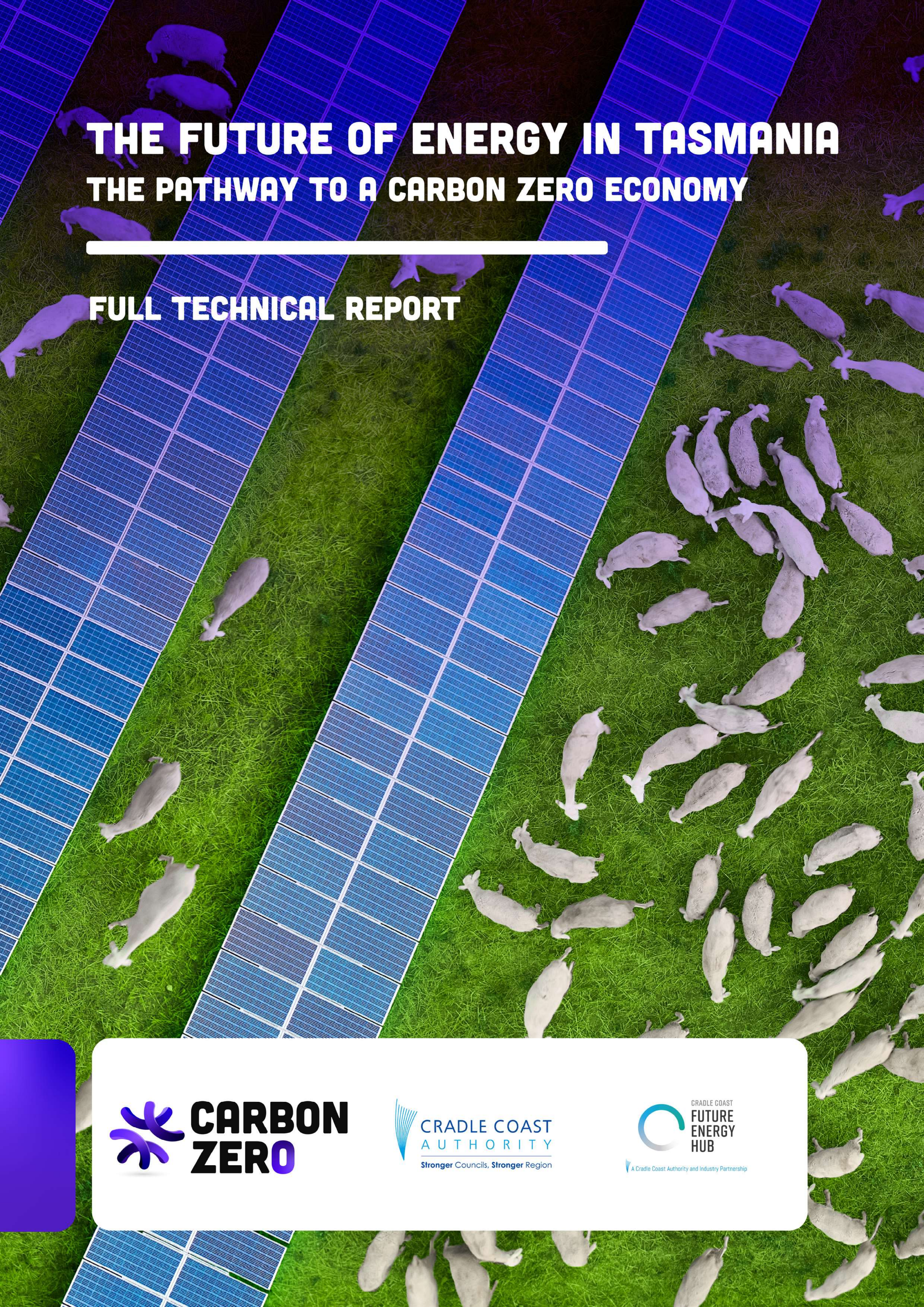
THE FUTURE OF ENERGY IN TASMANIA

THE PATHWAY TO A CARBON ZERO ECONOMY

FULL TECHNICAL REPORT



CARBON ZERO

CRADLE COAST AUTHORITY

Stronger Councils, Stronger Region

CRADLE COAST FUTURE ENERGY HUB

A Cradle Coast Authority and Industry Partnership

The Future of Energy in Tasmania

The Pathway to a Carbon Zero Economy

2024

Full Technical Report

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Carbon Zero Initiative acknowledges the traditional owners of the country on which we live, the Palawa, and recognises Aboriginal people's continuing connection to land, sea, waterways, sky and culture.

Acknowledgements

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Executive Summary

The Future of Energy in Tasmania report charts the pathway to a Tasmanian economy running entirely without fossil fuels - a carbon zero economy, the first of its kind in the world. The report sets out the opportunities this will unlock from investment in new energy infrastructure, reduction in carbon emissions, and the amount of new renewable energy required to make it happen. In order to model these opportunities, the authors used the Australian Energy Market Operator's (AEMO) forecasts for Tasmania, and added significant fuel switching away from industrial coal and gas to renewable energy. The report details the huge scale of this opportunity for Tasmania, including analysis of new energy infrastructure, investment and jobs created to phase out fossil fuels from energy, heavy industry, transport, commercial and residential sectors.

The report uses the AEMO's Integrated System Plan (ISP) 2024 *Step Change* scenario as a baseline. The *Step Change* model is the consensus scenario among Australia's expert energy planners and engineers. The ISP has over 2,100 expert contributors and is updated every two years which makes it an ideal foundation for this research. Carbon Zero Initiative has published a separate report which describes the AEMO ISP *Step Change 2024* scenario for Tasmania in depth.

However, this report departs from AEMO assumptions and resulting conclusions where they do not reflect local Tasmanian conditions and expected market developments. In preparing this report, Carbon Zero Initiative conducted an in-depth analysis of Tasmania's projected energy demand including announced changes in fuel use or electrification across:

- Tasmania's six largest industrial energy using facilities - coal, liquid fuels, fossil gas and electricity
- Other commercial energy users - fossil gas users in low and high temperature heat applications
- The transport sector - liquid fuels; and
- Electrification of households – gas and biomass.

The report uses this analysis to model demand for fuel and electricity use out to 2030 and 2050. Finally, using development costs published by Aurecon, Carbon Zero Initiative estimates the private and public investment and subsequent number of employees required to build generation and infrastructure to meet the modelled demand.

The report finds that in a scenario where Tasmania decarbonises in line with our 2050 target, the on-island consumption of electricity increases from *Step Change*.

Scenario Comparison	Baseline 2023-2024	Step Change 2050	Carbon Zero
Total Electricity GWh	10,710	16,200	21,200
Hydropower (MW)	2,176	2,176	2,176
Onshore wind (MW)	563	1,790	3,226
Utility Scale Solar (MW)	0	577	2,435
Rooftop Solar (MW)	362	1,670	1,323
Batteries (MW)	8.3	917	890
Offshore Wind (MW)	0	419	420
Interconnectors (MW)	500	500	500

Step Change predicts on-island electricity consumption to increase from 10,710 GWh in 2023 to 16,200 GWh in 2050. This report finds a greater increase to 21,200 GWh in order to meet our 2050 target. This is met with a modelled generation of 3,226 MW of onshore wind, 420 MW of offshore wind, 2,435 MW of utility scale solar, 1,323 MW of rooftop solar (residential and commercial premises) and a combined 890 MW of batteries in addition to existing hydropower of 2,180 MW. The total Tasmanian generation capacity in this scenario would be 10,475 MW, from 3,509 MW in 2023.

The primary source of increased consumption for electricity compared to *Step Change* is increased production of green hydrogen to replace high temperature fossil coal and gas. Hydrogen production is projected to consume 7,733 GWh of electricity, compared with 3,700 GWh in *Step Change*.

Other increases on *Step Change* include residential and commercial premises which increase by a combined 821 GWh and line losses which increase by 166 GWh. The total predicted consumption figures for the Carbon Zero Tasmania scenario are industrial and commercial 8,100 GWh, hydrogen 7,733 GWh, all electrification 1,818 GWh, Electric Vehicles 1,560 GWh, residential 1,193 GWh and losses 804 GWh. In addition,

Given the Tasmanian government and its business enterprises' ambitions to increase net exporters of electricity, Carbon Zero Initiative separately modelled electricity demand in Tasmania from Basslink and the proposed Marinus 1 and 2. The report assumes that the cables' export electricity three quarters of the time on average. In the main report, the new interconnectors have their own graphs and electricity projections which can be read separately or combined with other totals.

Basslink and Marinus 1 are estimated to export 7,963 GWh of electricity annually, whilst Basslink, Marinus 1 and 2 would export up to 12,890 GWh of electricity annually. In order to meet this additional consumption, Carbon Zero Initiative estimates an additional 1,500 MW of generation from renewable sources is necessary for Marinus 1 and Basslink, and 3,000 MW for Basslink, Marinus 1 and 2.

The report concludes by estimating the investment in new infrastructure including transmission, and one 500 MW hydrogen producing facility. Carbon Zero Initiative found that the infrastructure investment totalled $17.1 billion over 25 years, with 66% of that being private investment, and the bulk occurring by 2040. That combined investment was estimated to create 259 direct full-time jobs per year, on average over the 25 year period. The report conservatively assumes each full-time equivalent position has an average length of 18 months. The total number of jobs created can therefore be expressed as 6,475 jobs, each lasting an average of 18 months, or as 9,712 full-time equivalent job years.

In November 2020 the Tasmania government committed to a 200% renewable energy target of 21,000 MWh by 2040, with an interim target of 15,750 MWh by 2030. This research found the 200% target should be taken as the status quo, or a baseline requirement to meet the needs of existing commitments from heavy industry to phase out fossil fuels by 2040, and no later than 2050.

The report suggests that the government's 200% target does not account for the addition of large new industrial facilities opening, large datacentres, or the ability for Tasmania to become a significant net exporter of electricity via new undersea cables.

Contents

About Carbon Zero Initiative

Carbon Zero Initiative's (CZI) mission is to promote a fast, fair and sustainable transition to an economy powered by clean energy.

It brings people together in collaborative partnerships, drawing on the expertise of its members, diverse external stakeholders from industry, philanthropy, community organisations and government.

Carbon Zero Initiative has a systems theory of change, with a focus on statewide and national narratives, shaping policy through advocacy and leveraging public and private investment to fund world leading Tasmanian innovation and economic opportunities in emissions reduction.

Carbon Zero Initiative is a not-for-profit organisation governed by a constitution and the Australian Charities and Not-for-Profit Commission rules. Carbon Zero Initiative is funded by philanthropic donors with an interest in nature conservation, and clean energy led decarbonisation.

About Strategy Policy Research

SPR is a Tasmanian consulting firm based in Hobart that specialises in making the business case for sustainability.

Offering an ecosystem of highly experienced economists and other professionals, and servicing government, not-for-profit and ethical business clients throughout Australia and overseas, its key knowledge domains include: climate change, energy built environment and sustainability. Its services include: Policy research, analysis and report preparation, transformational strategies, zero carbon pathways and transition strategies and economic modelling.

Since 2016, SPR has contributed to AEMO electricity and gas statements of opportunities and Integrated System Plans by preparing detailed energy efficiency forecasts.

It also assists major transmission and distribution network service providers around Australia with consumption and demand forecasting.

About the Cradle Coast Authority

The Cradle Coast Authority and Future Energy Hub are key partners in publishing this report.

The Cradle Coast Authority (CCA) is a regional development and natural resource management organisation in Tasmania that represents eight councils in the Cradle Coast region. CCA was originally established in 1999 for the purpose of promoting collaboration among local councils to tackle regional challenges and leverage shared opportunities more effectively. CCA continues to play a pivotal role in coordinating efforts across councils and working in partnership with council, community, business and industry to support development in the region.

The Future Energy Hub is a CCA and Industry initiative located at the CCA building in Burnie and provides a neutral access point for information relating to the renewable energy transition on the north west coast of Tasmania. Members of the public are welcome and access brochures and connect with staff who can act as a conduit for questions and information.

About the Cradle Coast Region

The Cradle Coast region is on the north west and west coast of Tasmania including King Island and West Coast Council, with a population of around 120,000 people and existing economic strengths in agriculture, manufacturing, mining, tourism and retail.

The Cradle Coast is well positioned to play a leadership role in Tasmania's transition to a renewable energy future, with over $10 billion of renewable energy projects on the horizon. This investment is a significant opportunity to enhance regional growth, environmental sustainability, and create long-term economic and environmental resilience. This shift requires a coordinated effort to ensure that both the opportunities and challenges are managed in a way that benefits all stakeholders.

Like many regional parts of Tasmania and Australia, the Cradle Coast deserves development that strengthens its economy and promotes job creation, while safeguarding community interests and environment. This can be achieved with strategic and coordinated investment in communities, infrastructure, transport, healthcare, workforce development, and social procurement initiatives.

Background

The purpose of this report is to construct a credible pathway to a carbon zero economy for Tasmania's energy sector consistent with meeting Paris Agreement emissions targets, being a 50% reduction in greenhouse gas emissions by 2030 on 2005 levels and (for Tasmania) zero emissions by 2050.

The report examines current efforts to decarbonise and comments on how these efforts stack up against high level targets.

The report aims to guide Tasmanian policy makers and energy market stakeholders to appreciate the clean energy potential in Tasmania, taking into account competition and other market realities.

Methodology, Scope and Key Assumptions

The overall approach taken in this project is to review and make use of the extensive planning, research, modelling and stakeholder engagement that is embodied in AEMO's ISP, while retaining the flexibility to depart from AEMO assumptions where these do not agree with local Tasmania conditions and expected market developments.

The focus of this project is the energy sector in Tasmania, including stationary and transport-related energy demand and emissions from the residential, commercial, industrial and electricity generation sectors.

We discuss non-energy related emissions in the industrial sector in Tasmania as they are often directly adjacent to the energy sector and the subject facilities are planning to make facility-wide changes. However, the report is careful to delineate these emissions and energy sources where electrification is planned or not viable.

This report assumes that the proposed Marinus 1 and 2 interconnectors are commissioned in line with assumptions by the Australian Energy Market Operator (AEMO), and that Basslink is available until 2050. The report assumes that Tasmania will continue to have ambitions around net exports of clean electricity on average, while continuing to import electricity when required.

While the report quantifies expected net annual exports, it does not model short-term (daily or hourly) interconnector flows. The report does not seek to project spot-market price outcomes, as specialised models are required for this purpose. In addition, the report does not forecast new large energy using facilities opening in Tasmania.

The report assumes that least cost generation choices are made, and that only infrastructure projects that are deemed ‘actionable’ by AEMO occur. Departures from least-cost solutions may in fact occur, for example to add diversity of generation sources and therefore to enhance energy security (for example, due to low winter flows into hydro storages).

While the forecasts assume no future use of gas for power generation purposes, it may be that the existing gas generation capacity remains in place on a care and maintenance basis, for potential use if required for energy security purposes.

For our analysis of Tasmanian market conditions, including expected fuel demands, planned expansions and other project-related developments, CZI conducted a study of individual major industrial facilities, large commercial fossil gas users, the transport sector and fuel switching plans.

Emissions databases and factors were drawn from the Tasmanian Greenhouse Gas Inventory, Australian Energy Regulator Regulatory Information Notices, Australian Energy Update and the National Greenhouse Accounts.

Because a small number of firms play such a significant role in Tasmania’s energy and emission profile, the public statements and annual reports of these companies represent another key source of data in determining future fossil-fuel, and electricity demand.

This company data forms the basis of this report’s forecast for industrial coal, fossil gas, electricity and hydrogen demand where firms indicated they intended to meet aligned net-zero targets.

About AEMO’s Integrated System Plan

The Australian Energy Market Operator's Integrated System Plan (AEMO ISP) is a strategic roadmap designed to guide the transformation of Australia's energy system over the next 20 years.

Updated every two years, it outlines a series of future scenarios and recommended actions to ensure a reliable, secure, and affordable supply of electricity, while also facilitating the transition to a low-emissions energy future.

The ISP integrates technological advancements, policy developments, and market dynamics to inform investment and regulatory decisions, supporting the adoption of renewable energy, energy storage, and other innovative technologies essential for achieving Australia's energy and climate goals.

Summary of AEMO ISP Step Change Scenario 2024

Under AEMO's *Step Change* scenario, electricity consumption in Tasmania is forecast to increase by 48% by 2035 and 55% by 2050, when compared to 2023 (10,468 GWh, growing to 16,193 GWh by FY2050).

This is expected to be met with generation capacity of 1,670 MW of rooftop solar, 577 MW of utility scale solar, 1,790 MW of onshore wind and 419 of MW offshore wind, connected to 917 MW of firming capacity.

This models the total generation capacity in Tasmania at 7,888 MW by 2050 from 3,509 MW in 2024, and meets the Tasmanian government's 200% clean energy target in 2039.

While total consumption in the residential and business sector is predicted to increase, the modelling predicts that this demand is more than fully offset by increased rooftop solar.

Tasmania has a huge opportunity ahead in rooftop solar on residential and commercial premises and is currently lagging the rest of Australia in terms of capacity (kW) per head of population.

This is currently the cheapest form of installed electricity generation, reducing demands on transmission and land use impacts.

Under *Step Change*, the consumption of electricity for green hydrogen production is modest, reaching 3,700 GWh by 2050 with 45% of that hydrogen being used in Tasmania for industrial high heat applications, and 55% exported (including in hydrogen derivatives like methanol and e-fuels).

Carbon Zero Initiative has modelled potential on-island consumption of green hydrogen. The corresponding electricity consumption represented in *Step Change* may be conservative, or underestimated if major industrials follow through with stated intentions to phase out coal and gas between now and 2030.

Electricity-related greenhouse gas emissions are low under *Step Change*, but not zero due to occasional use of open cycle gas turbines (such as the plant at Bell Bay) and persistent residential and commercial fossil gas use totaling 5,300 TJ (5.3 PJ, equivalent to ~1,472 GWh) by FY2050.

Emissions from the energy sector in FY2030 would be 500,000 tonnes CO_2-e and would be around 200,000 tonnes CO_2-e by FY2050, with cumulative emissions over the FY2024 – FY2050 period would be some 9.9 million tCO_2-e. This excludes transport and process emissions which are reported under a separate sector.

Basslink and Marinus Stage 1 are features of the *Step Change* Least Cost (or CDP3) scenario in AEMO's detailed ISP analysis. Marinus Stage 2 is described as 'actionable' but is not assumed to proceed. It is important to note that AEMO scenarios are narrative-based and do not correspond to business-as-usual or 'frozen policy' scenarios.

Each scenario has a unique combination of assumed climate change outlooks (representative concentration pathways), economic and population drivers, and policy and program settings. Each therefore generates unique and deliberately diverging market outcomes.

The broad intent is to illustrate outcomes – and demand for and consumption of electricity and gas in particular – that would be expected should the key elements of the scenario narrative come to pass

Carbon Zero Initiative has published a separate report which describes the AEMO ISP *Step Change* scenario for Tasmania in depth.

In this study, we depart from AEMO scenarios in several respects, as set out below, but most importantly to illustrate the demand for and supply of clean energy with the assumption that zero greenhouse gas emissions must be achieved as soon as possible, and by no later than 2050.

While AEMO forecasts consider electrification in what it describes as 'coupled' sectors – transport, gas and hydrogen only – they do not consider the current or expected future use of solid and liquid fuels, including transport fuels (other than electricity).

This report contends that AEMO likely under-estimates the impacts associated with electrification of some end-uses, particularly coal and fossil gas in an industrial setting.

By analysing existing decarbonisation commitments from Tasmania's major fossil fuel users, Carbon Zero Initiative intends to demonstrate a significant deviation in electricity demand to AEMO's *Step Change* scenario.

Carbon Zero Tasmania (CZT) Scenario

The *Carbon Zero Tasmania scenario* differs from *Step Change* in the following ways:

1. It achieves a rapid reduction in greenhouse gas emissions, and reaches carbon zero energy-related emissions by or before 2050, depending on the sector.
2. It assumes that Marinus 1 and 2 interconnectors proceed in 2030 and 2032 respectively.
3. It assumes that Tasmania aims to export renewable electricity to the extent permitted by interconnector and local generation and storage capacity, to take advantage of Tasmania's competitive advantages and opportunities in the clean energy sector.
4. The consumption of coal and fossil gas is phased out in all sectors, while petrol and diesel are phased out of the transport sector by 2050.

The *Carbon Zero Tasmania scenario* assumes that the same degree of dispatchable (or firm) capacity is maintained as per *Step Change*, and that least-cost capacity decisions are made.

It assumes that wind projects, utility-scale and other solar photovoltaics (PV) are preferred to take advantage of Tasmania's unique resource profiles (windier and more hours of sunlight in summer) to provide diversity and energy security, even if a 'solar-PV-only' pathway may offer the theoretical lowest capital and energy costs.

This report does not deal with aviation and maritime transport, which in emissions inventories are generally treated under separate provisions relating to bunker fuels.

AEMO scenarios consider industrial fossil gas use, but do not consider industrial coal use or the use of liquid fuels (as AEMO has no operational role in these latter energy markets). However, as this report intends to demonstrate, with increasing electrification of all fossil fuel types, it is preferable to have an overview of all substitutable fuels, announced timelines for fuel switching and major economy-wide trends.

The next sections review expectations with respect to major users of fossil gas, coal and the transport sector.

Current Industrial and Large Commercial Fossil Gas Use

The total energy content of fossil gas burned for process heat in Tasmania in 2022-23 was ~5,911 TJ (equivalent to ~1,472 GWh), of which ~1,486 TJ was used in low temperature processes such as steam production, and ~4,424 TJ was used in high-temperature applications – see Figure 1.

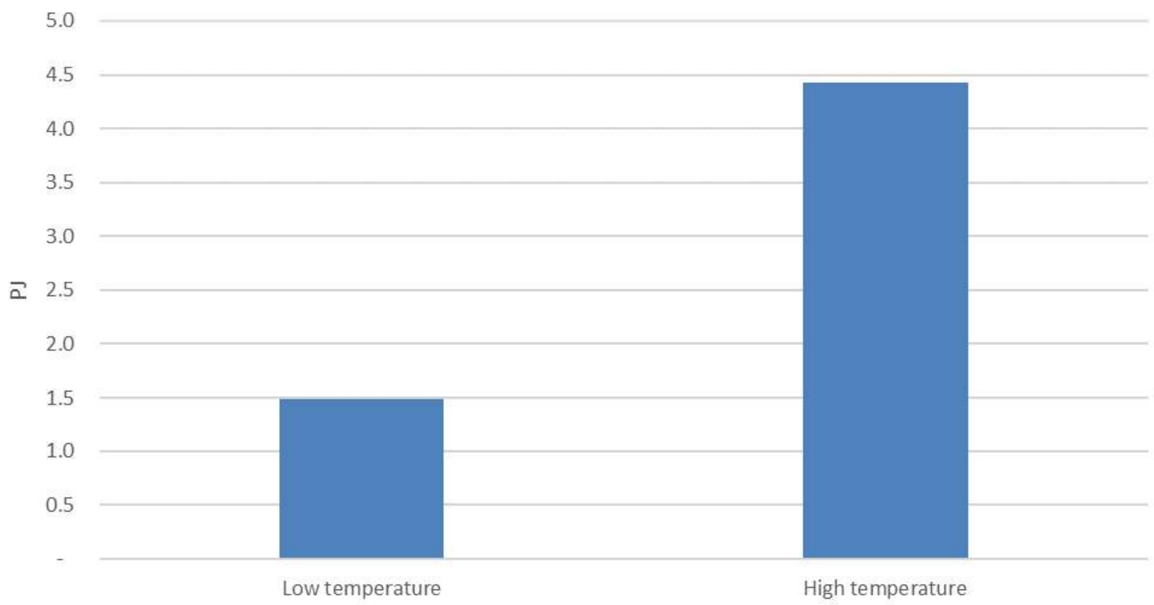

Figure 1: Industrial Sector Fossil Gas Use by Application, Tasmania, FY2023

Rio Tinto's Bell Bay Aluminium[1] and Grange Resources'[2] Port Latta plant account for over half of Tasmania's total fossil gas consumption (both are high temperature applications).

Other significant fossil gas consumers include Liberty Bell Bay, Nyrstar zinc smelter, the food and beverage sector and Liquefied Natural Gas (LNG) production for users not connected to the distribution network.[3] Total emissions as a result of gas combustion for industrial and large commercial users was ~304,000 t CO_2-e in 2022-23.

Rio Tinto Bell Bay and Grange Resource Port Latta have both committed to net-zero by 2050 targets and have set ambitious 2030 targets. Both firms have signalled an interest in switching to direct firing using hydrogen to meet emission reduction goals with key milestones at 2025 and 2030 in their respective

[1] **Rio Tinto, Environment Report, 2022**
[2] **Grange Resources, ESG Report Baseline, 2022**

[3] **LNG consumers may include residential and commercial customers – this consumption is not double counted.**

corporate reports. These two firms account for 50% of fossil gas use, as such there is more required in order to hit the targets presented for the purposes of this report.

Phasing out Fossil Gas

The zero emissions pathway below takes Tasmania's industrial users existing commitments as a starting point, while imposing the following additional constraints:

- The food and beverage sector and manufacturing firms requiring low-temperature heat switch wholly to existing heat-pump technology by 2030.
- Manufactures requiring high-temperature heat, and LNG production, transitions away from fossil gas gradually by 2050, using hydrogen and other emerging high temperature technologies where appropriate.

Food and Beverage

Because of the relatively low temperatures required in the food and beverage sector, there is no technical limitation on switching to high-temperature heat-pumps for all heat needs. These early reductions would reduce gas consumption by ~1,343 TJ, and emissions by 69,000 t-CO2e, by 2030.

Manufacturing

While a limited number of manufacturing firms require low-temperature heat, the overwhelming majority (97%) use fossil gas in high-temperature applications. These applications are currently harder to electrify, and early reductions are likely to come from more efficient processes. Electrical resistance heating is the likely pathway for those firms not using hydrogen in direct firing.

Hydrogen

Manufacturing firms which have signalled their intent to replace fossil gas use with hydrogen combustion would need to move quickly to meet these targets, considering the added lead-time required to build additional electricity generation to supply electrolysers. Grange Resources has developed a detailed business case for its transition to hydrogen in partnership with the state government.[4]

[4] **Hatch, Grange Resources Hydrogen Conversion, 2021**

CZT Modelled Fossil Gas Use

This zero emission pathway would see industrial and large commercial gas consumption decline 49% to ~3,020 TJ by 2030 and 100% to ~0 TJ by 2050. In this scenario emissions will fall to 155,000 t-CO_2e during the period by 2030 and then to 0 t-CO_2e in 2050 – see Figure 2.

There are likely to be three technologies deployed to electrify industrial and large commercial gas use: high-temperature heat pumps in low-temperature applications, and electrical resistance heating and hydrogen combustion in high-temperature applications. In the target scenario described, by 2050:

- High-temperature heat pumps, with an assumed COP of 2.5, will require an additional ~535 TJ, or 149 GWh, of electrical energy.
- Electrical resistance heating will require an additional ~1,033 TJ, or 287 GWh, of electrical energy.
- Hydrogen production for direct firing applications will require an additional ~5,443 TJ, or 1,512 GWh, of electrical energy.

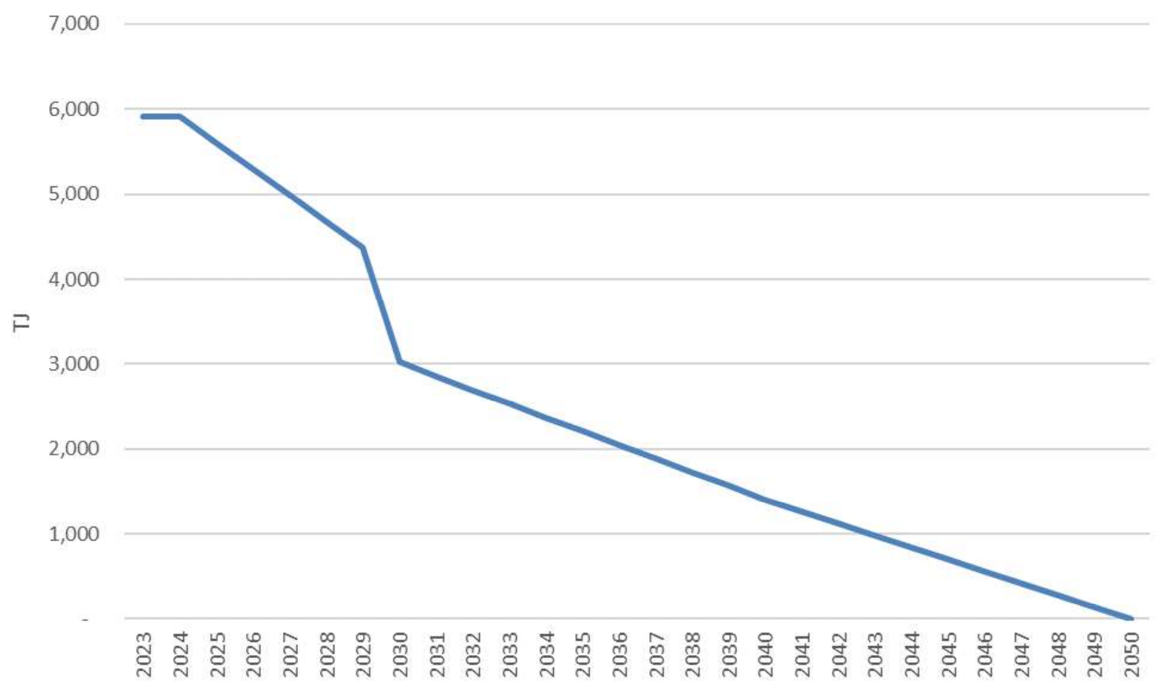

Figure 2: Target-aligned Industrial and Large Commercial Fossil-Gas Consumption, Tasmania

The total increase in electrical consumption in the target scenario hits 704 GWh in FY2030, before rising to 1,947GWh in FY2050 – see Figure 3.

The consequences of this are discussed further later in the report. This adjustment is the first major departure from *Step Change* as the report's baseline.

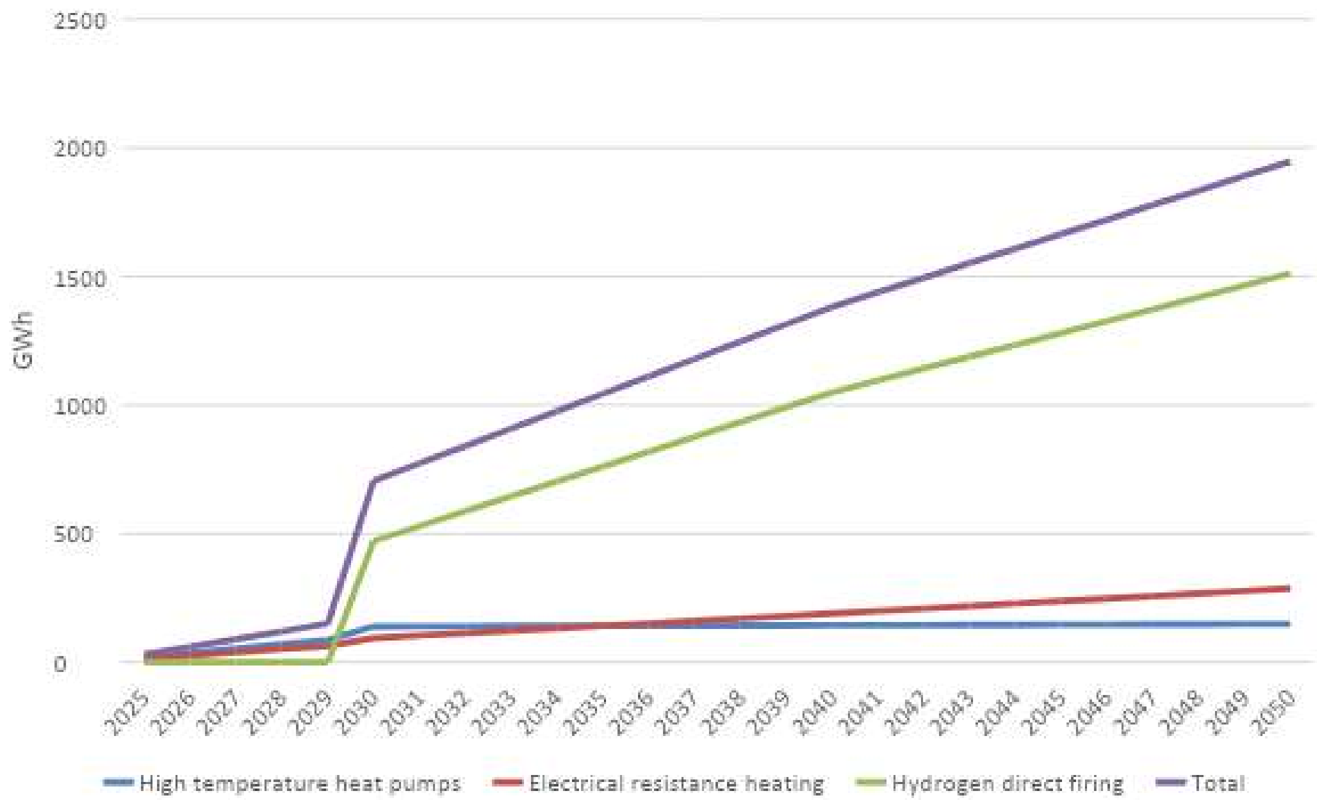

Figure 3: Additional Electrical Consumption in Target Scenario, due to Electrification of Gas Use

Current Industrial Coal Use

The total energy content of coal burned for process heat in Tasmania in 2022-23 was 8,000 TJ (8 PJ, equivalent to ~2,222GWh) according to AES data, of which ~2,600 TJ was used in low temperature processes such as steam production, while ~5,400 TJ was used in high-temperature applications including lime calcination and as a reductant in metallurgical facilities (Aluminium, ferro-manganese and iron ore pellets).

Only a handful of firms burn significant quantities of coal for process heat in Tasmania. Cement Australia's Railton plant consumed approximately ~3,800 TJ of coal-derived energy in 2022-23, while Norske Skog's Boyer mill consumed ~2,600 TJ. The only other firms known to be using coal are using it as a reductant - the Grange Resources' iron pelletising mill, and the Liberty Bell Bay Ferro-manganese smelter both document using coal in small to medium quantities for process heat in their sustainability reporting.[5] Rio Tinto Bell Bay did not report using coal, but their reporting does contain a large 'other emissions' basket which is assumed to contain coal. The emissions resulting from coal consumption for process heat in Tasmania were ~594,000 t-CO_2e in 2022-23.

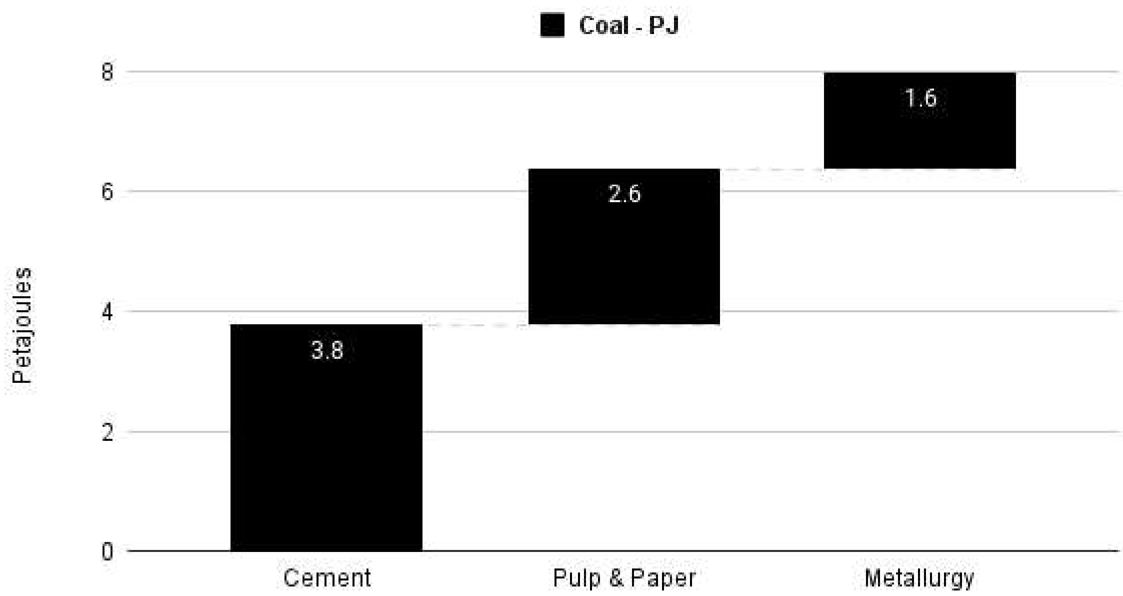

Figure 4: Known Industrial Coal Use, Tasmania, FY2023

[5] These figures are drawn from the annual and sustainability reports of the relevant firms.

Phasing out Industrial Coal Use

Cement Australia, Norske Skog, Grange and Liberty Bell Bay have committed to reduce or eliminate coal use in their processes in coming years and eliminate it by 2050. The carbon zero pathway below reflects these commitments. This is the second notable departure from *Step Change*.

Cement Australia

Cement Australia's Railton plant uses coal to heat limestone to produce lime, a process known as calcination. In addition to emissions resulting from coal combustion, calcination produces significant process emissions.

Calcination requires high-temperature heat, around 1,450°C, which limits economical electrification options. Cement Australia recently announced plans to increase the share of co-fired biomass and waste in its furnaces from 15% to 50%, supported by Commonwealth funding.[6] This move will mean a reduction in coal use from ~3,800 TJ to ~2,200 TJ pa by 2026, and a fall in emissions from 342,000 t-CO_2-e to 198,000 t-CO_2-e, according to company statements.[7]

Though Cement Australia has a corporate target of achieving net-zero by 2050, Carbon Zero Initiative assumes it is likely the firm will stop using coal at its Railton plant earlier than this target suggests.

Cement Australia owns both mines supplying coal to its Railton plant, the Cullenswood and Blackwood mines. As Cement Australia uses less coal in its processes, and as the wider economy decarbonises, the case for investing in these mines to extend production will become increasingly marginal. On this basis, this study factors in a 2040 coal-use end-date for Cement Australia into emission projections.

Norske Skog

Norske Skog currently uses coal to produce steam, which is then used as a heat source at multiple stages throughout the paper manufacturing process. Norske Skog recently announced the Boyer mill would begin importing coal from interstate, as local suppliers could no longer meet the site's requirements.[8]

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[6] **DCCEEW, Investing in Australian Heavy Industry, 2024**
[7] **Emissions savings will only be realised if biomass feedstock is plantation timber waste. Converting native forests to biomass will likely result in increased emissions overall.**
[8] **EPA Tasmania, Norske Skog Paper Mills Australia Ltd., 2022**

Norske Skog have signalled a desire to switch from using coal in their boilers to electricity in coming years.

At present, the major impediment to this move appears to be a lack of available generation.[9, 10] Depending on when this switch occurs, Carbon Zero Initiative expects Norske Skog's coal consumption to decline from ~2,600 TJ to ~0 TJ between 2024 and 2030. In 2022 Norske Skog was funded to produce a feasibility study on their proposed boiler replacement.[11,]

As this study is not complete, it is unclear what technology, or combination of technologies, the firm will use to replace its coal boiler. Given the relatively low temperatures required to produce steam, the most likely replacement would be a high-temperature heat-pump or electrical resistance boiler, or a combination of both.

Grange Resources

In 2023 Grange Resources used ~200 TJ of coal in the Port Latta iron pelletisation plant. Grange Resources have announced plans to replace this coal consumption entirely with fossil gas in the next two years, supported by Commonwealth funding.[12] Carbon Zero Initiative's calculations assume Grange Resources' coal consumption reaches ~0 TJ by FY2025.

Target coal use

Based on announced commitments, Carbon Zero Initiative expects annual coal consumption for process heat to decline to ~2,200 TJ in 2030, and to ~0 TJ by 2040. In this scenario emissions will fall to ~198,000 t-CO_2-e during the period 2030-40, a 67% reduction, and then to ~0 t-CO_2-e in 2040 – see Figure 5.

Because the bulk of coal consumption will be replaced by biomass or fossil gas, the additional electricity required to meet the heat needs of current coal users is only ~832 TJ, or 231 GWh, from 2030 onwards (assuming a coal boiler efficiency of 80% and a COP of 2.5 for a replacement boiler employing a high-temperature heat-pump).

[9] House of Assembly, Hansard, 2023
[10] ARN Media Limited, Boyer Electricity Claims, 2023
[11] DSRI, Norske Skog Boyer Plant Mill Feasibility Study, 2022
[12] DCCEEW, Investing in Low Emissions Industry, 2024

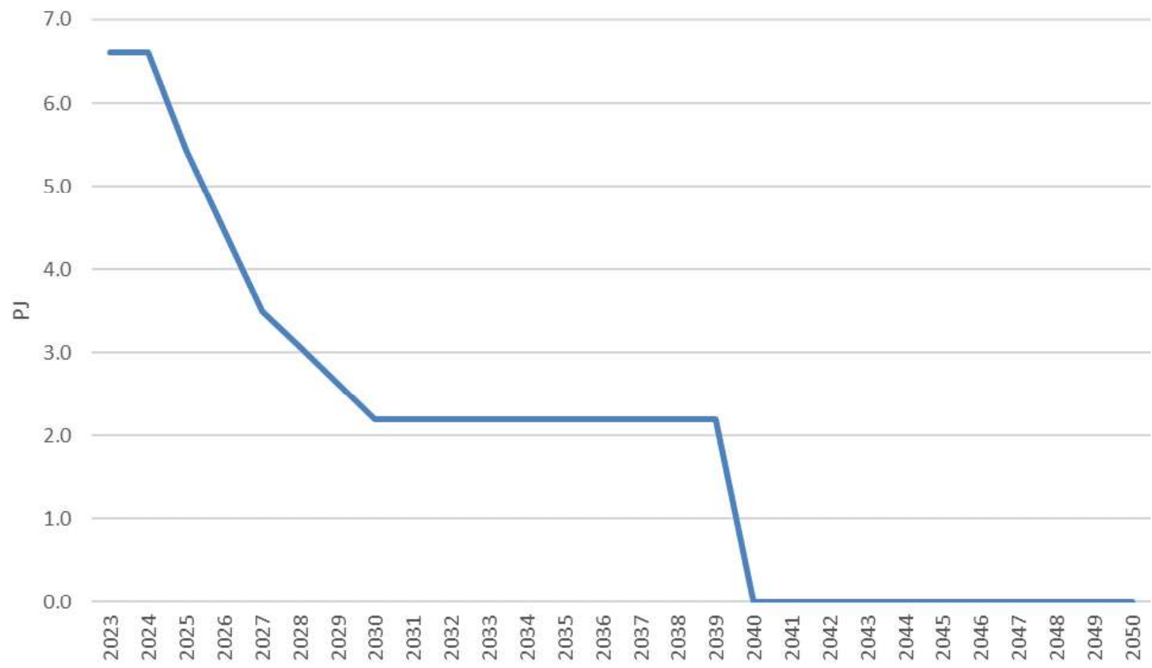

Figure 5: Coal Phase Out, Carbon Zero Tasmania

Industrial Processes and Product Use

Whilst not the focus of this report, industrial processes and product use (IPPU) emissions are a major contributor to Tasmania's total emissions and are immediately adjacent to the energy emissions for process heat discussed above.

To demonstrate the significance of these emissions, in 2022 industrial process emissions from the three largest emitters totalled ~892,000 t-CO_2e (11% of Tasmania's total emissions). Process emissions are difficult to reduce. They are often a result of altering materials' chemistry, such as with the example of Cement Australia above (p. 19), resulting in process emissions. Some of Tasmania's major industrial facilities are further advanced than others in addressing their process emissions challenges.

Case study: Bell Bay Aluminium

Aluminium smelting currently requires carbon-based anodes to remove oxygen from alumina, creating significant CO_2-e emissions in the process. Bell Bay Aluminium currently produces ~251,000 t-CO_2e in process emissions alone. Bell Bay's owners, Rio Tinto Aluminium, have set a 2050 net-zero target, including process emissions. To meet this target Rio Tinto have developed the ELYSIS technology, which uses a non-sacrificial anode, eliminating CO_2-e emissions in the smelting process.[13] A smelter fitted with the ELYSIS technology and supplied with renewable energy will produce aluminium metal with emissions 80%-100% less than the current global average. No timeline has been set for the global roll-out of this technology, which has not yet been applied at a commercial scale.

Current Transport Sector

Transport accounts for roughly half of Tasmania's energy related emissions. Of the total transport figure, road transport represents over 93%.[14]

The emission intensity of the Tasmanian vehicle fleet has fallen by roughly 25% since 2003, though intensity has remained static since 2017. This flatlining intensity has corresponded with a sharp rise in the sales of larger SUVs in recent years, and a corresponding decline in the share of smaller passenger vehicles.

Other factors influencing the earlier observed improvement in intensity, and recent lack thereof, include a shift to smaller engines and fuel switching from petrol to diesel – both trends which have largely run their course.

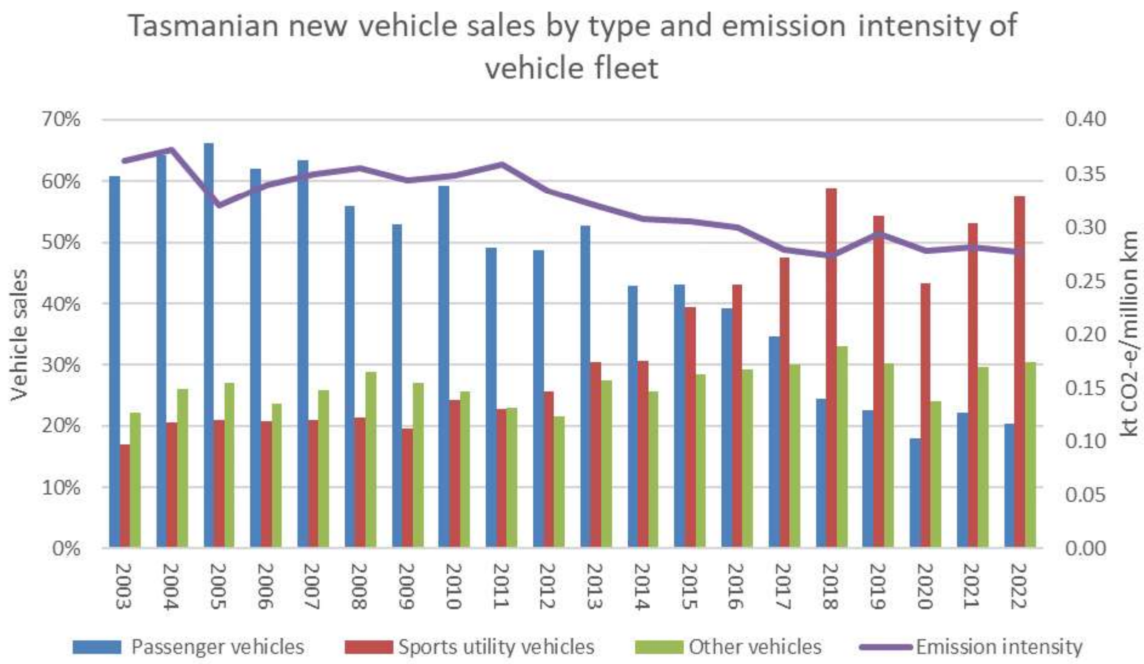

Figure 6: Vehicle Sales and Emission Intensity

Alongside emission intensity, the other factor influencing total road transport emissions is annual vehicle kilometres travelled. As might be expected, total vehicle kilometres travelled is strongly correlated with population.

[13] ELYSIS, What is ELYSIS, 2024
[14] DCCEEW, Australia's National Greenhouse Accounts, 2024

Using the ABS' medium series population projections to forecast future total kilometres travelled suggests the figure will increase from ~6,000 million kilometres at present to ~7,000 million kilometres by the mid-2030 and stay flat to the end of the forecast period.

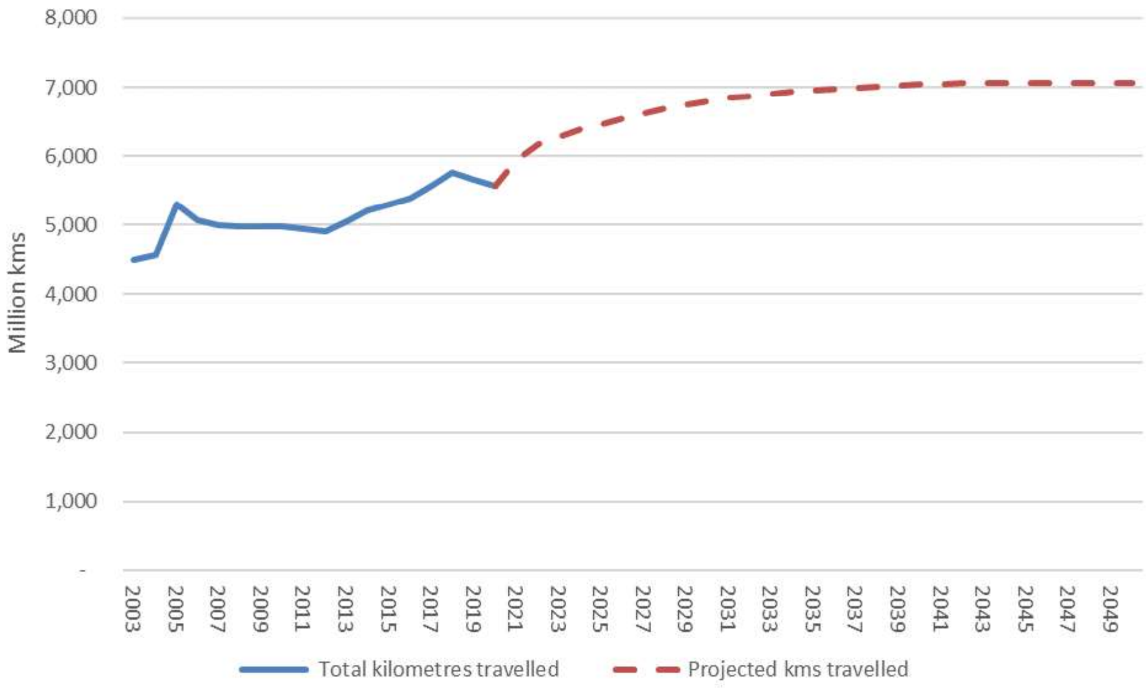

Figure 7: Annual vehicle kilometres, Tasmania

Neither AEMO's Step Change or Green Energy Exports scenarios deliver a 50% emissions reduction by 2030 – Step Change delivers a 5% reduction to 1,648,000 t-CO_2e, while Green Energy Exports achieves an 8% reduction to 1,612,000 t-CO_2e. Both scenarios achieve near zero-emissions by 2050, with Green Energy Exports reaching near-zero by 2045.

Phasing Out Oil for Transport

AEMO's Step Change and Green Energy Exports 2024 scenarios both imply rapid rates of electrification of the Tasmanian road transport task. This translates into a rapid reduction in transport-related greenhouse gas emissions – indeed, so rapid that it would likely require substantial policy intervention to realise, as discussed further below. The scale of required interventions can be seen in Figure 8, in which 26,000 to 36,000 internal combustion engine (ICE) vehicles need to be removed from Tasmania's vehicle fleet every year for 15+ years. More urgently, these reductions need to begin in 2025.

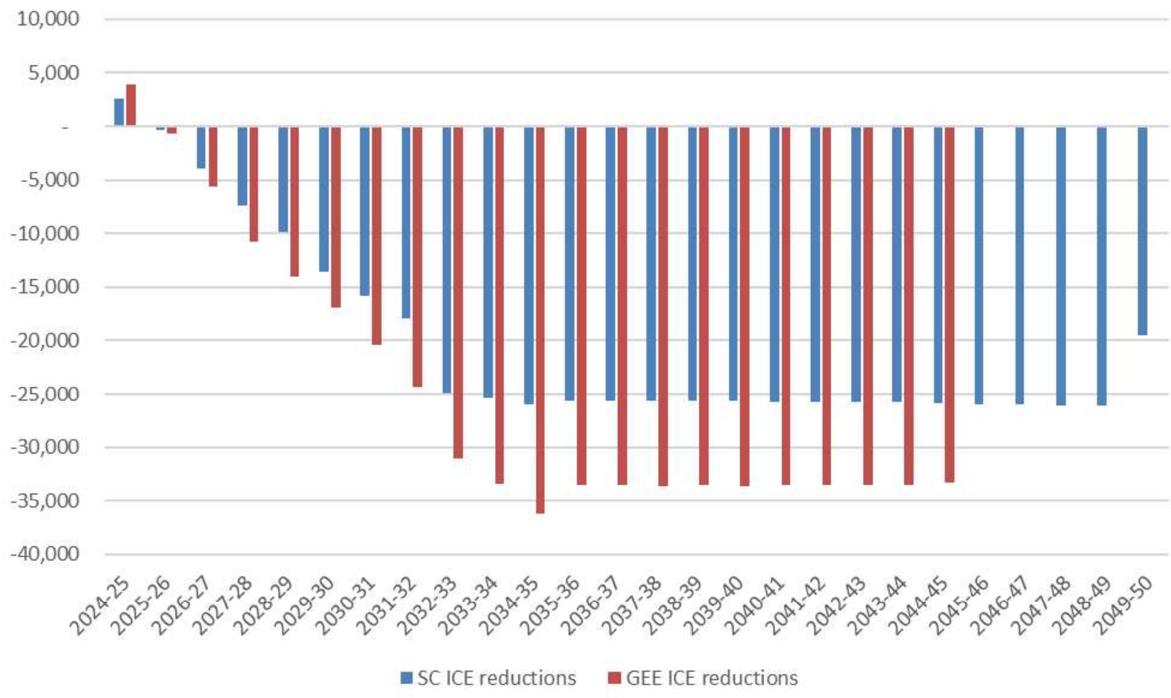

Figure 8: Change in Internal Combustion Engine (ICE) Vehicle Numbers, Tasmania, Step Change & Green Energy Exports Internal Combustion Engine Modelled Reductions.

The unique structure of the transport sector, with many small emitters investing in new vehicles infrequently and for complex reasons, mean emission savings take a long time to eventuate.

Though electric vehicle sales are growing rapidly, from a very low base, there is significant carbon lock-in in the existing vehicle fleet. For example, though the number of electric vehicles registered in Tasmania more than doubled in 2023, from 1,612 to 3,262, this is still less than 0.5% of the total vehicle fleet of 711,704 as of January 2024.[15] The last Australian Bureau of Statistics (ABS) motor vehicle census in 2021 found Tasmania had the oldest average vehicle fleet, at 13.3 years, compared with 10.6 years nationally.[16] Tasmania also has lower per-capita new vehicle sales than other jurisdictions, likely as a result of lower incomes and fewer large fleet purchasers.[17]

[15] DSG, Registration & Licensing Statistics, 2024
[16] ABS, Motor Vehicle Census, 2021
[17] ABS, New Vehicle Sales, 2021

The combined impact of these factors is that there will be a significant lag between the arrival of electric vehicles on the consumer market and meaningful emission reductions. This effect can be seen in Figure 9, in which AEMO assumes the number of zero-emission vehicles does not exceed the number of fossil fuel vehicles until 2038.[18]

Further highlighting the challenges posed by decarbonising Tasmania's transport fleet, AEMO's models anticipate annual electric vehicle additions rising to over 26,000 by 2032 in Step Change, and 34,000 in Green Energy Exports. Average annual new vehicle sales averaged under 19,000 over the past decade and, adjusting for population, are unlikely to significantly exceed 22,000 in coming decades. Adjusting AEMO's calculations to account for Tasmanian vehicle sales pushes back the crossover point at which zero-emission vehicles outnumber fossil fuel vehicles to 2041.

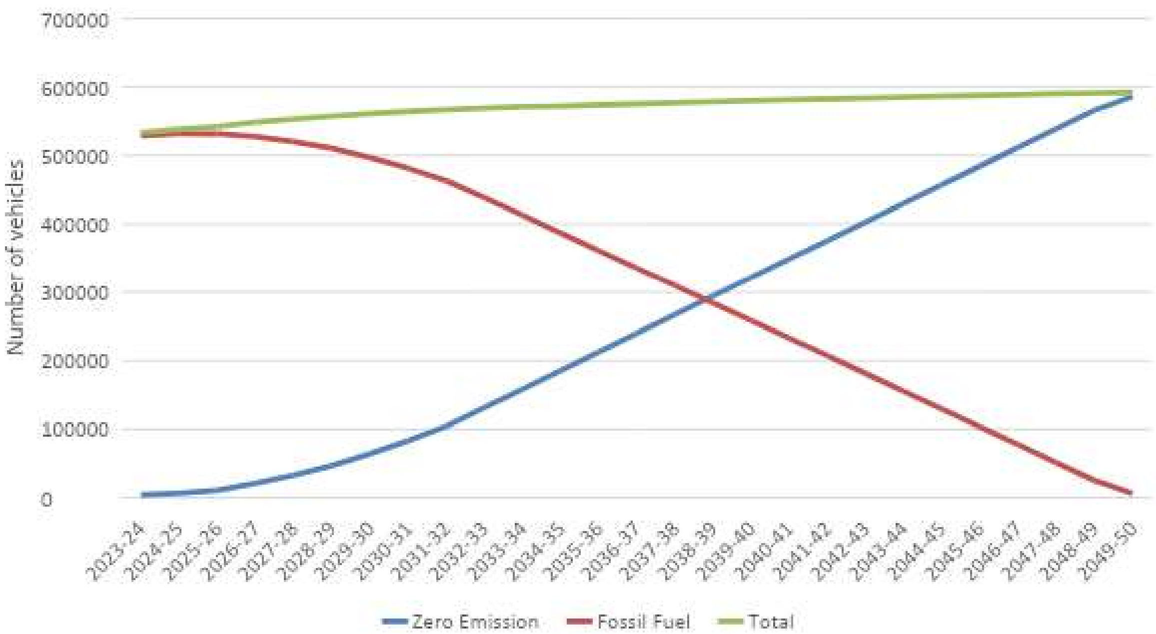

Figure 9: Change in Vehicle Fleet Over Time: AEMO Step Change

This dynamic highlights the need for ambitious policy earlier in the 2025-50 period, as emissions resulting from delays in the uptake of zero-emission vehicles will have a long tail. A new fossil fuel vehicle purchased in 2024 will, on average, still be emitting CO_2 in 2037. On the other hand, abatement arising from zero-emission vehicle uptake will have both an immediate and ongoing impact on transport emissions.

[18] **Note: AEMO's total vehicle numbers are lower than those provided by the Department of State Growth. Employing The Department's numbers in this analysis would exacerbate the challenges outlined above.**

In addition to encouraging the uptake of zero emission vehicles, policies to reduce total vehicle kilometres travelled will have an immediate impact on transport emissions. Examples of these complementary measures include improving public and active transport provision, increasing housing density, or shifting freight to rail.

Electrification in the Carbon Zero Tasmania scenario

Under Step Change over 1,800 GWh of electricity consumption in FY2050, or over 11% of total consumption, will be due to electrification of gas use and liquid fuels in the transport sector. However, neither Step Change nor Green Energy Exports are consistent with reaching zero greenhouse gas emissions in Tasmania, or indeed elsewhere in Australia. There are numerous emissions-reducing options in the energy sector, from energy efficiency improvement across the economy, to some forms of demand response or demand side participation.

We note that AEMO already assumes that significant contributions are made by energy efficiency improvement, and by demand-side participation to a lesser degree. Without diminishing these options, two additional strategies stand out in the Tasmanian context for their effectiveness and (current or future) cost-effectiveness - electrification and industrial decarbonisation using green hydrogen. We discuss these in detail and in sequence below.

Electrification may have an incremental investment cost, but in some cases – such as residential space heating – there may be capital cost discounts associated with electrification, in addition to significant operational energy cost and emissions savings.

Methodologically, we take the approach of estimating the expected extent of electrification in Tasmania over the period to FY2050, taking into account the specific local circumstances and developments noted above, and then deducting from this the amount of electrification already expected by AEMO, to avoid any double-counting.

We then review the supply-side options that are most likely to meet this additional electrical demand, while at the same time enabling zero greenhouse gas emissions in Tasmania's energy sector. To do this, we estimate the likely end-use of gas and coal by sector, in order to understand the likely electrification opportunities and the relative efficiency of the electrical technologies as compared to the fossil fuel ones they replace.

For example, gas furnaces or boilers may be able to achieve heat rates, or conversion energy efficiencies, averaging 80% at the device itself, but much lower when heat distribution systems and losses are taken into account. By contrast, electrical heat pumps may offer heat rates or peak conversion efficiencies of up to 400%, depending upon the size and nature of the application.

Some of this useful heat may be lost in distribution systems such as ducting. Overall, however, the very large difference in efficiency is what enables electrification to be cost-effective, in addition to being a rapid and easy pathway to zero emissions. For this study, we make conservative assumptions about relative fossil fuel and electrical efficiencies, as we are describing sector-wide averages (by end-use), and there will be variation in the relative efficiencies of electrification within each sector – see Table 1. In some cases, for example, direct resistance forms of electricity use may replace fossil fuel use, with a much smaller difference in relative efficiencies.

Table 1: Electrification Energy Efficiency Assumptions by Sector and End-Use

Sector	Fossil Fuel to be Replaced	Fossil Fuel End-use	Replace with	Average Fossil Fuel Efficiencies	Average Electrical Efficiencies
Residential	Gas	Space Heating	Electricity	0.85	2.50
Residential	Gas	Hot Water	Electricity	0.85	2.50
Residential	Gas	Cooking/other	Electricity	0.85	1.00
Commercial	Gas	Space Heating	Electricity	0.85	2.50
Commercial	Gas	Hot Water	Electricity	0.85	2.50
Commercial	Gas	Cooking/other	Electricity	0.85	1.00
Industry	Gas	Steam raising	Electricity	0.90	2.50
Industry	Gas	Direct firing/other	Electricity	0.75	1.00
Industry	Gas	Direct firing/other	Hydrogen	0.75	0.42
Industry	Coal	Steam raising	Electricity	0.80	2.50

Electrification Summary

The electrification pathways assumed for the Carbon Zero Tasmania scenario are that industrial coal use is expected to cease by around 2040 due to market forces, as discussed previously.

Industrial and large commercial gas use is modelled to be phased out by FY2050, although – consistent with AEMO assumptions – this may not occur purely due to market forces and may require targeted policy interventions.

The pathways modelled include electrification but also fuel switching to hydrogen. Residential and smaller commercial gas use – which is forecast to increase in Tasmania under *Step Change* conditions, albeit from a low base – is modelled to be phased out over 15 years.

This is expected to require two key interventions: first, phasing out new gas connections, and second, enabling electrification at time of replacement of gas-using equipment over a 15-year period.

The nature of the policy interventions required to achieve this outcome is not within the scope of this report, but we do note that changing relative fuel prices and consumer preferences are likely to achieve some but not all of the required change.

The viability of continuing to operate a gas network in the context of declining demand has to be considered, and therefore it should not be assumed that gas will necessarily remain available to the market in this context.

In transport, AEMO's Step Change scenario already assumes that there is complete electrification of the transport task in Tasmania by FY2050, therefore we do not model any additional electrification task. As a result, we do assume that diesel and petrol use tapers to zero by 2050.

As discussed above, we consider that this result is far from certain to occur as a result of market forces alone, and that significant and early policy interventions would be required to bring this outcome about.

We summarise the above in the following figures. Figure 10 shows the pathways for fossil fuel phase out in Tasmania, drawing on the above assumptions, whilst Figure 12 shows the replacement electricity required in the modelled scenario.

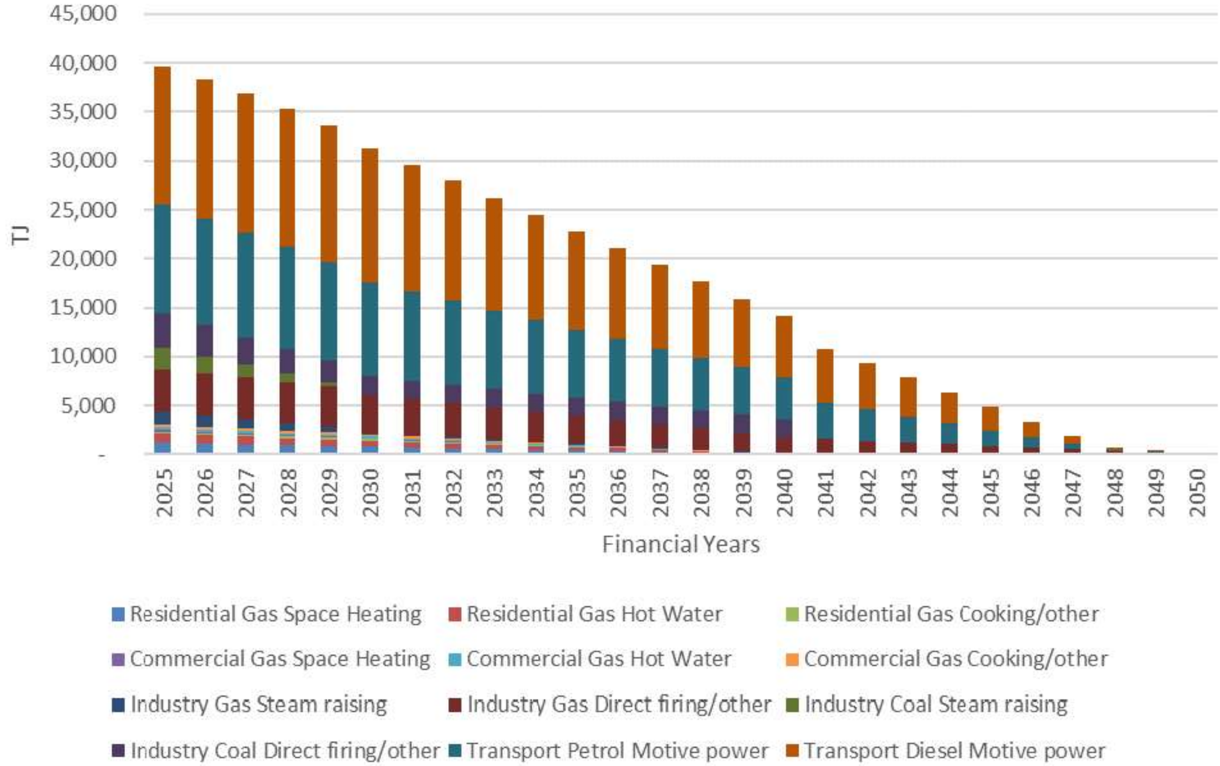

Figure 10: Fossil Fuel (Stationary) Energy Use Requiring Electrification (or other substitution) by Sector, Fuel and End-Use, Tasmania, Carbon Zero Tasmania scenario

If the Figure 10 pathways are met, and given underlying energy demand (by sector and end use) in Tasmania, Figure 10 shows the fossil fuel energy use that would be electrified, or else switched to other clean fuels (such as biomass for coal, gas to green hydrogen). Note this figure does not include transport fuels, as these are already assumed to be electrified in Step Change.

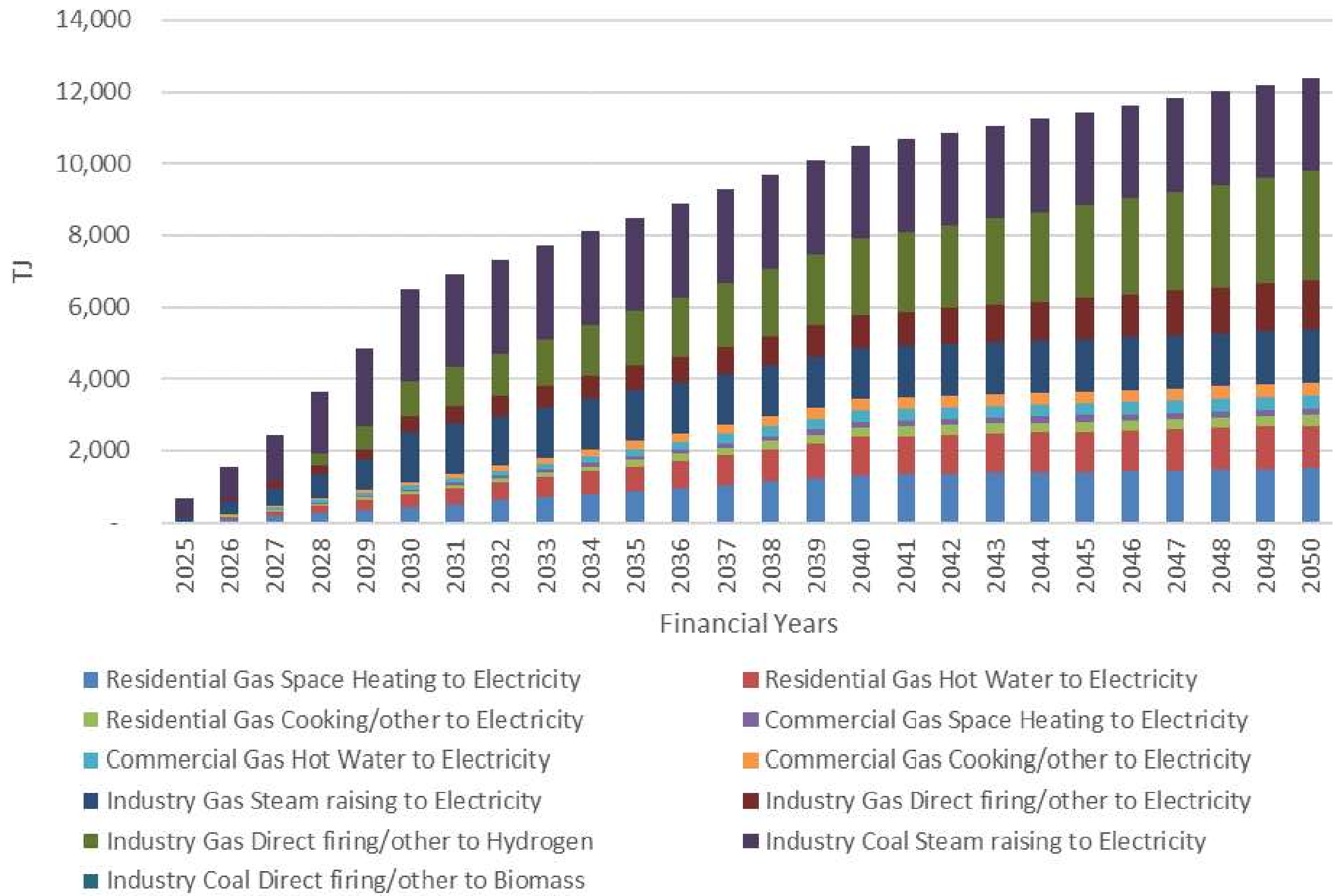

Figure 11 Fossil Fuel (Stationary) Energy Use Requiring Electrification (or other substitution) by Sector, Fuel and End-Use, Tasmania, Carbon Zero Tasmania Scenario

Applying the relative energy efficiencies of conversion noted in Table 2 to the data in Figure 11 results in the consumption of clean energy – specifically to replace the fossil fuel consumption noted above – as shown in Figure 12.

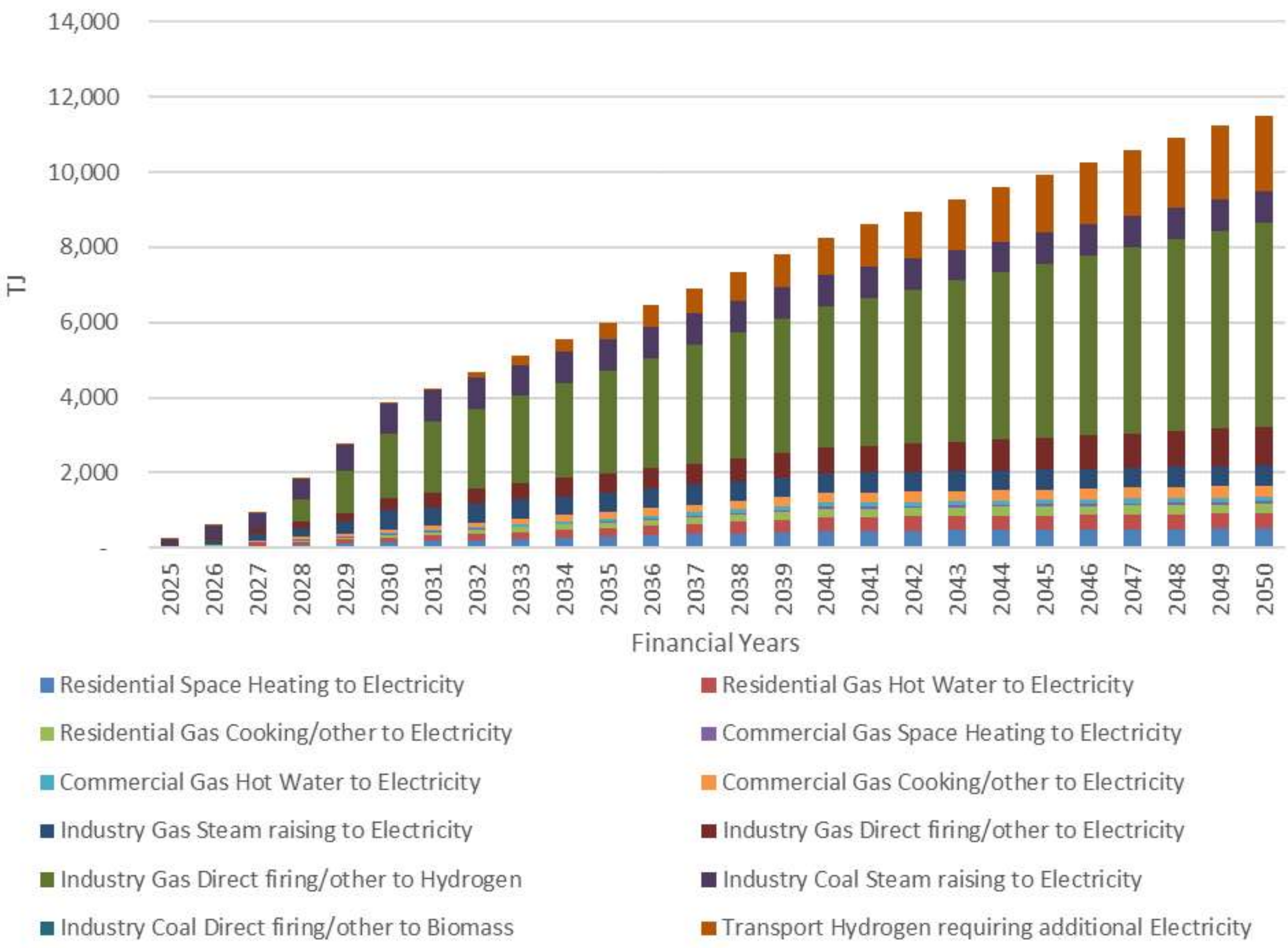

Figure 12: Consumption of Clean Energy to Replace Fossil Fuels, by Sector, Fuel and End-Use, Tasmania, Carbon Zero Tasmania Scenario

Green Hydrogen

This report identifies green hydrogen as an important abatement pathway to enable fuel switching out of fossil fuels such as coal or gas.

Hydrogen demand is expected to grow significantly in Tasmania, as discussed below, and may account for over 23% of all electricity consumption in Tasmania by FY2050.

This figure is largely based on the *Step Change* hydrogen scenario, adjusted to reflect modest additional export, and increased industrial decarbonisation based on the signalled plans of large emitters.

There is still significant uncertainty about the role hydrogen will play in local and global decarbonisation efforts.

While hydrogen will almost certainly play a major part in decarbonising key sectors of the economy, such as steel production, chemical synthesis, and long-haul shipping and aviation, the role it will play in decarbonising the broader global energy system is not yet clear.

Green Energy Exports, an alternate ISP pathway, assumes very large volumes of hydrogen are produced in Tasmania for export – between 1,600 and 2,000 kt/pa by 2050, depending on electrolyser efficiency.

These figures represent roughly two and a half to three times more than Australia's total current hydrogen demand (including fossil fuel derived hydrogen).

This level of production would require over 12 GW of Tasmanian electrolyser capacity, with almost 1 GW required by 2028, roughly the global installed total in 2023.[19]

The Tasmanian Government is currently developing a market offer to establish a hydrogen facility of several hundred Megawatts at Bell Bay, supported by $70m of Commonwealth funding.

Given challenging market conditions, as highlighted recently by the International Energy Agency, delivering this project by 2028 would be a major success.[20]

[19] **IEA, Global Hydrogen Review, 2023**

[20] **IEA, Renewables, 2023**

Substantial sums are being invested around the world to improve electrolyser efficiency and bring down capital costs, with the United States Department of Energy targeting a production cost of $1 USD/kg by 2031.[21] (AUD 1.50)

If this target is met, the volumes of hydrogen production set out in AEMO's Green Energy Exports scenario, though still ambitious, become more credible.

In contrast with Green Energy Exports, AEMO's Step Change scenario implies a much smaller role for Tasmanian hydrogen exports, between 38 and 47 kt/pa by 2050.

Step Change also assumes a slightly larger role for hydrogen in Tasmanian's domestic decarbonisation, reaching between 30 and 37 kt/pa by 2050.

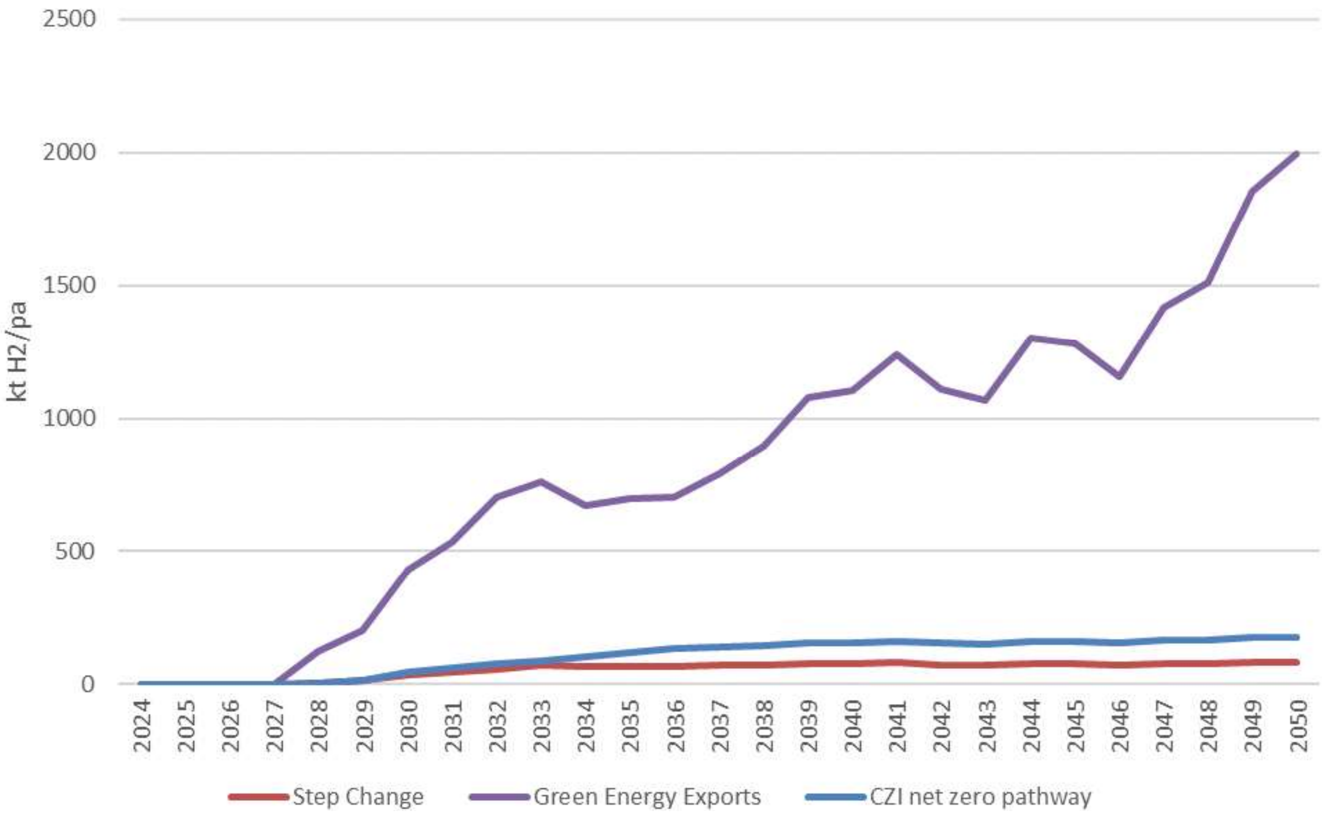

Figure 26: Hydrogen production by scenario. Calculations assume electrolyser efficiency of 54 kWh/kg in 2024 and 44 kWh/kg in 2050

[21] US Dpt of Energy, Hydrogen Shot, 2022

Absent clear signs of a global boom in export hydrogen, it seems prudent to assume lower export volumes than those envisaged in Green Energy Exports.

On this basis, Carbon Zero Initiative's net zero pathway errs on the side of caution and uses Step Change as its starting point.

Carbon Zero Initiative's net zero pathway builds on the Step Change scenario by assuming an additional large export facility comes online in 2035 and that hydrogen plays a larger role in decarbonising high-temperature industrial processes.

This first assumption acknowledges the role hydrogen, and hydrogen derivatives, will play in decarbonising international transport, such as maritime shipping and long-haul aviation, and the opportunity for Tasmania to be a competitive supplier of these products in our region.

This second assumption is based on our analysis of the decarbonisation plans of Tasmania's major industrials.

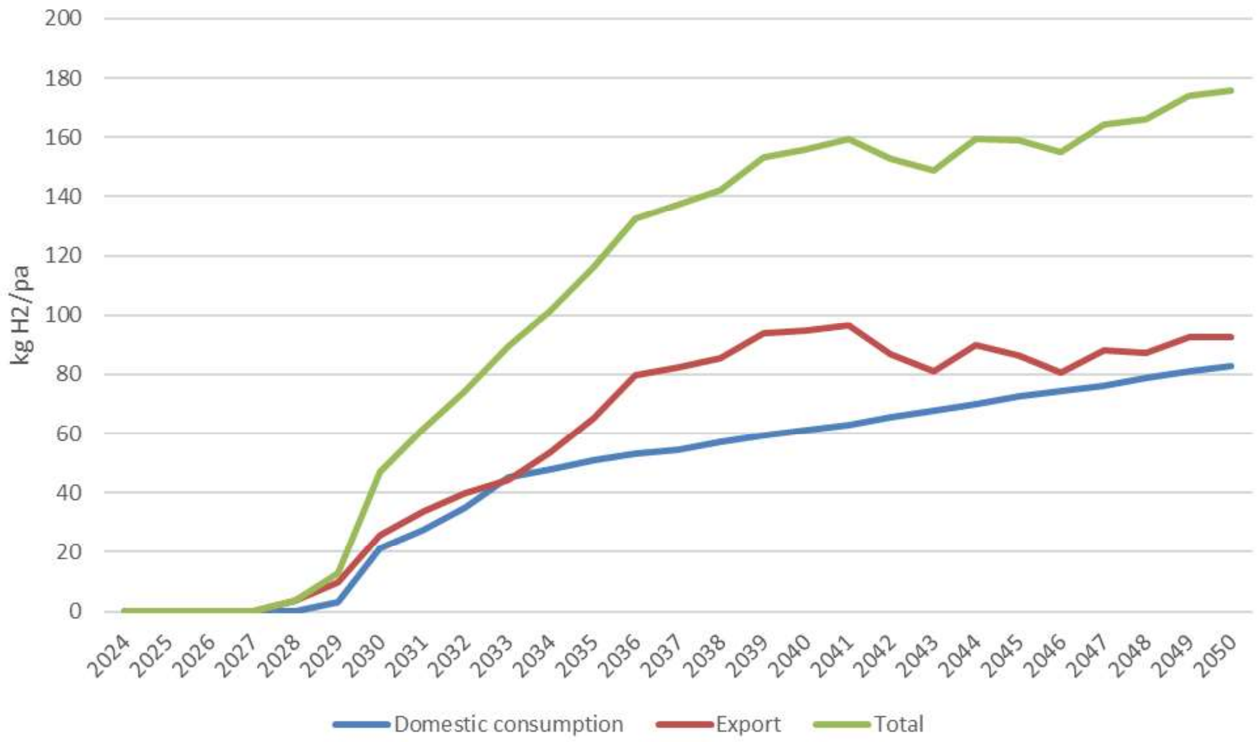

Figure 13: Zero Emissions Pathway Hydrogen Production

Electricity Demand and Supply

The third key abatement strategy is additional investment in renewable electricity generation, including to ensure that the emission intensity of electricity consumption in Tasmania is not simply low, but zero, despite both electrification and green hydrogen demand, domestic and export.

To project electricity consumption in the Carbon Zero Tasmania scenario, we apply the analyses above on electrification and green hydrogen, as summarised in Figure 13. However, as noted, we also need to avoid double-counting AEMO electrification assumptions. Therefore, we deduct those AEMO assumptions from the (electricity) values shown in Figure 13, in order to revise the overall Step Change electricity forecast for Tasmania. The resulting forecast is shown in Figure 14.

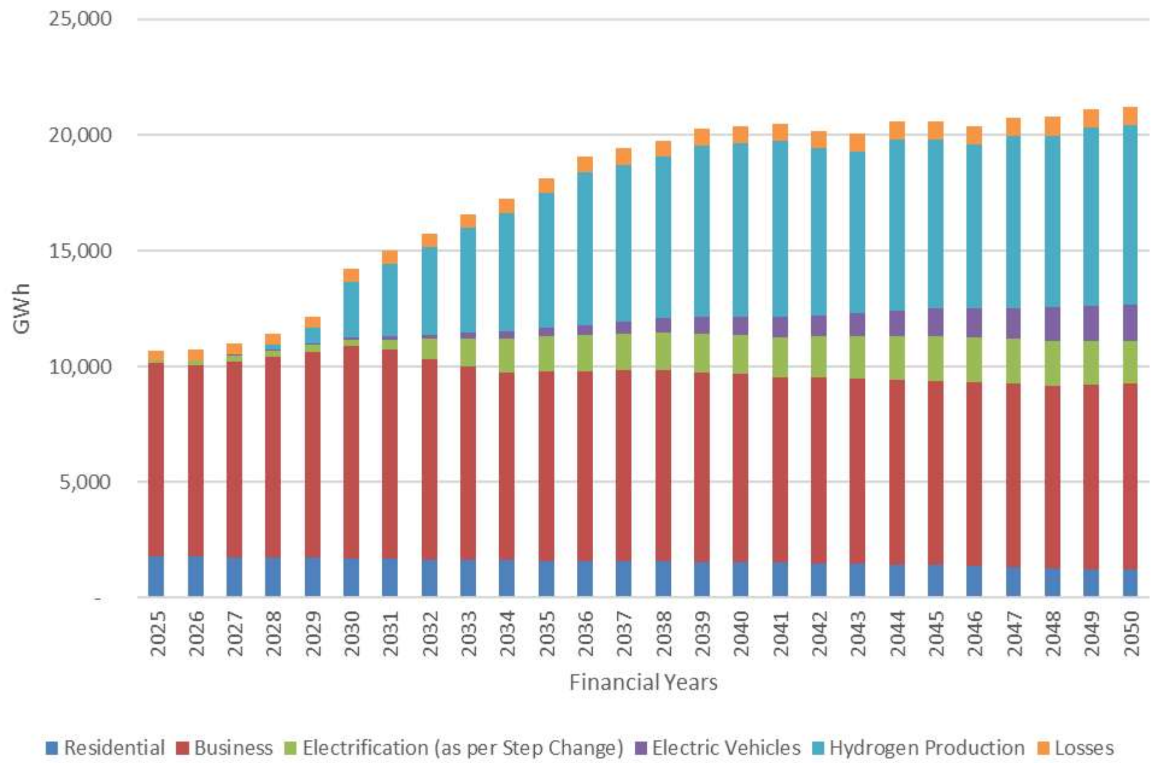

Figure 14: Electricity Consumption Forecast (Operational, sent to to the grid) by Sector, Carbon Zero Tasmania scenario

If we compare this forecast with the equivalent Step Change forecast (see Figure 2, Carbon Zero Initiative's study of the ISP), the totals are significantly higher, albeit nowhere near as high as under Green Energy Exports.[22]

Overall on-island electricity consumption (operational/sent-out) would be 21,207 GWh in 2050 compared to 10,709 GWh in 2024, or just over 5,000 GWh, higher in 2050 than would be the case under Step Change.

The main increase is for hydrogen production, where just over 4,000 additional GWh would be consumed in 2050 relative to Step Change. The total electricity consumption for hydrogen production would be just over 7,700 GWh in FY2050, compared to 3,700 GWh in Step Change, or more than double.

Residential consumption would also be higher (+249 GWh, or 26.4%), as would business consumption (+572 GWh, or 7.6%), due to additional electrification in both sectors, while losses would also increase (by 166 GWh, or 26%) due to the overall increase in network consumption.

The electrification values shown in Figure 14 are the original values in Step Change, with the additional electrification for this zero-emissions scenario being distributed across the relevant economic sectors, as noted above.

Electric vehicle consumption does not change in this scenario, relative to Step Change, as the latter already includes full electrification of the vehicle fleet by FY2050.[23]

As with all the projections in this report, there is some uncertainty in the final overall composition of the future energy mix.

Underlying demand could also increase in the Carbon Zero Tasmania scenario, relative to Step Change. For example if energy efficiency were improved (as would be likely), or if there were more investment in rooftop PV (also likely) or in small non-scheduled generation, this would change.

The quantity of rooftop PV generated and consumed would have consequences for the quantity of additional utility-scale generation. However, given that Step Change assumes significant growth in rooftop PV, we have not changed these assumptions.

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[22] Note that since we have changed back to electricity consumption forecasts, the metrics have changed back to GWh, as used by AEMO.

[23] AEMO also assumes that some vehicle fossil fuel consumption switches to hydrogen rather than to electricity. However, given recent market developments, this now appears less likely. If there is fuel switching to hydrogen in the transport sector, the share of overall domestic hydrogen demand attributable to this sector would be very small, and readily covered by the production volumes modelled in the Carbon Zero Tasmania scenario.

Interconnector Capacity

The default outlook for interconnector capacity under Step Change is Basslink with Marinus 1 & 2 described as 'actionable' but not assumed to proceed for the purposes of forecasting capacity demand. For the Carbon Zero Tasmania scenario, we assume that both Marinus 1 and 2 proceed, as this would be consistent with long-standing government policy in favour of seeking to maximise economic advantage for the state by exporting clean energy of all types and firming to the extent possible. The report separates out forecast electricity generation for interconnectors in the section immediately below.

Net Electricity Exports

Figure 15 shows the net exports that we model in the Carbon Zero Tasmania scenario, given the supply and demand balance implied. The net export line is the modelled surplus of generation over domestic consumption (operational, sent-out) each year.

This figure also shows the transfer limit that would apply if exports (or, for that matter, imports) were soft capped at 75% of the annual capacity of the installed interconnector. The three steps shown correspond to Basslink, Marinus 1 and Marinus 2 respectively.

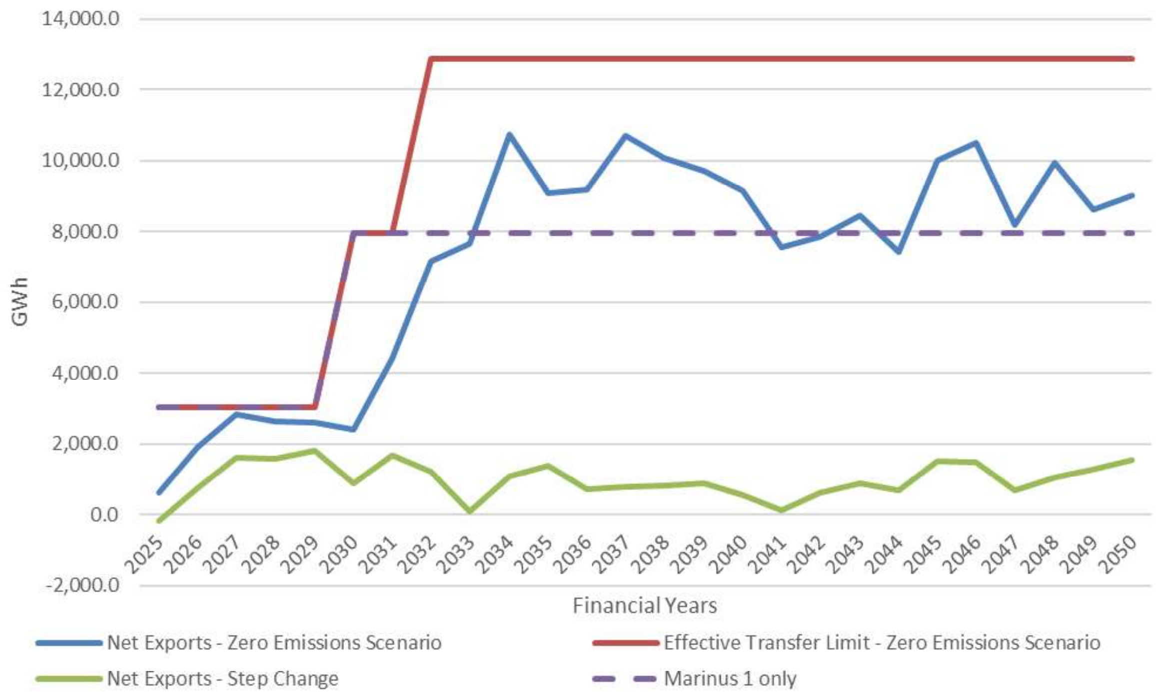


Figure 15: Net Electricity Exports, Carbon Zero Tasmania Scenario

As noted above, this level of net electricity exports – which is very high compared to past volumes – is not essential but is assumed to fit with Tasmanian government aspirations.

Given these assumptions, Carbon Zero Initiative estimates that Basslink and Marinus 1 would export an additional 7,963 GWh of electricity compared to figure 14, whilst Basslink, Marinus 1 and 2 would export up to 12,890 GWh of electricity. In order to meet this additional demand, an additional 1,500 - 3,000 MW of generation capacity is necessary for Marinus 1 and Basslink, or Basslink, and Marinus 1 and 2.

If less interconnector capacity were installed, or less generation capacity, than assumed above, then lower net exports (or even net imports) should be expected. To illustrate this, the net exports implied by AEMO's Step Change scenario are also shown on Figure 15.

Generation Mix and Capacity

Table 1: Installed Cost of Generation Assumptions

Generation Type	Installed Cost of Capacity ($million/MW)
Solar	$1.53
Onshore wind	$2.95
Conventional hydro	$5.50
Pumped storage (24 hrs)	$5.75
Pumped storage (48 hrs)	$6.75
Wind - offshore (fixed)	$5.32
Wind - offshore (floating)	$7.36

Table 1 is derived from Aurecon Gencost 2023-2024. Costs are still falling for clean energy technologies including solar and batteries as these technologies are rapidly scaled up. Other costs such as labour and finance can be volatile and vary by project. Nevertheless Table 1 represents a robust cost estimate for the fully installed cost of capacity as of the date of publication (Q4 2024). Installed capacity in the Carbon Zero Tasmania scenario is based on AEMO's 2024 Step Change including the capacity factors from 2023 Inputs, Assumptions and Scenarios[24], but modified to cover the following conditions:

1. Dispatchable capacity does not fall below that expected in Step Change, for system security reasons.
2. Sufficient generation is installed to cover both domestic demand including hydrogen and electrification.
3. Zero greenhouse gas emissions (on-island – that is, where electricity is imported from Victoria, those imports may be associated with greenhouse gas emissions).

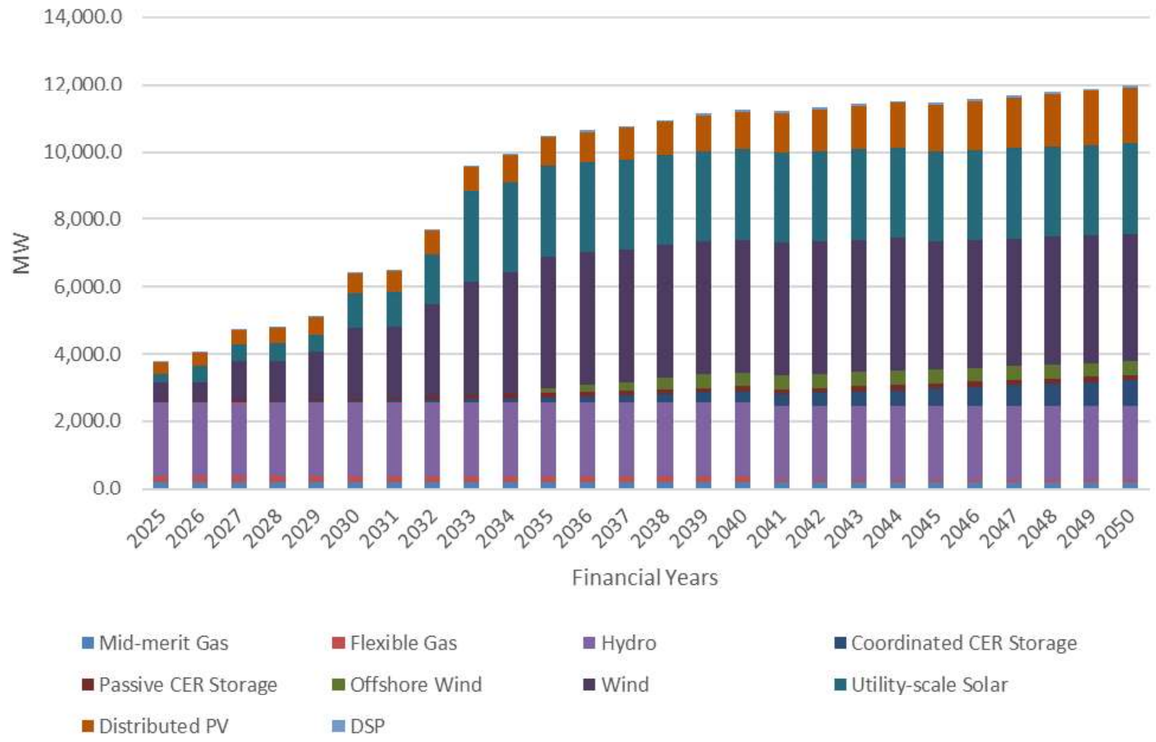


Figure 16: Installed Capacity, Carbon Zero Tasmania scenario, Tasmania

Figure 16 indicates that, in total, and as framed above, the Carbon Zero Tasmania scenario would require almost 12,000 MW of installed generation capacity in

[24] **AEMO, IASR Assumptions Workbook, 2023. Note, capacity factors for wind 41- 52%, and 19-22% for Solar PV.**

Tasmania in FY2050. This includes 266 MW of gas capacity that is assumed never to run (but which could be retained for energy security purposes).

This would be a significant increase over the approximately 3,509 MW of capacity installed today (noting this includes Demand Side Participation (DSP), rooftop solar, and storage).

Capacity would be some 52% higher in FY2050 when compared to Step Change, but less than one third (31.3%) of the capacity required under Green Energy Exports in the same year.

The Tasmanian Government' target is to double generation to 21,000 GWh per year by 2040. The Carbon Zero Tasmania scenario exceeds this, modelling 29,500 GWh in FY2040 (a 275% increase). This is met with an increase in installed capacity of 300%. It models significant increases in onshore wind capacity, which would reach 3,790 MW by FY2050, and in utility-scale solar capacity rising to 2,685 MW by FY2050, on the basis that these represent the least-cost generation choices.

However, as noted previously, the exact mix of renewable generation technologies may be left to the market to determine – the emissions outcomes will be the same, and dispatchable capacity is unchanged in this scenario. Given the different installed costs for the different generation technologies – as summarised in Table 1 earlier – there may, of course, be different economic outcomes, depending upon the final mix.

The report has not modelled new pumped hydro capacity because the methodology selects generation by least cost. However pumped hydro may be built to provide system strength; for example firming for the increased industrial scale load.

Finally Carbon Zero Initiative has estimated the following generation capacity values are needed to align with the modelled 75% annual average net exports over Marinus 1 and 2.

Approximately 1,500-2,000 MW of generation capacity is utilised by Basslink and Marinus 1 and up to 3,000 MW for Basslink, Marinus 1 and 2. As with all the values in this report, these numbers are annual average approximations, with significant uncertainty introduced by hydro output and long term changes in rainfall.

Annual Increments in Generation Capacity

The potential annual increments to generation capacity in Tasmania in the Carbon Zero Tasmania scenario are shown in Figure 17.

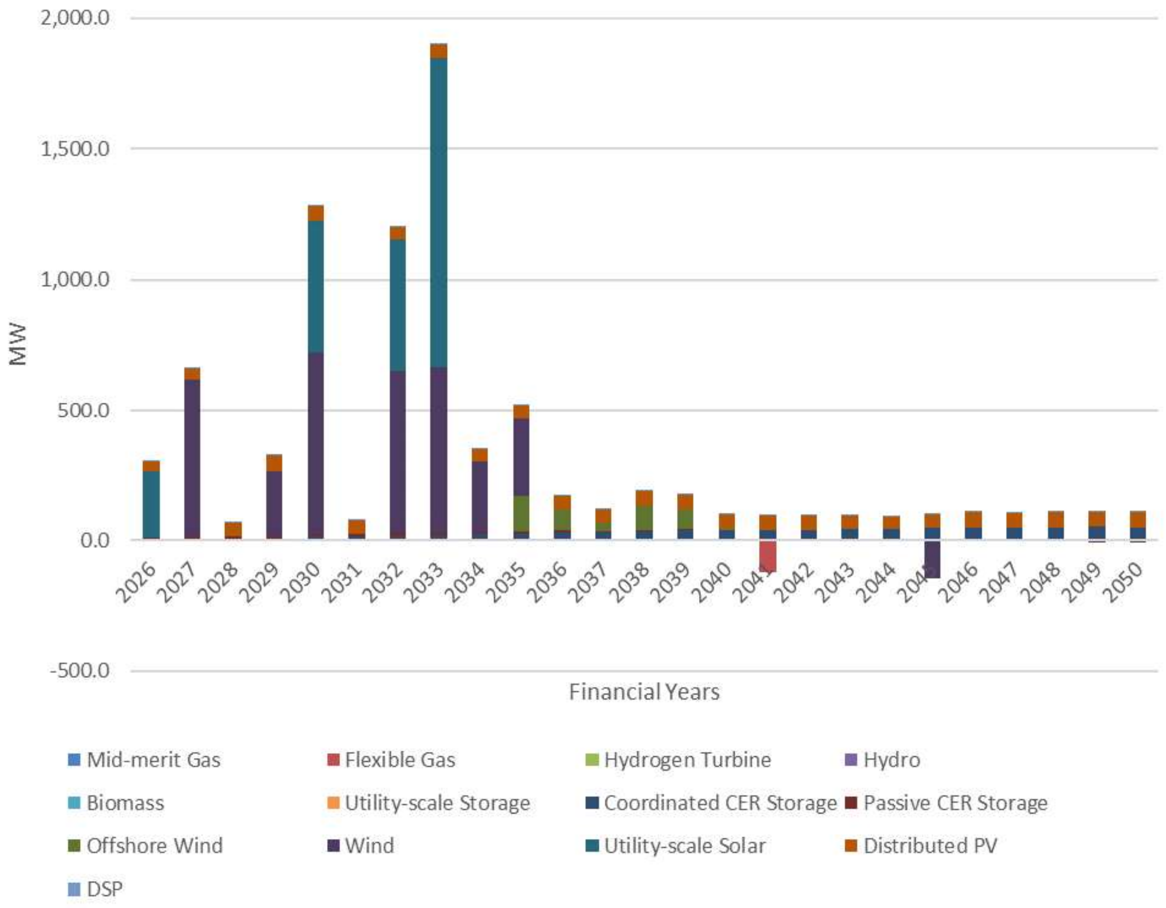


Figure 17: Annual Increments to Generation Capacity, CZT

As noted, this is based on a least cost mix of new generation – comprising primarily onshore wind and utility scale solar – reflecting an assumption of a relative cost advantage in wind generation for Tasmania compared to other NEM regions, along with the installed cost assumptions derived from Aurecon, as per Table 1.

Utility scale solar already has a significant cost advantage over wind, but Tasmania has better wind resources, relative to other NEM regions, than it does solar resources, and this would somewhat diminish the cost advantage of solar. However, we note that other zero emissions options may eventually be selected by the market, without detriment to the realisation of the zero emissions target.

Generally, Figure 17 maps new capacity investment, but there is also expected retirement of flexible gas and wind capacity shown. The net increase is just over 8,200 MW, but it is distributed over the period, albeit with a peak around the early 2030s. This is associated with an increase in hydrogen demand, but also the assumption that Marinus 1 and 2 become available during this period and support significant increases in net electricity exports.

Investment in New Capacity

We estimate the investment costs associated with the above pathway for new capacity – and also for Marinus 1 and 2 interconnectors – drawing on data from AEMO's Draft ISP for 2024 and 2023 Inputs, Assumptions and Scenarios Report Workbook (for Marinus), and inputs to the ISP process from Aurecon, as per Table 1.

These should be understood as estimates only, and they do not assume particular projects or sites, and therefore do not take into account *specific* site- or project-related costs. The intention is simply to estimate the order of magnitude of investment requirements.

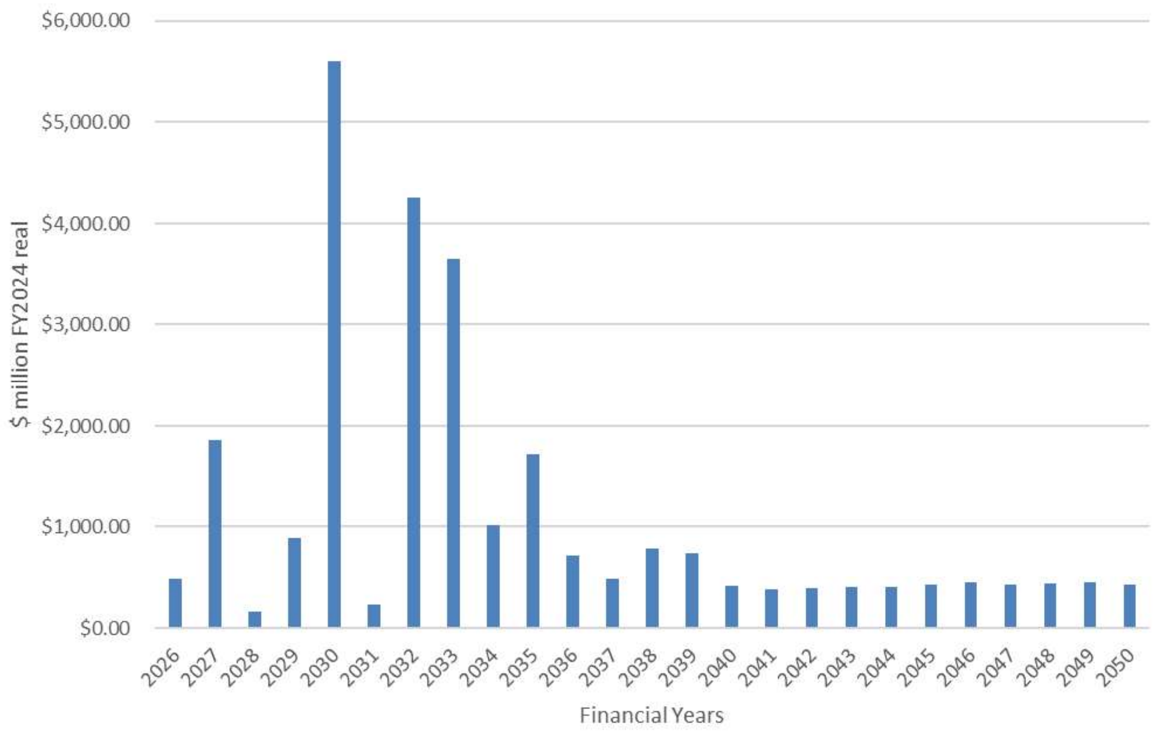


Figure 18: Estimated Investment, Tasmania, Carbon Zero Tasmania Scenario

Noting the above cautions, and also recalling that many other combinations of generation investments could equally occur and still deliver zero emissions outcomes, this particular scenario would require capital investment with a present value (real FY2024 dollars, 7% real discount rate) of $17.1 billion over 25 years, with 66% of that being private investment (see Table 2).

Table 2: Present Values of Capital Investment in Clean Energy Infrastructure, Carbon Zero Tasmania scenario

Capacity / Infrastructure Type	Present Value of Investment Stream to FY2050 @ 7% real discount rate, FY2024 real millions of dollars
Coordinated CER Storage	$2,381
Passive CER Storage	$230
Offshore Wind	$836
Wind	$6,258
Utility-scale Solar	$2,268
Distributed PV	$656
DSP	$76
Marinus Link 1 & 2	$5,910
Sub-Total (electricity)	$17,096
Hydrogen Electrolysers	$508
Total (electricity and hydrogen)	$17,603

When estimating the capital cost of the total hydrogen electrolyser capacity implicit in the Carbon Zero Tasmania scenario – which would reach 1.1 GW by FY2050 – the present value of the capital investment (over the FY2026 – FY2050 period) would be around $17.6 billion.

Employment Outcomes – Carbon Zero Tasmania scenario

Estimation of the full employment creation associated with $17.1 billion of investment requires additional analysis and ideally access to a Computable General Equilibrium (CGE) economic model. CGE models use highly detailed input/output tables to describe many rounds of flow-on effects that occur in the wake of an economic change, including major new investments.

Also, factors such as where the capital goods are manufactured, and even how they are transported, would be relevant to the analysis. However, in the absence of a CGE model or project-specific details, we can estimate the direct employment consequences of the Carbon Zero Tasmania scenario. The method involves:

1. Capturing data from the ABS on the number of persons employed (full-time equivalents, or FTEs) for each sector of the Tasmanian economy.
2. Capturing data (from the same source for the same year) on industry gross value added (GVA), in $ millions.
3. Calculating the average employment intensity of economic activity by sector (FTEs per $ million GVA).
4. Calculating a weighted average employment intensity that is relevant to the types of investments envisaged for this scenario (primarily in the electricity (gas and water) sector, but also spilling over into professional services, mining and construction).
5. Calculating the employment associated with the annual investment totals, for which industry GVA is a close proxy.

Appendix 1 presents the data for Tasmania for 2021 (aligned with the last Census year) for points 1 – 3 above, drawing on two ABS publications:

- Australian Bureau of Statistics, Census of Population and Housing 2016 and 2021. Compiled and presented by .id (informed decisions)
- 5,220.0 Australian National Accounts: State Accounts Table 7. Expenditure, Income and Industry Components of Gross State Product, Tasmania, Chain volume measures and current prices.

To estimate the weighted average employment intensity that is relevant to this scenario, we apply the weightings shown in Table 3.

Table 3: Employment Weightings by Sector

Industry sector	Weightings for Clean Energy
Mining	**5%**
Electricity, Gas, Water and Waste Services	**80%**
Construction	**10%**
Professional, Scientific and Technical Services	**5%**
Total	**100%**

Combining these with the data above indicates an average employment intensity of 0.21 persons employed (FTE basis) per $million of GVA.

This implies a first order estimate of 259 direct full-time jobs created per year, on average over the 25 year period, but peaking at 1,478 jobs around 2030, which coincides (in this scenario) with the Marinus 1 project – see Figure 19.

For the purposes of this report we conservatively assume each FTE has an average length of 18 months.

The total number of jobs created can therefore be expressed as 6,475, each lasting on average 18 months, or as 9,712 full-time equivalent job years.

Overall, these are likely to be very conservative estimates, as they do not take into account employment creation in earlier years associated with planning and engineering design studies, geotechnical investigations, etc.

As noted, indirect employment creation in supply chains and services stimulated by the spending of new employees in regional areas are not included in this estimate.

Conclusion

This project set out to quantify the potential amount of clean energy capacity, investment and direct employment creation in Tasmania as the state seeks to phase out fossil fuels and replace them with clean energy completely by 2050.

The Carbon Zero Tasmania scenario outlines the significant transformation in Tasmania's energy sector needed in order to meet future demand. The following key points summarise the expected changes in electricity demand, generation capacity, and fuel usage:

Electricity Demand: Tasmania's electricity consumption is projected to increase from to 21,200 GWh, from a base of 10,710 GWh in 2023, driven by the electrification of residential, commercial, and industrial premises, transportation and green hydrogen production. This forecast includes a significant contribution from rooftop PV, which will offset the decline in residential and business electricity consumption due to energy efficiency improvements.

Generation Capacity: By 2050, the total generation capacity in Tasmania is modelled to reach between 9,000 MW and 12,000 MW up from 3,509 MW in 2024 (a 256% to 341% increase in nameplate capacity). The projected generation mix under the Carbon Zero Tasmania scenario includes:

- 3,226 MW of Onshore Wind
- 2,435 MW of Utility-scale Solar
- 2,200 MW of Hydro-power (No change in capacity)
- 1,323 MW of Rooftop Solar
- 890 MW of Battery Storage, with a majority in coordinated utility-scale projects
- 420 MW of Offshore Wind.

The scenario forecasts a significant reduction in fossil gas consumption. Residential and commercial gas consumption is projected to fall over time, while industrial gas consumption is expected to decline by 2.7% per year, from over 5,200 TJ in FY2024 to zero in 2050. Given existing commitment and the ongoing direction of travel of industrial decarbonisation, Carbon Zero Initiative forecasts that Tasmania's major industrial coal users will replace coal use in all facilities by 2040. However, electrification of residential and commercial gas consumption cannot be assumed to occur without clear direction, and policy support, from governments.

Transport is less of a positive story requiring significant policy intervention beginning immediately if emissions from this sector are to be reduced in line with the AEMO ISP and Carbon Zero Initiative's Carbon Zero Tasmania Scenario. The modelling suggests that between 26,000 to 36,000 ICE vehicles need to be removed from Tasmania's vehicle fleet every year for 15+ years.

Carbon Zero Initiative emphasises here that current new vehicle sales are less than the total new sales required year over year to completely electrify Tasmania's transport fleet. In order to address this, Tasmania needs both a rapid change in consumer behaviour toward purchasing new electric vehicles, and a policy mechanism to speed up the conversion.

Carbon Zero Initiative estimates that Basslink and Marinus 1 would export an additional 7,963 GWh of electricity, whilst Basslink, Marinus 1 and 2 would export up to 12,890 GWh of electricity. In order to meet this additional demand, an additional 2,000 MW of generation capacity is necessary for Marinus 1 - Total of 11,000 MW of on-island generation capacity, and 3,000 MW for Marinus 1 and 2 - total of 12,000MW of on-island generation capacity.

The report concludes by estimating the cost of the new infrastructure including transmission and a 500 MW hydrogen production plant. Carbon Zero Initiative found that the infrastructure investment totalled $17.1 billion over 25 years, with 66% of that private investment.

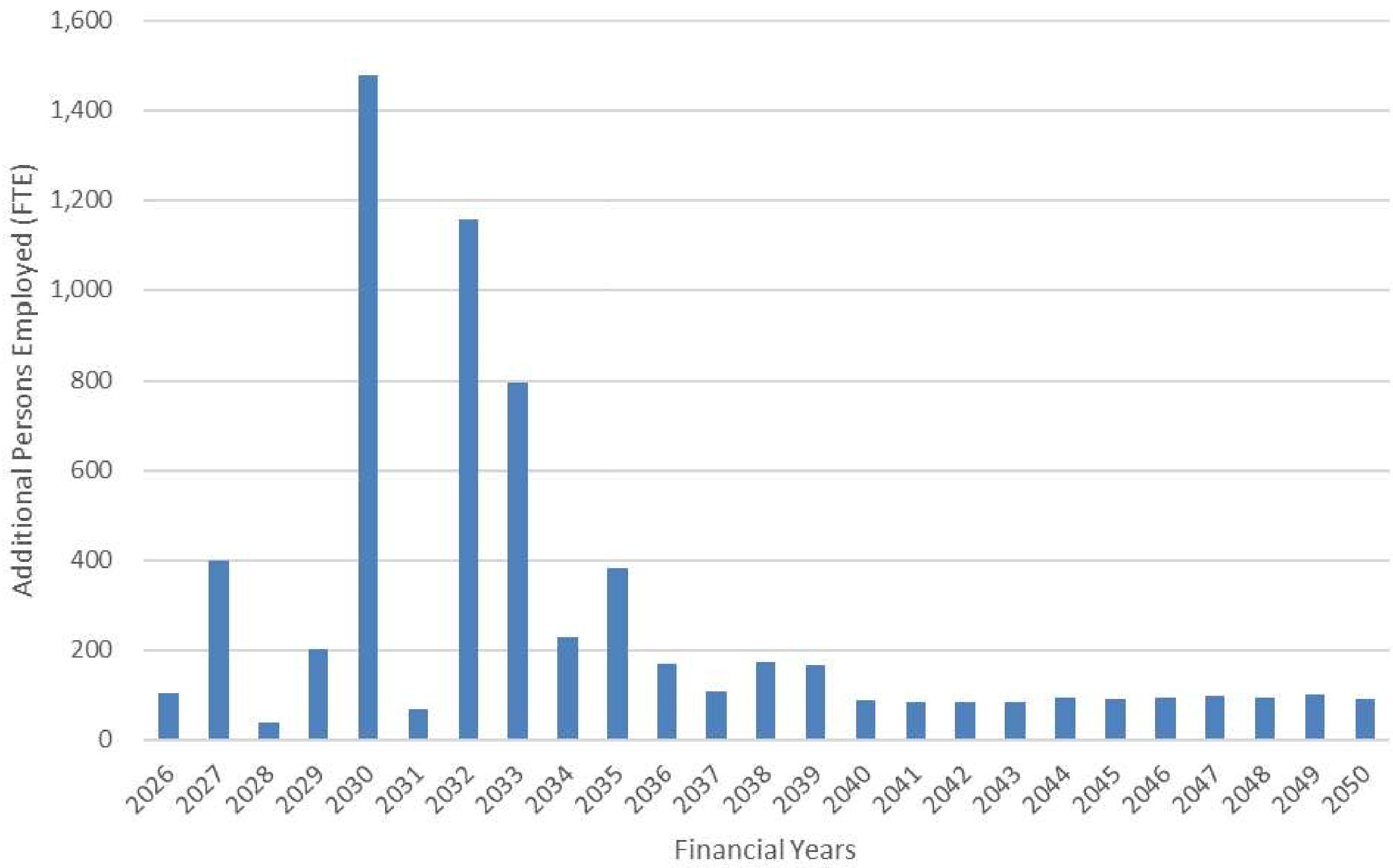
That combined investment was estimated to create 259 direct full-time jobs per year, on average over the 25 year period. The report conservatively assumes each full-time equivalent position has an average length of 18 months (to account for the high percentage of construction roles). The total number of jobs created can therefore be expressed as 6,475, each lasting an average of 18 months, or as 9,712 full-time equivalent job years.

For further information and commentary, see *The Future of Energy in Tasmania* Briefing paper at: https://carbonzero.org.au/energy

Appendix One – Key Employment Intensity Indicators, Tasmania, 2021

Industry sector	Employed Persons (2021)	% by Sector	Industry GVA ($ million) June 2021	% of Industry GVA (June 2021)	Employed persons per $m value added), 2021
Agriculture, Forestry and Fishing	13,422	5.4%	$3,670	12.0%	0.3
Mining	2,653	1.1%	$1,624	5.3%	0.6
Manufacturing	16,202	6.5%	$2,012	6.6%	0.1
Electricity, Gas, Water and Waste Services	4,463	1.8%	$933	3.0%	0.2
Construction	21,821	8.8%	$2,461	8.0%	0.1
Wholesale trade	5,729	2.3%	$935	3.0%	0.2
Retail Trade	24,430	9.9%	$1,636	5.3%	0.1
Accommodation and Food Services	19,461	7.9%	$796	2.6%	0.0
Transport, Postal and Warehousing	10,368	4.2%	$1,285	4.2%	0.1

Information Media and Telecommunications	2,561	1.0%	$965	3.1%	0.4
Financial and Insurance Services	4,751	1.9%	$1,788	5.8%	0.4
Rental, Hiring and Real Estate Services	2,819	1.1%	$582	1.9%	0.2
Professional, Scientific and Technical Services	12,908	5.2%	$1,190	3.9%	0.1
Administrative and Support Services	7,399	3.0%	$644	2.1%	0.1
Public Administration and Safety	18,545	7.5%	$2,352	7.7%	0.1
Education and Training	24,060	9.7%	$2,106	6.9%	0.1
Health Care and Social Assistance	41,724	16.9%	$4,857	15.8%	0.1
Arts and Recreation Services	4,619	1.9%	$308	1.0%	0.1
Other Services	9,641	3.9%	$546	1.8%	0.1
Inadequately described or not stated	7,138				
Total employed persons aged 15+ (excl. not stated)	**247,576**	**100.0%**	**$30,690**	**100.0%**	**0.1**



Appendix 2 – Figure 19: Direct Employment Impact, Carbon Zero Tasmania scenario