarbonisation

Many companies with operations in Gladstone have significant ambitions for decarbonisation. State and federal governments are supportive of these ambitions – the 2024–25 Federal Budget provides seven new funding streams for new low-carbon industries, including through the Future Made in Australia agenda.

This is on top of roughly 20 existing funds from federal or state governments available for industrial and energy decarbonisation. The combination of industry and government ambitions has led to Gladstone being at the forefront of the Australian energy and low-carbon industrial transition. Gladstone is material to both Australia's economy and emissions and the actions proposed position the region, and Australia, to optimise the opportunity of the global low-carbon economy.

Production tax credits have been proposed as part of the Future Made in Australia Act. At the time of writing, a production tax credit for renewable hydrogen had been passed by the House of Representatives (Parliament of Australia 2024). This kind of incentive could encourage potential offtakers of low-emissions hydrogen and boost green ammonia production before electrolysis-based hydrogen using wind and solar comes down in cost. Production tax incentives for critical minerals were passed as part of the same bill. The current government has also proposed a production tax credit for green aluminium produced using renewable energy (DISR 2025).

However, financial incentives to support the use of renewable electricity are only effective if sufficient renewable energy capacity is brought online. Current expectations for the supply of renewable energy in Central Queensland would result in a mismatch between energy supply and demand if decarbonisation ambitions are to be met. Industry and government are stuck in a 'chicken and egg' situation, with industry waiting to be confident that there will be firmed renewable energy at scale, and energy investors – including governments – unable to increase the scale of generation and infrastructure plans. In particular, governments must have commitments from large energy customers that specific large-scale electrification or hydrogen projects will be implemented.

Compounding this problem, historically, dialogue between industrial stakeholders is siloed, and individual industrial players are required to

take individual projects to separate government departments, resulting in a piecemeal, cost-inefficient project-by-project approach. The Future Made in Australia Act's 'Front Door' for investors is intended to reduce this risk, enabling coordinated engagement with relevant agencies (The Treasury 2024).

These challenges could counteract Gladstone's natural resource advantage and delay the development of its low-carbon production, potentially losing a vital first-mover advantage to capitalise in a decarbonising international market.

---

## 3.1 A net zero industrial precincts approach in Australia could support Gladstone's existing and new industries

Australian industrial regions have internationally competitive advantages to be market leaders in low-carbon industrial products due to the potential for low-cost renewable energy, high reserves of mineral resources, stable governance and a strategic location proximate to Asian markets. A green product strategy at a regional level would complement whole-of-system 1.5°C-aligned scenarios and national strategies.

Gladstone has attracted attention as a potential frontrunner in the decarbonisation of Australian industry. The pursuit of industrial decarbonisation in Gladstone is motivated by the objectives of governments, companies and trading partners, who desire to position the region for ongoing and future economic success. The Queensland Government and the Australian Government have committed to net zero by 2050 goals, as have many of Gladstone's major trading partners. Companies in the region have also made commitments to emissions reduction targets and to working together, with one promising initiative being the Central Queensland Statement of Cooperation, a group of corporate and other stakeholders from the region seeking to unlock more opportunities for an 'industrial and advanced manufacturing powerhouse' (Department of State Development n.d.).

In Gladstone, where heavy industry is co-located, a collaborative, regional approach to the task of decarbonising 'hard to abate' industries could promote economic prosperity and a just transition. By organising highly productive industrial zones and naming them NZIPs, key industrial actors and government agencies can more easily come together to implement technological, economic and policy changes. These changes could aim to reduce investment costs and risks, secure firm renewable energy and produce competitive low-carbon goods in a net zero world.

A Gladstone NZIP strategy would enable policy and economic coordination. Existing industry, the Port of Gladstone, existing electricity networks, abundant land, skilled workforces and emerging low-carbon energy projects are all assets that can be leveraged. An NZIP strategy would build on plans, strategies and studies produced by governments and NGOs who have worked in the region (The Next Economy 2022; Edmonds et al. 2022). Climateworks has previously published analyses of industrial regions, which included an analysis of Gladstone (Climateworks Centre and Climate-KIC Australia 2022; Climateworks Centre 2023a). Governments, industry and other local stakeholders have made important progress.

It is likely that other Australian industrial regions will face challenges similar to Gladstone's in transitioning to low-carbon production. To coordinate decarbonisation at scale in industrial regions, Climateworks proposes an NZIP strategy be adopted in regions like Gladstone with multiple large industrial energy users.

## 3.2

### Net zero industrial precinct approaches consider people, land and investment

NZIP strategies create a holistic approach to the decarbonisation of local industries, taking into full account people, land and investment.

Industry stakeholders and the private sector, including in the energy system, will play a crucial part in reducing industrial emissions, given that most of the capital expenditure for decarbonisation technologies will come from these parties. However, governments are not only key investors but can also optimise this transition by organising regulation, policy interventions and financial incentives using an NZIP approach.

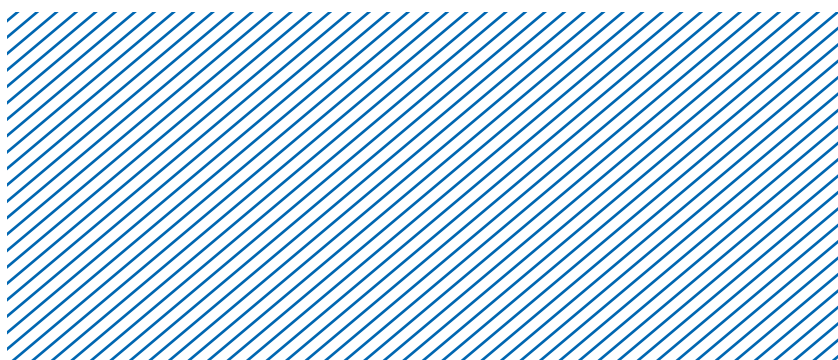
There is a role for government to develop policy to support an NZIP strategy, and indeed, there has recently been strong industrial policy that partly provides this. The Future Made in Australia agenda, including funding and related legislation, introduces a framework for guiding public investment. The Future Made in Australia agenda aims to bring forward private investment to support Australia's economic transition and emissions reduction goals. The budget also announced additional funding for the federal government's Australian Renewable Energy Agency (ARENA), which can combine with recently expanded funding and role for the Clean Energy Finance Corporation (CEFC) and the National Reconstruction Fund. The federal government's Net Zero Economy Authority (NZEa) will play an essential coordinating role in some regions – including Gladstone.

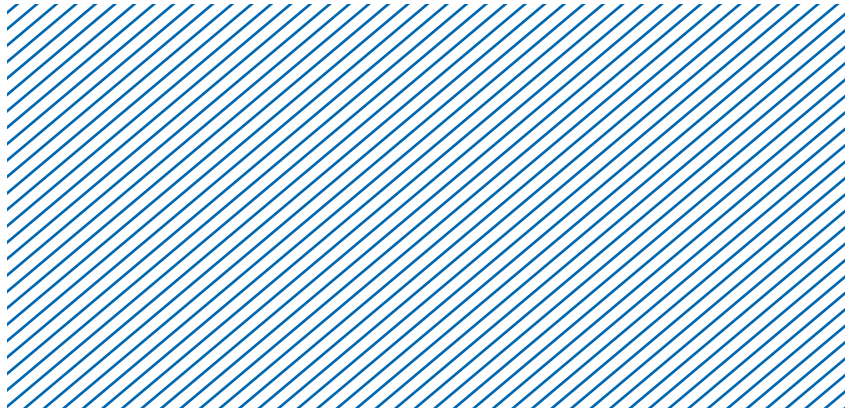
Each Australian industrial region has made strides towards transition. A place-based approach can identify the biggest opportunities, challenges and practical steps towards achieving regional prosperity through low-carbon product manufacturing.

A collaborative approach, with action from both industry and government, will accelerate renewable energy deployment in line with customer demand and ease the burden on regional energy systems by reducing the total power and generation capacity needed.

In addition to region-specific energy planning and a low-carbon product strategy, three other important aspects to an NZIP strategy could include:

1. Lowering financial barriers to the deployment of abatement technologies and infrastructure
2. Designing or creating a singular governing body capable of bridging regional needs, synergies and competitiveness with federal and state strategy
3. Securing social license, local community support and a skilled workforce through effective consultation, social infrastructure, community investment and benefit-sharing.





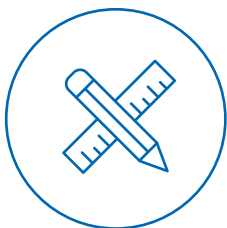
### 3.3

## Recommendations for Gladstone and Australian industrial region transitions

In line with our findings from the Gladstone study, this report makes five interrelated recommendations to facilitate a rapid and sustainable transition in Australia's industrial regions.

1.

### Energy planning authorities create 'regional Integrated System Plans' for Gladstone and other major industrial regions, building on AEMO's 'Green energy exports' scenario, resulting in new electricity infrastructure being built at the scale required.



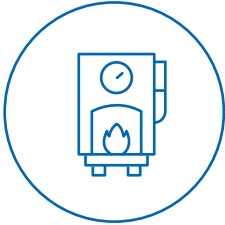
It is critical that industrial regions can secure access to low-cost renewable energy to be competitive in global markets. This will allow local industries to grow production in a net zero world in which Australia's fossil fuel exports will decline. Currently, most energy infrastructure is being planned based on the AEMO 2024 ISP 'Step change' scenario, which solves for a scenario with moderate industrial decarbonisation and a slow increase of low-carbon energy exports over time. Our bottom-up analysis shows that this would risk constraining investment in infrastructure planning and, consequently, industrial decarbonisation.

The scale of the 'Green energy exports' scenario is a better reflection of a future in which regions like Gladstone continue to thrive in a decarbonising global economy. A scale of energy supply similar to the 'Green energy exports' scenario is essential to ensure that corporate or asset-level emissions reduction targets can be met, and with sufficient pace to help Gladstone maintain and grow local industries.

Whole-of-economy planning at the scale of 'Green energy exports' would complement regional planning of energy supply and transmission for regions like Gladstone to support the supply of renewable energy to multiple large energy users at the lowest possible overall system cost. The NZEA is one body that can support the coordination of regions like Gladstone.

## 2.

## **Governments develop policies to support low-carbon industrial heat at scale, including national and state-level industrial heat strategies, financing models and a coordinated funding response to support early-stage technologies and deployment of low-carbon heat technologies at scale.**



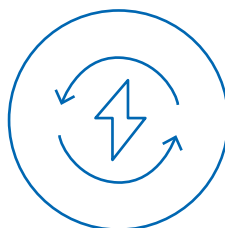
An industrial heat strategy at a national and state level will assist industries to deploy low-carbon heat technologies at the scale needed and at least-cost.

In Gladstone heavy manufacturing, 79 per cent of energy use today is direct consumption of gas or coal, mainly to produce heat, and 20 per cent is electricity. Climateworks' energy assessment showed that power requirements for the low-temperature heat in alumina production alone could reach 13 TWh/year by 2040, nearly 40 per cent of the total of 34 TWh/year.

Government support to decarbonise heat would accelerate the implementation of commercially applicable technologies that are already deployed in other markets. There are a range of possibilities for this support. For instance, government could support financing models for reducing up-front costs, such as 'heat-as-a-service', where energy operators take on the financial burden of heating assets. A coordinated effort between CEFC and ARENA focused on industrial heat could be very effective – as they did to rapidly accelerate large-scale solar deployment. ARENA can support early-stage technology development, while CEFC can support technology deployment at scale. There is a role for government in providing coordination and advice to support a precinct-wide transformation.

## 3.

## **Energy demand management policy and energy efficiency mechanisms for heavy industry be expanded, optimising infrastructure development and costs for all energy users.**



There is significant potential for overall system costs to be reduced through flexibility and demand management from large industrial energy users. Large industrial energy users have signalled a willingness to adopt new industrial operation regimes that can respond to the variability of wind and solar energy. Ramping up when levels are high and reducing energy demand when low would help stabilise the grid and reduce energy costs.

To take low-carbon ammonia as an example, a study from Griffith University found that coupling hydrogen and ammonia production in Queensland could result in lower electricity system costs and carbon emissions. The study also argued that the integration of low-carbon ammonia production into an electricity grid with a high VRE share could provide significant value through lower electricity costs via demand response practices (Fletcher et al. 2023).

Further developments of existing policies, such as the Wholesale Demand Response Mechanism, would enable demand management and grid stabilisation services to become sources of revenue for industry. This would, in turn, benefit residential and commercial consumers by reducing electricity costs. In many facilities, this is likely to require installing new equipment.

Energy planning could benefit from increased data sharing between large energy users and government, including projected energy use and technical potential for demand management. This would enable NZIPs to optimise energy consumption and technology choices.

4.



## **Governments enact measures to support early hydrogen demand in existing industries, catalysing a low-carbon hydrogen market in industrial regions.**

Climateworks' analysis suggests that Gladstone's existing industries alone could require 300 kt of hydrogen per year by 2040. With this high demand for hydrogen from local industry, the domestic hydrogen market is the most effective way of meeting early market demand, with exports of hydrogen a mid- to long-term goal.

Some of the most promising uses of hydrogen in Australian heavy industry are in the production of ammonia, alumina and iron. These industrial applications could use hydrogen efficiently and cost-effectively at a scale that could support a viable, long-term hydrogen industry.

The co-location of hydrogen supply and demand has lower storage and transport costs. Where possible, production should be located close to large hydrogen buyers to reduce these costs. This would be a low-regrets action with many potential benefits, supporting both Australia's emissions reduction targets and companies' decarbonisation strategies.

However, almost all hydrogen development today is on an asset-by-asset basis. It is important to plan for and incentivise regional hydrogen markets. Such an approach has been successful in Europe, which is building strong regional hydrogen markets to bring down the cost of hydrogen for all consumers. The H2Global mechanism facilitates market creation by matching supply and demand through contracts between producers and consumers and enabling public or private funding to cover the price difference between the cost of supplying clean hydrogen and the price at which it is sold to consumers (H2Global n.d.). A similar approach would help Australia accelerate the integration of hydrogen into the overall energy and industrial landscape.

5.



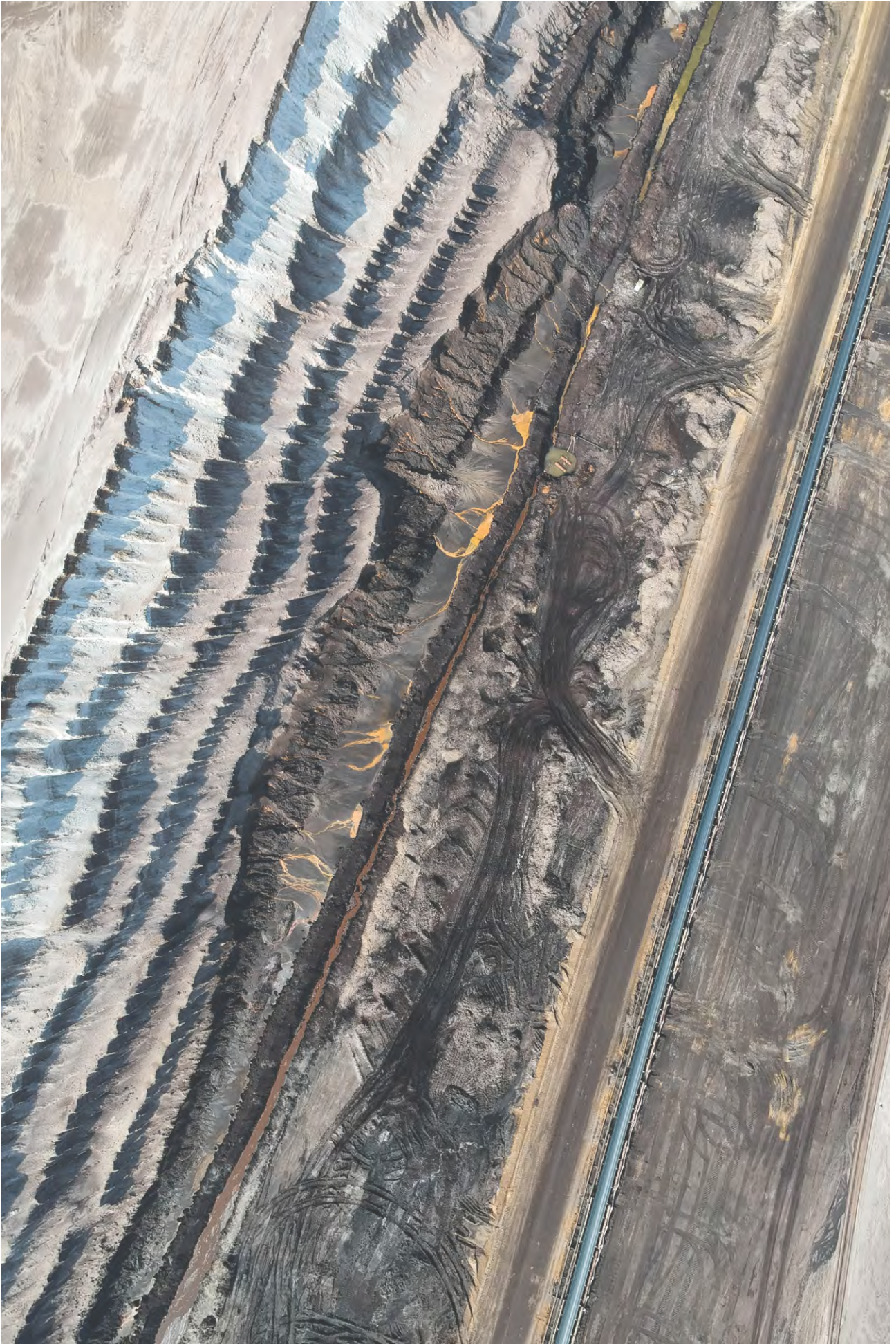
## **Governments and industry endorse high-quality standards for low-carbon products, ensuring consistency between Australia's emissions intensity standards and international standards.**

Emerging markets for low-carbon products and projected increases in demand for products represent an opportunity for Australia. Low-carbon products require certification to ensure that products marketed as 'low-carbon' meet the appropriate emissions intensity standards. Consistency between Australian and international emissions intensity standards will make it easier to certify that a product is low-carbon.

The Australian Sustainable Finance Taxonomy, under development by the Australian Sustainable Finance Institute, is an opportunity to provide benchmarks for specific products and industries. Adoption by government of 1.5°C-aligned climate and nature-related goals for industry would provide high-quality certification for products like low-carbon metals, aluminium and ammonia.

There is also an opportunity to expand the Guarantee of Origin scheme. The Guarantee of Origin is a way of tracking and verifying the emissions intensity of a given product, and it is being developed by the federal government for hydrogen and renewable energy. A similar approach could be applied to metals and chemicals (Clean Energy Regulator 2024).

These kinds of mechanisms could combine quantifiable emissions standards with effective emissions verification, allowing regions like Gladstone to demonstrate certified low-carbon manufacturing and become a first-mover supplier of materials that will be in demand in a net zero global economy.



# Appendix: Inputs and assumptions for Gladstone energy modelling

This report is based on analysis conducted for a 'Gladstone clean industry hub' project between January and July 2024, which was funded by Stanwell Corporation. This analysis included an energy demand assessment, a policy analysis and a demand and competitiveness analysis. The Gladstone clean industry hub project was one of several projects that informed Climateworks Centre's net zero industry and resources work and that informed the key findings presented in this report. The views expressed herein are those of Climateworks Centre and are not necessarily those of Stanwell Corporation.

## Modelling methodology

Climateworks conducted energy and emissions modelling, focused on key existing and emerging industries in the Gladstone region, to understand industrial decarbonisation's implications on energy use.

The primary aims of the modelling were to illustrate how electricity consumption would increase as a function of two assumptions:

1. The speed of decarbonisation of Gladstone's industries
2. Quantity of industrial products each year.

Climateworks' modelling draws on the Australian Industry ETI scenario modelling where possible (for further technical assumptions, see the Pathways to industrial decarbonisation – Technical report [Climateworks Centre and Climate-KIC Australia 2023]). These scenarios are supply chain specific and some of Gladstone's industrial stakeholders (Rio Tinto and Orica) were involved in their development for the Australian Industry ETI.

In addition to the inputs from the Australian Industry ETI, Climateworks incorporated regionally appropriate inputs, such as those from *A roadmap for decarbonising Australian alumina refining* (ARENA 2022). We also drew on modelling from *Climateworks Centre decarbonisation scenario 2023* (Climateworks Centre 2023b) to provide more up-to-date electricity emissions results than the Australian Industry ETI modelling.

The modelling uses a 2022 baseline year, with asset-level energy and emissions data used to define the baseline. Future energy consumption and emissions are modelled at a sector level. This methodology was used to avoid making assumptions about the future of specific assets or industry actors in the region.

Generation capacity estimates were made using a post-modelling analysis based on electricity consumption. The analysis is intended to illustrate the scale of wind and solar that could be required. The analysis assumes optimal conditions, including sufficient transmission and diversity of renewable energy sources, plus sufficient firming, inertia and system strength provisions.

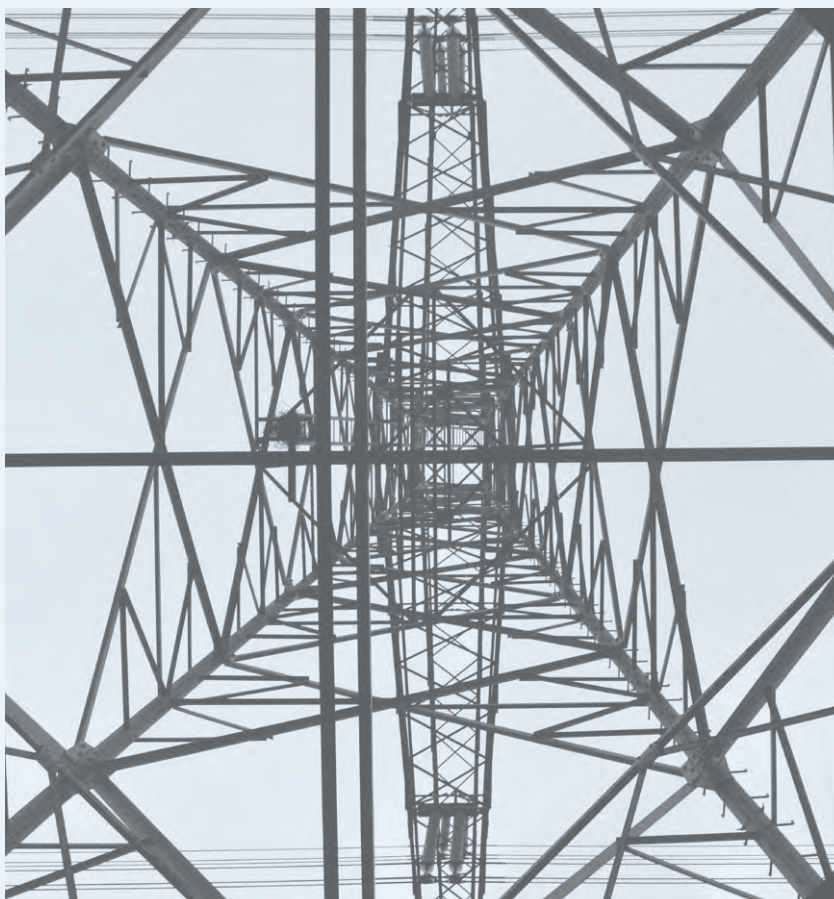
## Inputs and assumptions

### Baseline assumptions

The modelling uses a 2022 baseline, as this was the last year with complete datasets available. Asset-level data was used to define the energy consumption and emissions intensity of operations. Note that modelling results for the years 2023 to 2040 are presented at a product level rather than by asset.

**TABLE 1: Data sources and number of facilities used to define baseline**

PRODUCT	NUMBER OF FACILITIES	SOURCE FOR BASELINE FOR EACH FACILITY
Alumina	2	<p>A baseline of energy use, emissions and production has been developed based on existing facilities. 2022 data sources are used as much as possible.</p> <ul style="list-style-type: none"> <li>+ scope 1 emissions (reported)</li> <li>+ scope 2 emissions (calculated with high-level assumptions from desktop research)</li> <li>+ energy consumption (Australian Industry ETI and Climateworks analysis)</li> <li>+ current production (desktop research and Climateworks analysis)</li> </ul>
Aluminium	1	
Cement/clinker	1	
Ammonia/explosives	2	

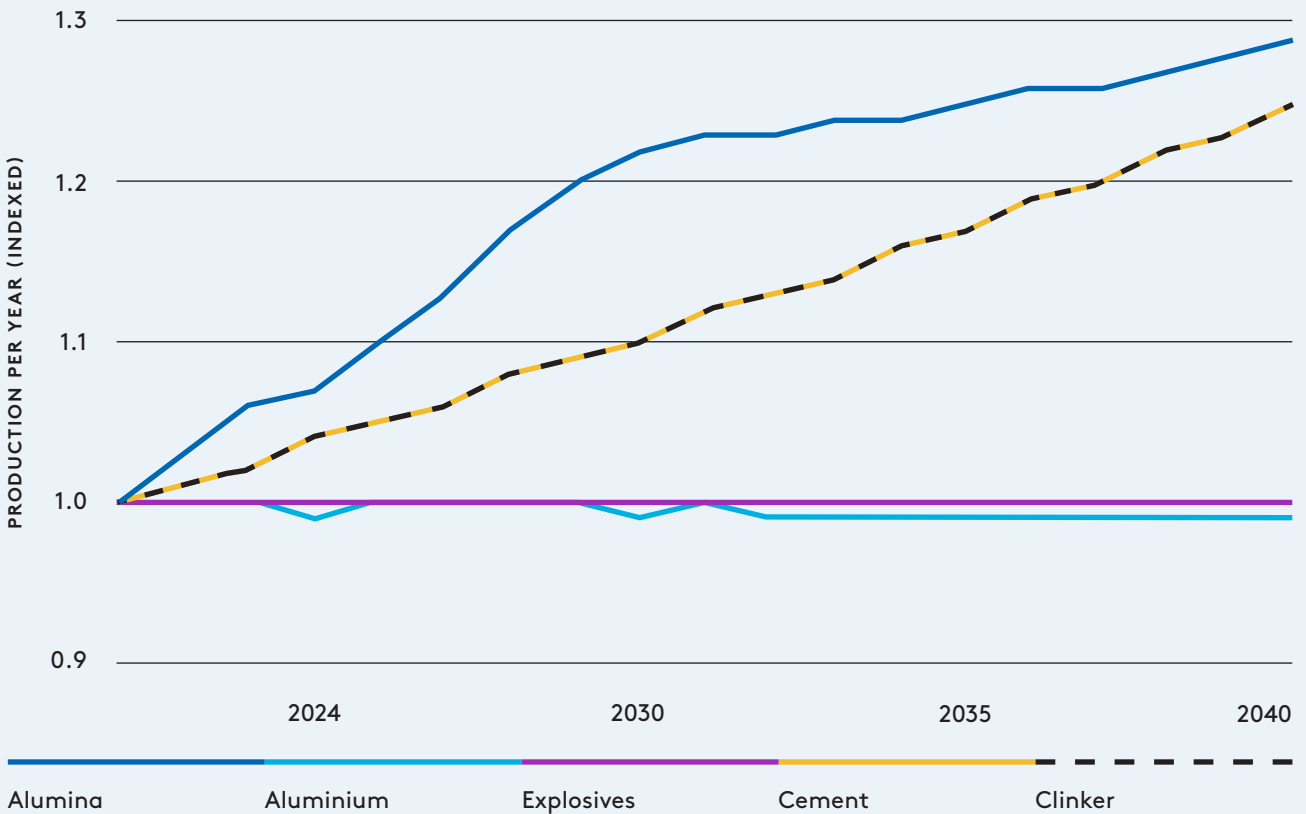


## Industrial activity inputs

### EXISTING INDUSTRIES

Five existing products are modelled: Alumina, aluminium, cement, clinker and explosives. Assumptions for future industrial activity (i.e. amount of production) in these sectors are aligned with the Australian Industry ETI 'Incremental' scenario. The cement industry is assumed to use all clinker that is produced, resulting in identical demand growth (Figure 11).

**FIGURE 11: Assumed production of Gladstone's existing industries (indexed)**



Aluminium and explosives activity stays relatively constant throughout the modelling period. Cement and clinker activity experiences steady growth across the period, growing by 25 per cent by 2040 compared to 2022. Alumina activity sees the most growth, growing by 22 per cent by 2030 and 29 per cent by 2040 compared to 2022 (Figure 11).



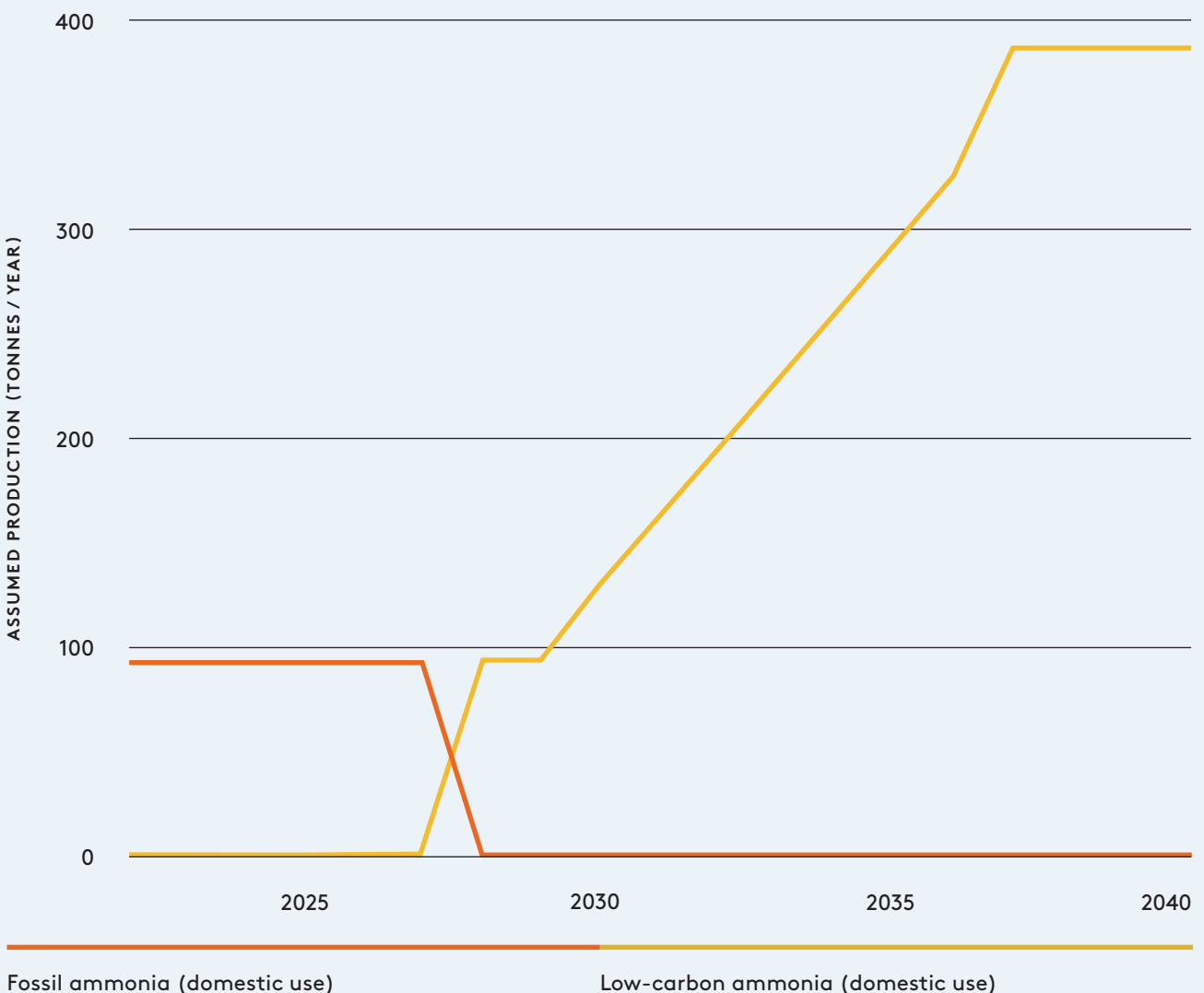
**NEW INDUSTRIES  
AND AMMONIA**

Climateworks’ modelling of new industries includes low-carbon, electricity-based hydrogen. Hydrogen cannot be shipped directly overseas without being prepared (e.g. by liquefying it) or converted into another chemical (e.g. ammonia), which would then be processed at the destination. Low-carbon ammonia for the Central Queensland region is also included, which displaces both domestic and imported fossil ammonia.

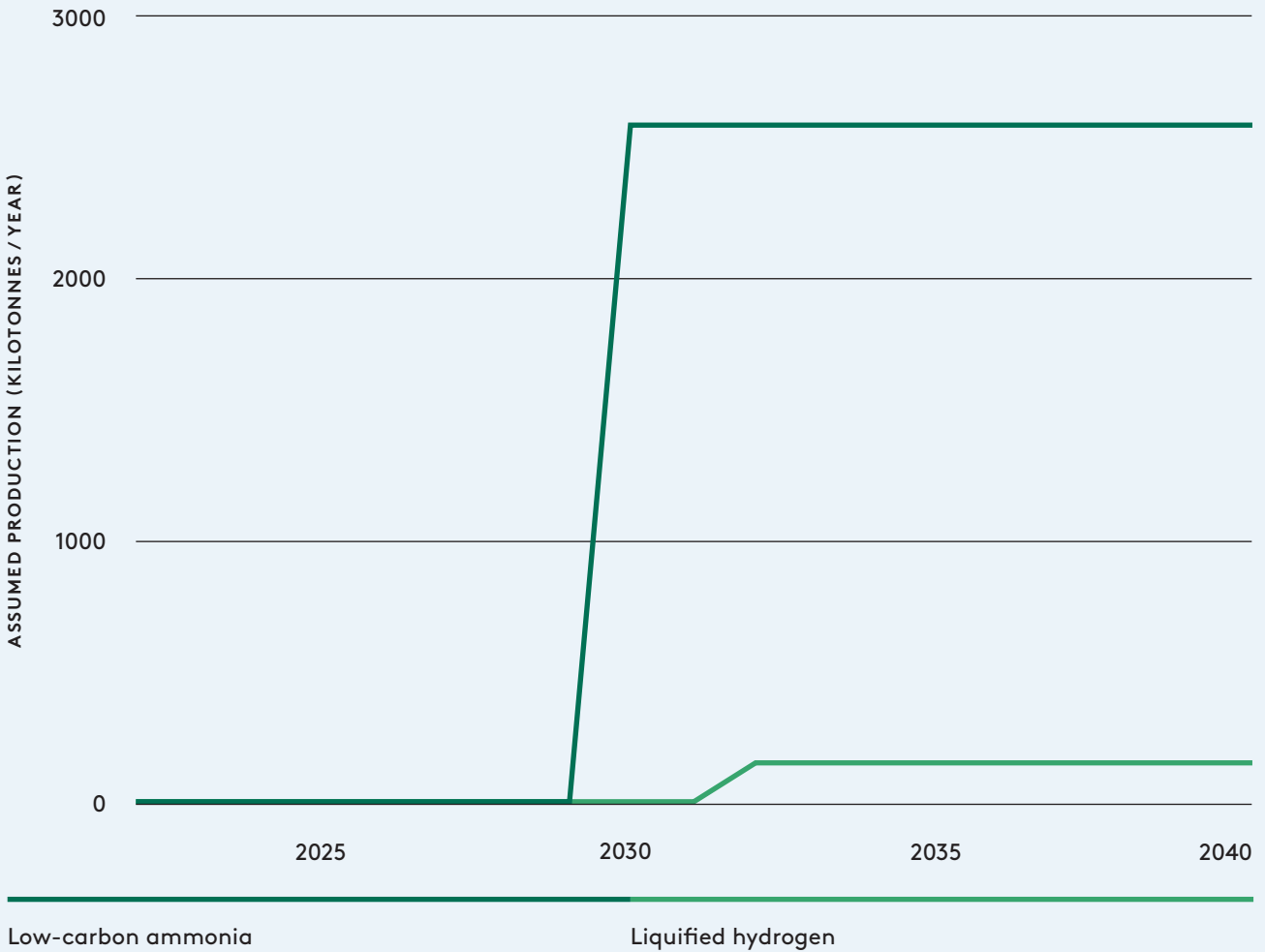
Figure 12 shows the projected growth of low-carbon ammonia production and phase-out of fossil ammonia production for domestic manufacturing (explosives). Figure 13 shows the assumed export of both liquefied hydrogen and low-carbon ammonia as a fuel carrier. The total potential hydrogen production for Central Queensland is assumed to be 610,000 t/year, derived from a Queensland Government study (Queensland Government 2022). To put this number into perspective, roughly half of the 610,000 tonnes could be supplied by the CQ-H2 project being co-developed by Stanwell, while the other half could be produced by an additional large hydrogen project led by H2U (Stanwell 2023; H2-hub Gladstone 2022).

We assumed a gradual increase in activity roughly based on the publicly stated goals of selected regional hydrogen projects. Twenty-five per cent of hydrogen produced for export is assumed to be liquefied, with the remainder converted to low-carbon ammonia.

**FIGURE 12: Assumed changes in Gladstone’s ammonia production for explosives feedstock**



**FIGURE 13: Assumed production of Gladstone's new low-carbon energy exports**



**Technology deployment timelines**

Technology deployment assumptions are mostly based on inputs from the Australian Industry ETI 'Incremental' scenario. This results in a more delayed timeline than the central 1.5°C-aligned 'Coordinated action' scenario, which has a 2020 baseline and significant energy system and industrial transformation by 2025.

As described in Box 1, the choice of the non-1.5°C-aligned 'Incremental' scenario reflects the fact that progress towards decarbonisation has not kept up with the pace of the 'Coordinated action' scenario since its 2020 baseline year. However, the pace of technology introduction is not derived from the 'Incremental' scenario. For example, the 'Climateworks Gladstone' scenario assumes the replacement of fossil gas with electricity-based hydrogen in 2028, while the 'Incremental' scenario output sees significant fossil gas use beyond 2030.

The electricity grid is also assumed to decarbonise rapidly in line with the 1.5°C scenario in *Climateworks Centre decarbonisation scenarios 2023* (Climateworks, 2023).

Below are key assumptions regarding technology deployment in the 'Climateworks Gladstone' scenario.

**ALUMINA**

- + Electric boilers for digestion deployed 20 per cent in 2029, increasing to 100 per cent by 2033
- + Hydrogen calcination deployed 14 per cent in 2026, 57 per cent in 2032, 100 per cent in 2035

**ALUMINIUM**

- + Electricity supplied by Gladstone Power Station is completely phased out by 2031 (linear decrease from 2022)
- + This is replaced by a mixture of grid and renewable supply, with renewable supply providing 5 per cent in 2026 and 50 per cent by 2035
- + Inert anodes for smelting are deployed in 2030
- + Secondary production for smelting is deployed in 2028

**AMMONIA FOR EXPLOSIVES**

- + In 2028, direct hydrogen replaces fossil gas and steam methane reforming
- + In 2028, the power required for Haber Bosch is provided by electricity

**CEMENT AND CLINKER**

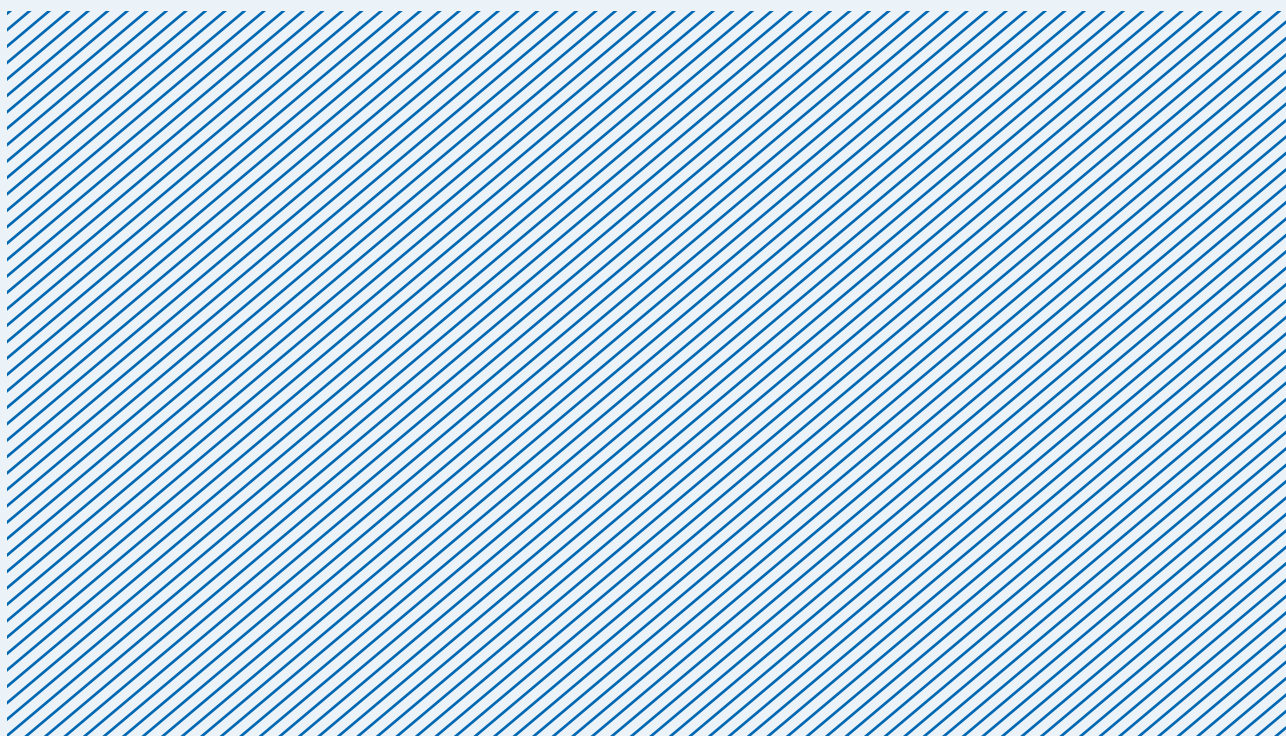
- + Alternative fuels used to power clinker heat reach 30 per cent by 2032 (linear increase from 2022)
- + Hydrogen is introduced in 2035 to provide 10 per cent of fuel for clinker heat
- + Carbon capture and storage is introduced for clinker process emissions between 2033 and 2036 (90 per cent capture rate)
- + No new technology is deployed for cement milling

**EXPLOSIVES**

- + Fuel mix of gas and electricity remains the same
- + Explosives plant 1 introduces tertiary catalysts in 2025 (impacts 25 per cent of total production in Gladstone)
- + Explosives plant 2 introduces tertiary catalysts in 2028 (impacts 75 per cent of total production in Gladstone)

**LOW-CARBON ENERGY EXPORTS**

- + Proton exchange membrane electrolyzers (52 kWh/kg H<sub>2</sub>); 100 per cent renewable energy for liquefaction and low-carbon ammonia production



# References

AEMO (2023) *2023 inputs, assumptions and scenarios report*, <https://aemo.com.au/-/media/files/major-publications/isp/2023/2023-inputs-assumptions-and-scenarios-report.pdf?la=en>.

— (2024a) *2024 Integrated System Plan for the National Electricity Market: A roadmap for the energy transition*, Australian Energy Market Operator, <https://aemo.com.au/-/media/files/major-publications/isp/2024/2024-integrated-system-plan-isp.pdf?la=en>.

— (2024b) *Appendix 3: Renewable energy zones*, <https://aemo.com.au/-/media/files/major-publications/isp/2024/appendices/a3-renewable-energy-zones.pdf?la=en>.

Alpha HPA (2022) *Alpha HPA*, <https://alphahpa.com.au/>, accessed 31 July 2024.

American Bureau of Shipping (2020) *Sustainability whitepaper: Ammonia as marine fuel*, <https://preprod.eagle.org/content/dam/eagle/advisories-and-debriefs/ammonia-as-marine-fuel-whitepaper-20188.pdf>.

ARENA (2022) *A roadmap for decarbonising Australian alumina refining*, <https://arena.gov.au/knowledge-bank/a-roadmap-for-decarbonising-australian-alumina-refining/>.

Ark Energy (21 September 2022) 'Ark Energy forms major hydrogen consortium' <https://arkenergy.com.au/news/2022/9/21/318-ark-energy-forms-major-hydrogen-consortium/>, accessed 29 January 2025.

Australian Sustainable Finance Institute (October 2024), *Australian Sustainable Finance Taxonomy V0.1* [https://static1.squarespace.com/static/6182172c8c1fdb1d7425fd0d/t/67522af9c8f2f52a34c952ed/1733438243130/789ASFI\\_Australian-Sustainable-Finance-Taxonomy\\_v10b.pdf](https://static1.squarespace.com/static/6182172c8c1fdb1d7425fd0d/t/67522af9c8f2f52a34c952ed/1733438243130/789ASFI_Australian-Sustainable-Finance-Taxonomy_v10b.pdf), accessed 29 January 2025.

Australian Aluminium Council (2020) *Recycling, The Australian Aluminium Council*, <https://aluminium.org.au/australian-industry/recycling/>, accessed 3 October 2022.

— (2023) 'Fact sheet #4', <https://aluminium.org.au/wp-content/uploads/2022/07/FACT-SHEET-04-ALUMINIUM.pdf>.

Australian Bureau of Statistics (5 April 2023), 'Analysing Australian exporter performance' <https://www.abs.gov.au/statistics/research/analysing-australian-exporter-performance>.

Azevedo M, Moore A, Van den Heuvel C and Van Hoey M (2022) *Capturing the green-premium value from sustainable materials*, <https://www.mckinsey.com/industries/metals-and-mining/our-insights/capturing-the-green-premium-value-from-sustainable-materials>, accessed 11 July 2024.

Cement Industry Federation (n.d.) *Cement industry & emissions – cement*, <https://cement.org.au/sustainability/climate-change/>, accessed 31 July 2024.

Central Queensland Regional Organisation of Councils (n.d.) 'Gladstone region' <https://cqroc.org.au/gladstone-region/>.

Clean Energy Regulator (19 December 2024) 'Guarantee of Origin', <https://cer.gov.au/schemes/guarantee-origin>, accessed 29 January 2025.

Climateworks Centre and Climate-KIC Australia (2022) *Setting up industrial regions for net zero, Phase 2 report*, <https://www.climateworkscentre.org/resource/setting-up-industrial-regions-for-net-zero-australian-industry-energy-transitions-initiative-phase-2-report/>, accessed 4 February 2025.

— (2023) *Pathways to Industrial Decarbonisation*, <https://www.climateworkscentre.org/resource/pathways-to-industrial-decarbonisation-positioning-australian-industry-to-prosper-in-a-net-zero-global-economy/>.

Climateworks Centre (2023a) *Brief for policy-makers: Renewable energy industrial precincts*, Climateworks Centre, <https://www.climateworkscentre.org/resource/brief-for-policy-makers-renewable-energy-industrial-precincts/>, accessed 11 April 2024.

— (2023b) *Climateworks Centre decarbonisation scenarios 2023: Australia can still meet the Paris Agreement*, <https://www.climateworkscentre.org/resource/climateworks-centre-decarbonisation-scenarios-2023-australia-can-still-meet-the-paris-agreement.>, accessed 11 July 2024.

DCCEEW (Department of Climate Change, Energy, the Environment and Water) (2024a) *National Hydrogen Strategy 2024*, <https://www.dcceew.gov.au/sites/default/files/documents/national-hydrogen-strategy-2024.pdf>, accessed 29 January 2025.

— (2024b) 'Energy data' <https://www.energy.gov.au/energy-data/australian-energy-statistics/electricity-generation>.

— (2024c) *Safeguard Mechanism: Prescribed production variables and default emissions intensities*, <https://www.dcceew.gov.au/sites/default/files/documents/safeguard-mechanism-document-production-variable-definitions-2024.pdf>.

Department of Energy and Climate (2022) *Enabling Queensland's Hydrogen production and export opportunities report*, <https://www.energyandclimate.qld.gov.au/hydrogen/information-for-industry/production-and-export-opportunities>, accessed 29 July 2024.

— (26 July 2024) 'Emissions data' [https://www.energyandclimate.qld.gov.au/climate/climate-analytics-reporting/emissions-data#:~:text=Queensland%20net%20greenhouse%20gas%20\(GHG,were%20124.1%20MtCO%E2%82%82%2De\\*.](https://www.energyandclimate.qld.gov.au/climate/climate-analytics-reporting/emissions-data#:~:text=Queensland%20net%20greenhouse%20gas%20(GHG,were%20124.1%20MtCO%E2%82%82%2De*.)

Department of Infrastructure, Transport, Regional Development and Trade (March 2024) 'Singapore and Australia green and digital shipping corridor', <https://www.dfat.gov.au/sites/default/files/singapore-australia-green-digital-shipping-corridor.pdf>, accessed 29 January 2025.

DISR (Department of Industry, Science and Resources) (2024) *Resources and energy quarterly: June 2024* <https://www.industry.gov.au/publications/resources-and-energy-quarterly-june-2024>.

— (20 January 2025) 'New Green Aluminium Production Credit will support the transition to green metals' <https://www.industry.gov.au/news/new-green-aluminium-production-credit-will-support-transition-green-metals>, accessed 30 January 2025.

Department of State Development (n.d.) 'Statement of cooperation', [https://www.statedevelopment.qld.gov.au/\\_\\_\\_data/assets/pdf\\_file/0026/64547/statement-of-cooperation.pdf](https://www.statedevelopment.qld.gov.au/___data/assets/pdf_file/0026/64547/statement-of-cooperation.pdf).

Edmonds H, Ng C, Kashyap T, Mella S (2022) *Gladstone's renewable energy industrial precinct*, Beyond Zero Emissions, <https://www.bze.org.au/research/report/gladstone-renewable-energy-industrial-precinct-briefing-paper>, accessed 31 July 2024.

ELYSIS (n.d.) 'A new era for the aluminium industry' <https://elysis.com/en>.

Fletcher A, Nguyen H, Salmon N, Spencer N, Wild P and Banares-Alcantara R (2023) *Queensland green ammonia value chain: Decarbonising hard-to-abate sectors and the NEM*, Griffith University, [https://www.griffith.edu.au/\\_\\_\\_data/assets/pdf\\_file/0035/1875167/No.2023-16-QLD-Green-Ammonia-Value-Chain-Main-Report.pdf](https://www.griffith.edu.au/___data/assets/pdf_file/0035/1875167/No.2023-16-QLD-Green-Ammonia-Value-Chain-Main-Report.pdf).

Fortescue (2024) *Fortescue officially opens Gladstone Electrolyser Facility*, Fortescue, <https://fortescue.com/news-and-media/news/2024/04/08/fortescue-officially-opens-gladstone-electrolyser-facility>, accessed 31 July 2024.

Gladstone Ports Corporation (2022) *Port of Gladstone: Port Information Handbook*, <https://gpcl.com.au/wp-content/uploads/2022/08/Port-of-Gladstone-Information-Handbook.pdf>.

— *Cargo Statistics Selections*, <https://content3.gpcl.com.au/viewcontent/CargoComparisonsSelection/>, accessed 29 July 2024.

Green Hydrogen Organisation (2023) *Green Hydrogen Standard*, [https://gh2.org/sites/default/files/2023-01/GH2\\_Standard\\_A5\\_JAN%202023\\_1.pdf](https://gh2.org/sites/default/files/2023-01/GH2_Standard_A5_JAN%202023_1.pdf), accessed 29 January 2025.

H2Global n.d. 'The H2Global mechanism', <https://www.h2-global.org/the-h2global-instrument>, accessed 30 January 2025.

H2-hub Gladstone (2022) *State Development and Infrastructure*, <https://www.statedevelopment.qld.gov.au/coordinator-general/assessments-and-approvals/coordinated-projects/current-projects/h2-hub-gladstone>, accessed 29 July 2024.

International Aluminium Institute (2021) *Aluminium Sector Greenhouse Gas Pathways to 2050*, <https://international-aluminium.org/resource/aluminium-sector-greenhouse-gas-pathways-to-2050-2021/>, accessed 26 July 2024.

IEEFA (2024) 'How mining could ignite Australia's green hydrogen boom', <https://ieefa.org/resources/how-mining-could-ignite-australias-green-hydrogen-boom>.

International Energy Agency (2021a) *Ammonia Technology Roadmap: Towards More Sustainable Nitrogen Fertiliser Production*, OECD Publishing, [https://play.google.com/store/books/details?id=dfC\\_zgEACAAJ](https://play.google.com/store/books/details?id=dfC_zgEACAAJ), accessed 3 October 2022.

— (2021b) *Ammonia Technology Roadmap: Towards more sustainable nitrogen fertiliser production*, <https://www.iea.org/reports/ammonia-technology-roadmap>.

IRENA (International Renewable Energy Agency) (2023) *World Energy Transitions Outlook 2023: 1.5°C pathway*, <https://www.irena.org/Publications/2023/Jun/World-Energy-Transitions-Outlook-2023>, accessed 24 July 2024.

Aluminium Stewardship Initiative (2022) 'Issue brief: Low carbon aluminium', <https://aluminium-stewardship.org/low-carbon-aluminium>, accessed 11 July 2024.

Ministry of Economy, Trade and Industry (2 December 2022) 'Ammonia strategy and policy in Japan', <https://www.jogmec.go.jp/content/300381295.pdf>, accessed 29 January 2025.

Mission Possible Partnership (n.d.) 'Home' <https://www.missionpossiblepartnership.org/>, accessed 5 February 2025.

— (2022) *Making 1.5-aligned ammonia possible*, [https://3stepsolutions.s3-accelerate.amazonaws.com/assets/custom/010856/downloads/Making-1.5-Aligned-Ammonia-possible%20\(1\).pdf](https://3stepsolutions.s3-accelerate.amazonaws.com/assets/custom/010856/downloads/Making-1.5-Aligned-Ammonia-possible%20(1).pdf).

— (2023) *Making Net-Zero Aluminium Possible: An industry-backed, 1.5°C-aligned transition strategy*, <https://3stepsolutions.s3-accelerate.amazonaws.com/assets/custom/010856/downloads/Making-1.5-Aligned-Aluminium-possible.pdf>.

Parliament of Australia (2024) *Future Made in Australia (Production Tax Credits and Other Measures) Bill 2024*, [https://www.aph.gov.au/Parliamentary\\_Business/Bills\\_Legislation/Bills\\_Search\\_Results/Result?bld=r7297](https://www.aph.gov.au/Parliamentary_Business/Bills_Legislation/Bills_Search_Results/Result?bld=r7297), accessed 12 February 2025.

Pistilli M (2023) *Top 10 aluminum-producing countries*, INN, <https://investingnews.com/daily/resource-investing/industrial-metals-investing/aluminum-investing/aluminum-producing-countries/>, accessed 9 August 2024.

Quinbrook (2024) *Quinbrook sponsors development of 'Green Iron' Project in Gladstone, Queensland*, <https://www.quinbrook.com/news-insights/quinbrook-sponsors-development-of-green-iron-project-in-gladstone-queensland/>, accessed 30 July 2024.

Rio Tinto (21 February 2024) *'Rio Tinto signs Australia's biggest renewable power deal as it works to repower its Gladstone operations'*, <https://www.riotinto.com/en/news/releases/2024/rio-tinto-signs-australias-biggest-renewable-power-deal-as-it-works-to-repower-its-gladstone-operations>.

Stanwell (2023) *CQ-H2: Central Queensland renewable hydrogen Project*, <https://www.stanwell.com/energy-assets/new-energy-initiatives/stanwell-hydrogen-project/stanwell-hydrogen-project/>, accessed 29 July 2024.

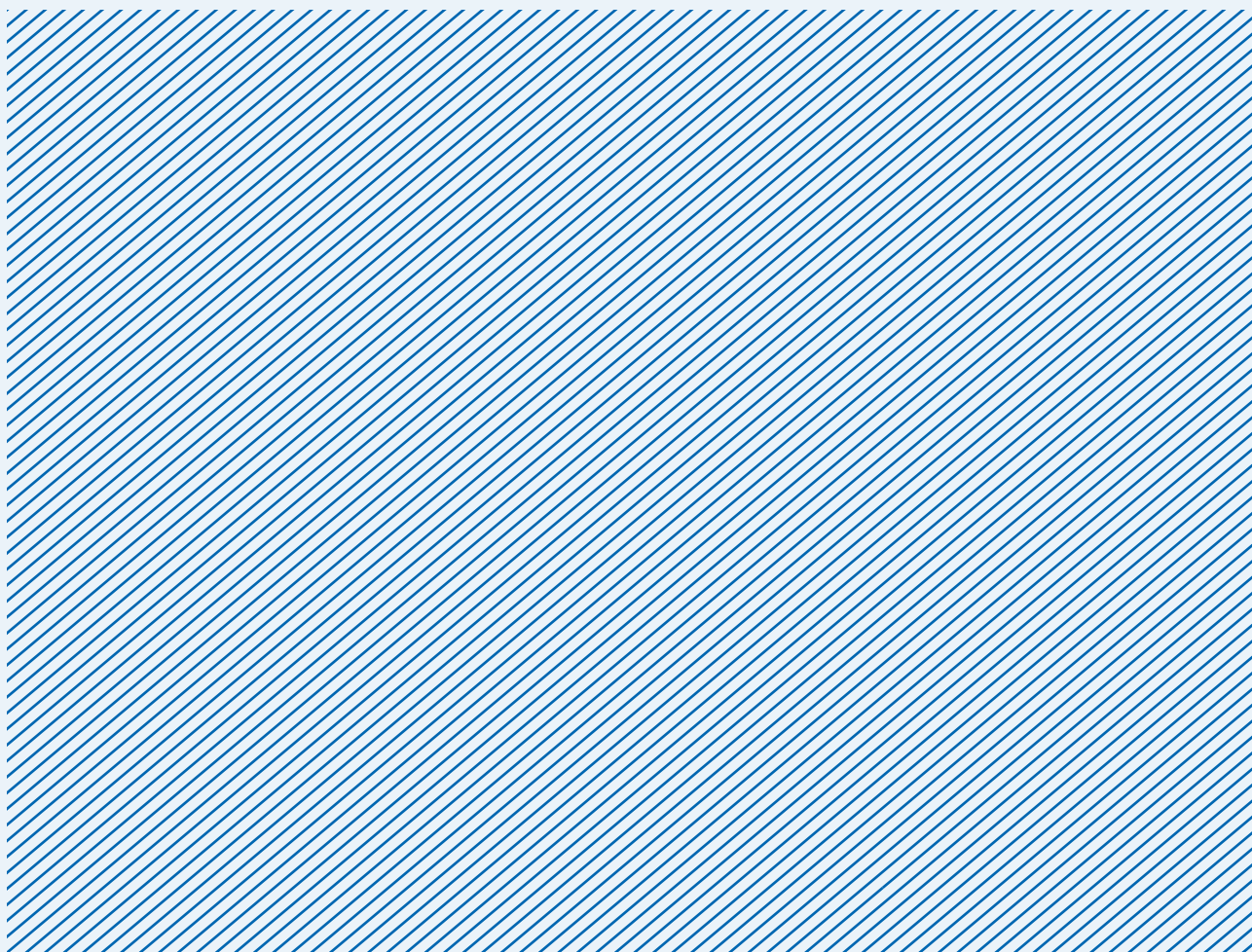
The Next Economy (2022) *Gladstone region economic transition roadmap 2022-32*, <https://www.gladstone.qld.gov.au/downloads/file/4714/gladstone-region-economic-transition-roadmap-2022-2032>.

The Treasury (September 2024) *Establishing a 'Front Door' for major, transformational projects*, <https://treasury.gov.au/sites/default/files/2024-09/c2024-571335-consultation-paper.pdf>, accessed 30 January 2025.

Wood Mackenzie (2022) *Aluminium under an accelerated energy transition 1.5 °C scenario*, Wood Mackenzie, <https://www.woodmac.com/reports/metals-aluminium-under-an-accelerated-energy-transition-15-c-scenario-150054760/>, accessed 29 July 2024.

World Economic Forum (2020) *Why addressing the aluminium industry's carbon footprint is key to climate action*.

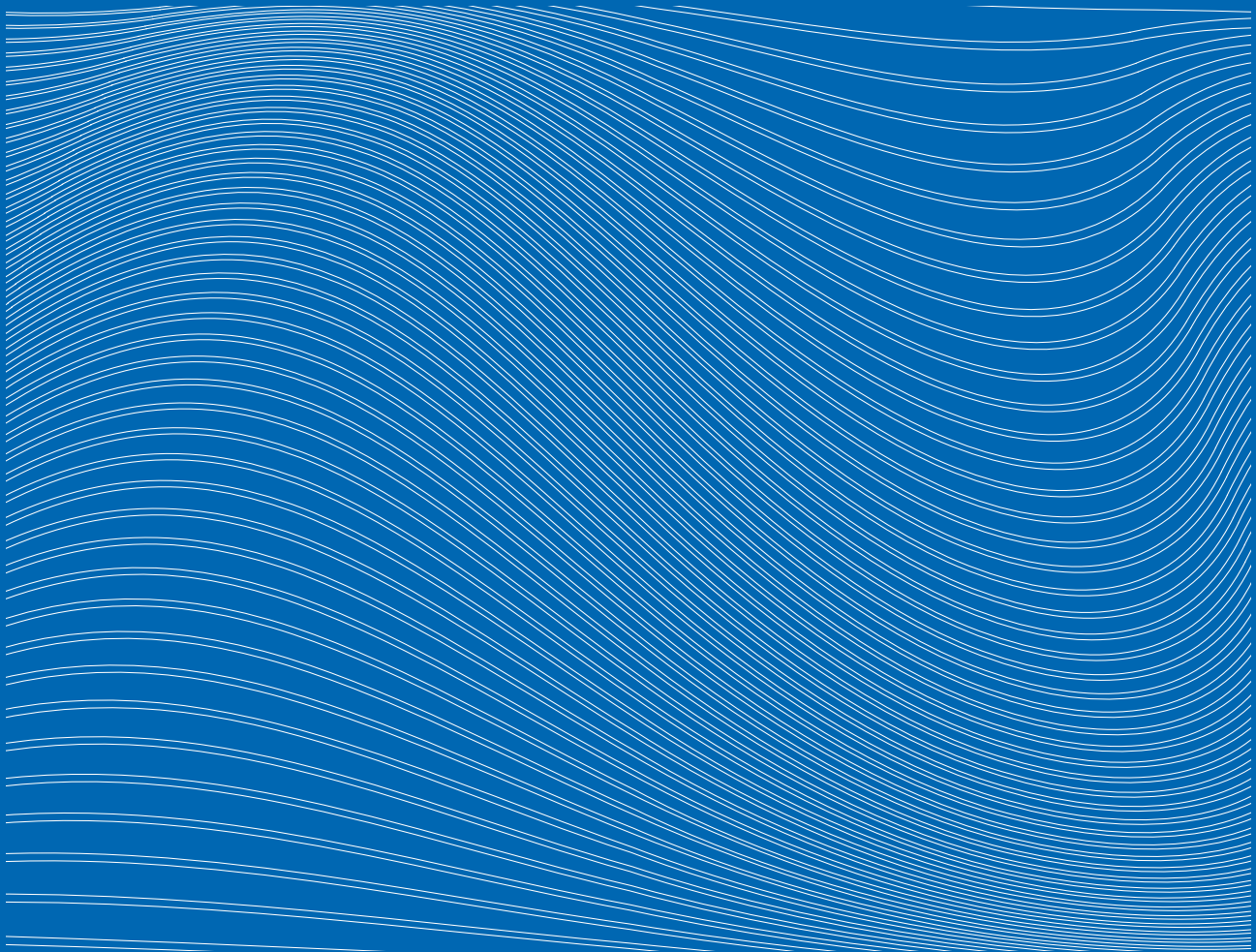
Yara (30 November 2023) *'The world's first clean ammonia-powered container ship'*, <https://www.yara.com/corporate-releases/the-worlds-first-clean-ammonia-powered-container-ship/>, accessed 29 January 2025.



# Glossary

<b>AEMO</b>	Australian Energy Market Operator
<b>ARENA</b>	Australian Renewable Energy Agency
<b>CQ</b>	Central Queensland
<b>CSIRO</b>	Commonwealth Scientific and Industrial Research Organisation
<b>ETI</b>	(Australian Industry) Energy Transitions Initiative
<b>GDP</b>	gross domestic product
<b>GW</b>	gigawatt
<b>H<sub>2</sub></b>	hydrogen
<b>IEA</b>	International Energy Agency
<b>ISP</b>	Integrated System Plan
<b>kg</b>	kilogram
<b>kWh</b>	kilowatt hour
<b>MPP</b>	Mission Possible Partnership
<b>Mt</b>	megatonne (million tonnes)
<b>NEM</b>	National Electricity Market
<b>NGO</b>	non-government organisation
<b>NH<sub>3</sub></b>	ammonia
<b>QLD</b>	Queensland
<b>REZ</b>	renewable energy zone
<b>tAl</b>	tonnes of aluminium
<b>tNH<sub>3</sub></b>	tonnes of ammonia
<b>tCO<sub>2</sub>e</b>	tonnes of carbon dioxide equivalent
<b>TWh</b>	terawatt hour
<b>VRE</b>	variable renewable energy





**For further information  
please contact:**

**DR TESSA LEACH**  
Senior Project Manager  
[tessa.leach@  
climateworkscentre.org](mailto:tessa.leach@climateworkscentre.org)

**HUGH SHEEHAN**  
Program Impact Manager -  
Net Zero Industrial Precincts  
[hugh.sheehan@  
climateworkscentre.org](mailto:hugh.sheehan@climateworkscentre.org)

Climateworks Centre  
Level 8, 750 Collins Street,  
Docklands VIC 3008  
Wurundjeri Country

Climateworks Centre, 2025,  
*Seizing Gladstone's low-carbon  
opportunity: A net zero industrial  
precinct approach.*

Published by Climateworks  
Centre Melbourne, Victoria,  
February 2025  
© Climateworks Centre 2025

This work is subject to copyright.  
Apart from any use permitted  
under the Copyright Act 1968,  
no part may be reproduced by  
any process without written  
permission from the publisher.

This publication can be  
downloaded at:  
[www.climateworkscentre.org](http://www.climateworkscentre.org)