Committee for GIPPSLAND

GIPPSLAND HYDROGEN ROADMAP

Gippsland Hydrogen Cluster

ACKNOWLEDGEMENT OF TRADITIONAL OWNERS

The Committee for Gippsland acknowledge the Traditional Custodians of Country and recognise their continuing connection to the land, water, air and sky, culture and community. We pay our respects to their Elders past and present. We acknowledge that the region for the strategy 'A Hydrogen Industry for Gippsland' is on traditional lands, including those lands of the Gunaikurnai, Bunurong, Wurundjeri, and Taungurung nations as well as other Traditional Owner Groups in Victoria who are not formally recognised.

ABOUT THE COMMITTEE FOR GIPPSLAND

The Committee for Gippsland (C4G) offers a positive and influential voice for Gippsland helping to create a thriving and sustainable future for the region.

As Gippsland's lead industry representative voice to government, C4G brings together groups representing an array of business and industry views and interests to collaborate on regional priorities to benefit Gippsland communities.

C4G actively engages across industry and throughout the region. Its membership is diverse and includes emerging and established industries such as energy, agriculture and health, and small to medium businesses as well as organisations that provide support services, education and professional services, to help drive a positive future for Gippsland.

CONTENTS

1. INTRODUCTION

Clean hydrogen is now widely accepted as a crucial fuel in a decarbonised world, and Gippsland has the potential to play an important role in this emerging industry. It has a unique concentration of advantages which should be leveraged to make the region an early, low cost hydrogen producer. Its output should be progressively expanded and diversified into a clean hydrogen industry which supports a net zero economy by mid-century.

However, the clean hydrogen industry is in its infancy, so considerable investment and innovation is needed across the world. The Hydrogen Energy Supply Chain project underlines the importance of hydrogen and the promise of Gippsland. The successful $500 million pilot project, funded mainly by the Japanese Government and private industry, with a combined $100m contribution from the Victorian and Australian Governments. It has led to the award of a Japanese Government A$2.35 billion Green Innovation Fund grant to develop a commercial scale project, which is now subject to detailed studies.

The purpose of this strategy is to attract support from governments, investors, and the community for a large clean hydrogen industry in Gippsland. It outlines Gippsland's strengths and opportunities, and sets out what can be done to unlock the benefits of a flourishing hydrogen industry in the region.

The strategy builds on Gippsland's Clean Energy Future, which was drafted with wide input from across the region, and reflects additional consultation with key stakeholders, and analysis by Nous Group and Melbourne Energy Institute.

Gippsland can make clean or low-carbon hydrogen by two methods: **'blue' hydrogen** can be extracted by lignite through gasification with carbon capture, utilisation and storage (CCUS), while **'green' hydrogen** is made by electrolysing water using renewable electricity. The Committee for Gippsland supports either method provided the carbon intensity of the resultant hydrogen produced is low enough to be compatible with a national target of net zero emissions and meet international emission limits that will be applied to global hydrogen markets. Both should be pursued using complementary strategies that suit their different prospects.

Gippsland's key strengths for a future hydrogen industry include:

- A workforce ready to adapt to a new industry
- Education and training institutions including TAFE and university campuses, with a history of connection to the energy sector
- Community support, with a long history of energy production
- Transport and transmission infrastructure, such as roads, rail, gas pipelines and easements
- The nation's best carbon storage sites in the Gippsland Basin
- Existing lignite resources and infrastructure in the Latrobe Valley
- Gas production infrastructure in the Bass Strait
- Renewable energy resources, including offshore wind, onshore wind, and solar.

Globally, the debate about the merits of the different 'colours' of hydrogen (or more accurately, the sources) is giving way to a focus on the carbon emissions arising from its production. This plan refers to blue and green hydrogen only because their prospects and applications are materially different in Gippsland, not because one is superior to the other. Indeed, the synergies between them should be a longer-term advantage to the region in expanding a clean hydrogen industry that can be established before 2030.

Blue hydrogen extracted from lignite with CCUS is the region's most promising, early, large-scale source, because it would use the region's lowest cost and most abundant stranded resource which is already available. It can replace industrial and agricultural uses of 'grey' hydrogen[1] derivatives (e.g. ammonia and urea); oil and natural gas in heavy and long distance transport, industrial processes, large-scale space and water heating; and natural gas for peak electricity production to back-up variable renewables. Early production of blue hydrogen has been made more attractive by international energy and food security concerns, and high natural gas prices.

In the 2030s, green hydrogen made from wind and solar power is forecast to become commercially viable. However, this pathway will only become prospective in Gippsland once Victoria's power grid approaches full decarbonisation, and a sufficient renewable surplus is available to make commercial quantities of hydrogen. This may not occur until the late 2030s. When it does, the co-located production of blue and green hydrogen may add to Gippsland's competitiveness in the production of vital economic inputs, such as urea, leveraging foundational investments in blue hydrogen infrastructure.

In summary, Gippsland's best early prospect is to produce blue hydrogen using lignite with CCUS. A surplus of lignite production is already available, and the Gippsland Basin is highly prospective for CCUS – more so than any other basin in Australia. There are already two prospective projects – the Exxon Mobil Gippsland Basin Joint Venture Hub, and the CarbonNet Project. Resource-constrained countries are preparing to import hydrogen. Although Gippsland hydrogen producers will face strong competition from renewables in more northerly regions of Australia, blue hydrogen should have an early competitive advantage, and non-energy products such as urea have durable export potential.

Hydrogen's potential is great, but it is an infant industry, which is why governments and businesses world-wide are gearing up to support its growth – by demonstrating new technologies, building demand, attracting investment in supply, and developing public support. State and Federal Governments are encouraged to act early to realise the 'first-mover' potential for Gippsland to host a hydrogen industry. This report identifies priorities for action to build a Gippsland clean hydrogen economy.

As soon as possible, blue hydrogen and CCUS should be commercialised as the core of a chemical industry which produces ammonia, urea and other valuable derivatives. This transformation has already begun with the announcement of Japanese Government support for commercialisation of the HESC project. Crucially, demand for clean hydrogen and derivatives must be stimulated to support investments in supply. Preparations should also begin to take advantage of the longer-term potential to produce commercial quantities of green hydrogen in Gippsland.

2. GIPPSLAND CAN BE CENTRAL TO VICTORIA'S HYDROGEN INDUSTRY

2.1 Hydrogen is crucial to achieving net zero

Australia is committed to net zero carbon emissions by 2050. Renewable energies such as solar power and onshore and offshore wind are already making significant progress towards decarbonising the electricity grid. However, the use of oil and gas as an energy source and chemical feedstock also requires a clean alternative. In 2019-20, oil accounted for 37% of Australia's energy consumption and gas comprised 27%[2]. The current uses of oil and gas include:

- Passenger transport and freight by land, sea and air
- Providing industry with process heat and chemical feedstocks
- Generating 'firming' power to rapidly balance electricity supply and demand
- Space heating of many homes and businesses.

While passenger transport and domestic space heating have good potential to be electrified using battery electric vehicles and heat pumps, other uses are not as easy to electrify. Long-range and heavy transport of people and goods, and industrial heat, appear to be suited to hydrogen and its derivatives. The European Commission says that clean hydrogen will play a key role in achieving the EU's climate goals, estimating that 24% of global energy demand in 2050 could be met from that source.[3]

Clean hydrogen production and use is in its infancy, but analysis suggests that the most prospective applications are fertilisers, steel production, power storage, shipping and aviation. Applications such as space and water heating are less promising, particularly at small scales (see figure on next page).

READINESS AND CONFIDENCE FOR POTENTIAL USES OF HYDROGEN[4]

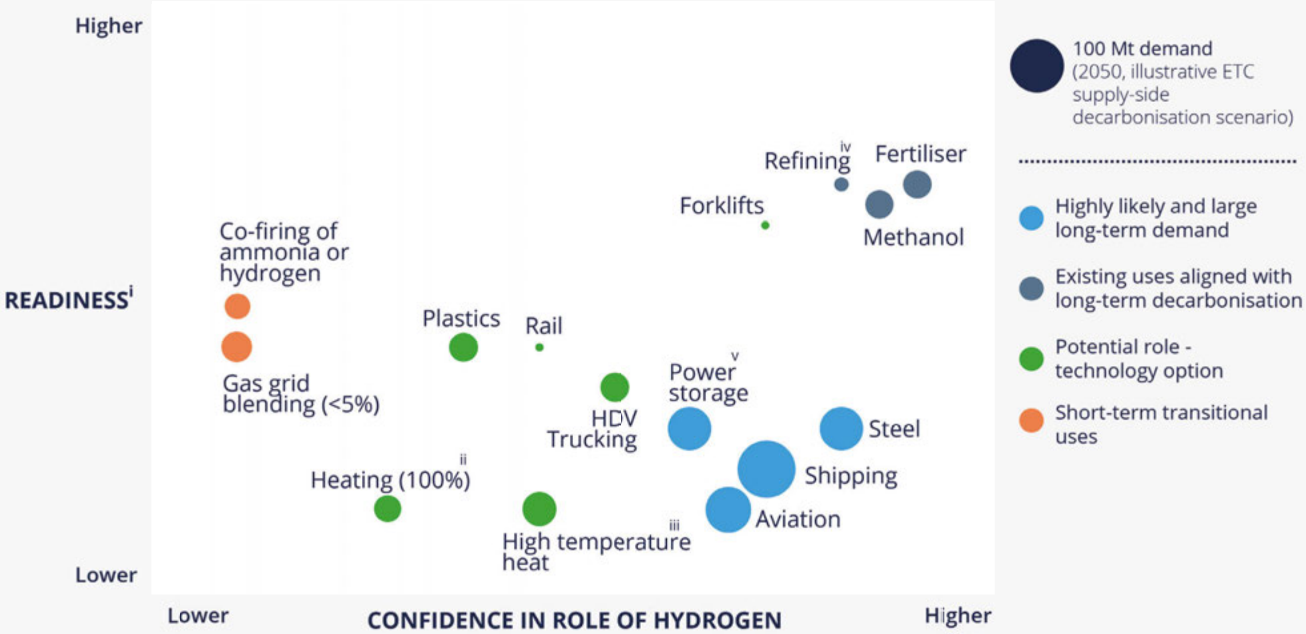


Chart notes:

[i]'Readiness' refers to a combined metric of technical readiness for clean hydrogen use, economic competitiveness and ease of sector to use clean hydrogen. [ii] 'Heating (100%)' refers to building heating with hydrogen boilers via hydrogen distribution grid, [iii] 'High temperature heat' refers to industrial heat processes above ca. 800°C, [iv] Current hydrogen use in refining industry, is higher due to greater oil consumption. [v] Long-term energy storage for the power system.

2.2 Gippsland is in a strong position to make green hydrogen

Hydrogen produced with low emissions is widely accepted as a vital contributor to reaching net zero emissions, in Australia and globally. Gippsland has a combination of crucial advantages that are rarely found in one region.

Gippsland's Clean Energy Future describes the region's potential and plans to become a major producer of clean energy – building on its natural resources (offshore wind, onshore wind and solar, biomass, lignite, gas, water and carbon storage), infrastructure (powerlines, pipelines, ports, road, rail and mines), people (a skilled workforce, supportive community, and leaders in energy companies); proximity (to major energy loads and export facilities); and education, training and research institutions. Many of these resources could be leveraged to establish a hydrogen industry in Gippsland.

RESOURCES FOR MAKING BLUE HYDROGEN

Lignite

Gippsland has world-class lignite[5] resources of around 65 billion tonnes, with up to half considered economically viable.[6] Low mining costs make it a cheap input to hydrogen production. A large enough production surplus to make commercial quantities of blue hydrogen can be made readily available.

Natural Gas

The Gippsland Basin delivers 97 per cent of Victoria's natural gas, though declining supply and reserves are forecast.[7]

Carbon storage

The Gippsland Basin has the largest carbon storage potential of any east coast basin[8]. This is proposed to be developed through the Victorian Government's CarbonNet project and/or the South East Australia carbon capture hub, which ExxonMobil is assessing.

Biomass

Gippsland is home to timber plantations that could provide biomass to blend with lignite in producing blue hydrogen with lower, neutral or negative emissions[9].

Water

The production of blue hydrogen requires process water, some of which could be reallocated from cooling water supplies that were previously used by now-closed power stations – noting that climate change and mine rehabilitation needs may limit that source. Other water may be obtained from additional desalination at the Gippsland coast, and even from lignite itself, which contains a large proportion of entrained water (though further exploration of this potential is needed).

The Hydrogen Energy Supply Chain (HESC) Project

The Hydrogen Energy Supply Chain (HESC) project has been in development for over 10 years. The first stage was the pilot, with an objective to create the world's first liquid hydrogen supply chain. Successfully completed in early 2022, it concluded with the production of 99.999% pure hydrogen, extracted from Latrobe Valley coal, liquefaction at the Port of Hastings, sea transportation and unloading in the Port of Kobe, Japan. The HESC pilot was financially supported by several Japanese companies and the Japanese government through its New Energy and Industrial Technology Organisation (NEDO), an incorporated administrative agency within the Ministry of Economy, Trade and Industry (METI). In addition, the Victorian and Commonwealth governments contributed a combined $100M towards the ~$500M pilot.

Concurrently, the Japanese Government's ¥2 trillion (A$24b) Green Innovation Fund (GIF)[10] was established to provide 10 years of funding support to business-led carbon reduction projects and initiatives, ranging from R&D to implementation.[11] One of the areas of focus for the GIF is the establishment of large-scale liquid hydrogen supply chains[12].

After assessing hydrogen production projects within Australia and internationally, in March 2023 the Japanese Government announced ~A$2.35b in financial support to take the HESC to commercial demonstration scale. A joint venture between J-Power and Sumitomo Corporation will produce about 40,000 tonnes per year of clean hydrogen extracted from Latrobe Valley coal with carbon capture, utilisation and storage under the Bass Strait. About 10,000 tonnes per year will be for domestic consumption and the remaining 30,000 tonnes per year will be delivered to Japan Suiso Energy (JSE) to liquify at the Port of Hastings, transport, and then unload in Kawasaki City in Japan. This is a major milestone in Gippsland's growth as a clean hydrogen hub and a major initiative to reduce global atmospheric CO2 emissions to achieve our net zero targets.

Other prospective proponents

There are a range of other proponents in Gippsland developing technologies or facilities that could be important to Gippsland's hydrogen industry. These include:

- **ExxonMobil,** developing a CCS project for the Gippsland Basin
- **CarbonNet**, a government-owned CCS project for the Gippsland Basin
- **Environmental Clean Technologies (ECT),** offering coal drying and processing technologies suitable for hydrogen production and other applications
- **Australian Carbon Innovation**, a not-for-profit supporting the creation and development of new opportunities in low-emissions carbon-based products, including hydrogen and derivatives
- **Port Anthony**, which has potential as an operational port for offshore clean energy applications including renewable energy supply and CCS.

Technology and project developers are also exploring **advanced coal preparation** and the manufacture of **ammonia and urea**.

INFRASTRUCTURE

Road and rail

The region has established rail and road links to Melbourne, facilitating easy access to ports including Melbourne and Hastings as well as agricultural hubs in central Victoria. This has been explored in the Gippsland Freight Infrastructure Master Plan (GFIMP). The Hydrogen Energy Supply Chain project has already established a liquefaction facility at Hastings. Barry Beach may also have potential as an operational port, for one or both of offshore wind and CCS.

Gas pipelines and easements

Gippsland's network of gas easements and pipelines currently has limited spare capacity during winter peak demand but can be repurposed to transport hydrogen in future. Easements are a key advantage for a Gippsland hydrogen industry even if gas pipelines prove unsuitable.

PEOPLE, PROXIMITY, EDUCATION AND TRAINING

Workforce

There is a highly skilled workforce in Gippsland currently employed in the fossil fuel industry. Unlike other areas, less investment would be required to attract quality workers.[13]

Education and training

Gippsland has a university campus and several training institutes with the capacity to help re-train the local workforce and support research into the production and use of clean hydrogen.

Social licence

The Gippsland community is accustomed to hosting large industries and has a proud history of generating energy.

Established industry

Large energy and resource companies have a presence in Gippsland.

RESOURCES FOR MAKING GREEN HYDROGEN

Wind

Gippsland’s high potential for offshore and onshore wind power makes it a prospective longer-term source of green hydrogen, as a renewable power surplus becomes available. At least 10GW of offshore wind capacity can be accessed in Gippsland.

Solar

Gippsland has a solar resource that is modest (~15.3 MJ/sqm) compared to its wind resources but has attracted investor interest.

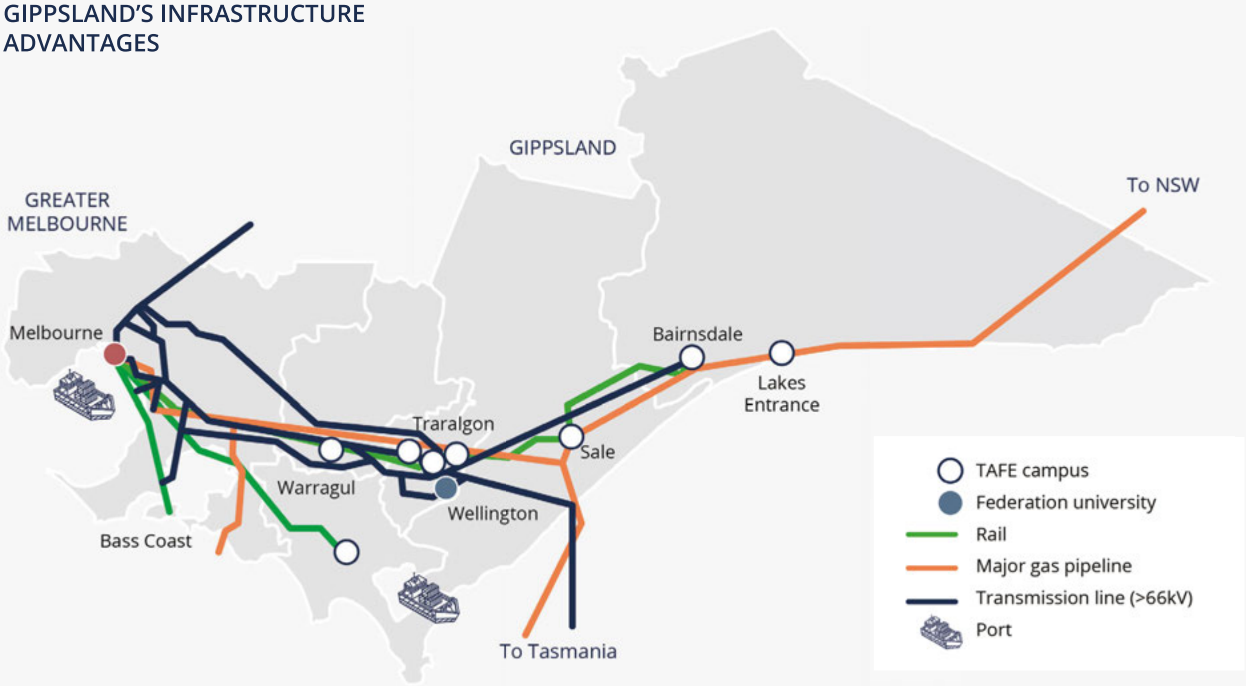
Water

Gippsland has water supplies, some of which could be reallocated from cooling coal-fired power stations as they close, for use in green hydrogen production. However, climate change and use of that water for lignite mine rehabilitation may limit that source. Water can come from a modest increase in renewable power for additional desalination, for example by expanding the Wonthaggi plant.

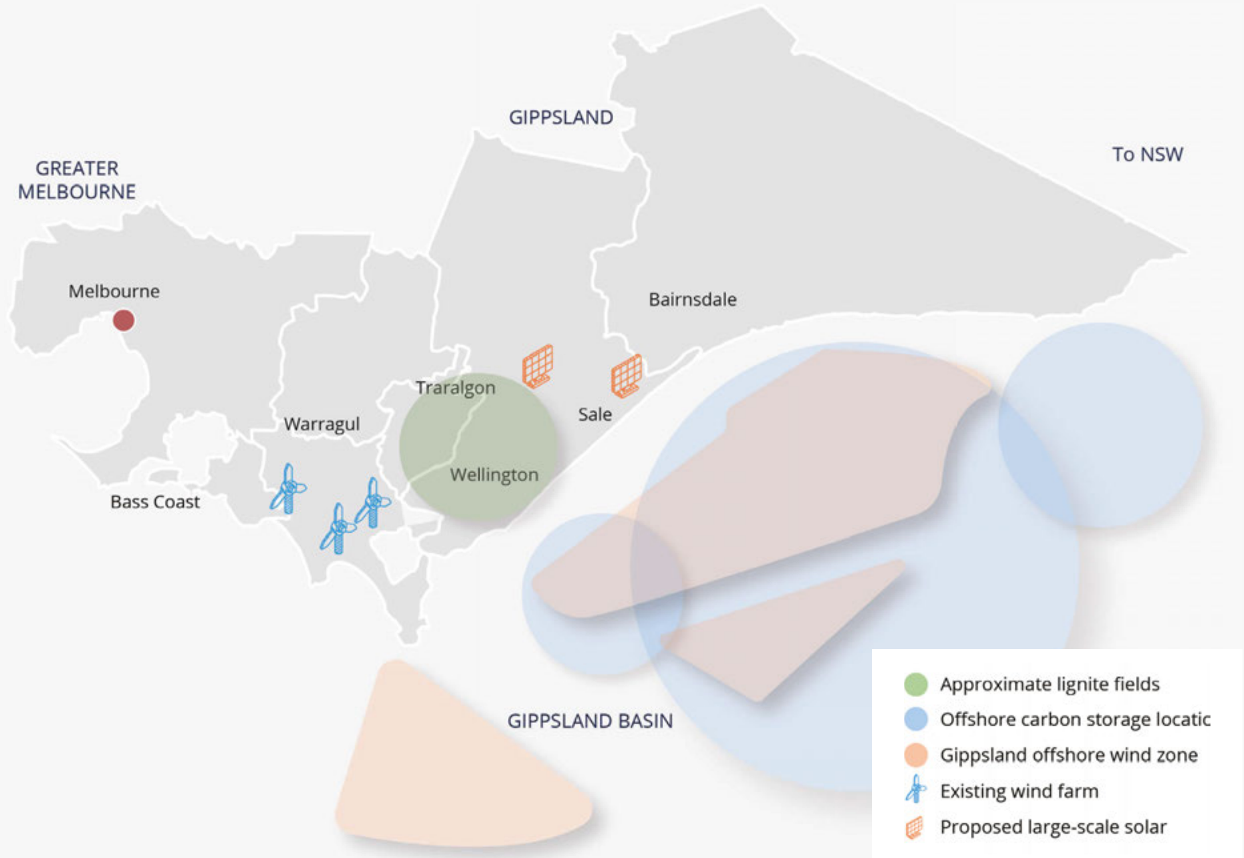
Co-location of these resources is Gippsland's key advantage as a producer of hydrogen.

Key resources are outlined in the two figures below.[14]

GIPPSLAND'S INFRASTRUCTURE ADVANTAGES



GIPPSLAND'S RESOURCE ADVANTAGES



Gippsland's advantages enable the region and State to be an early, clean hydrogen producer using lignite and CCUS. Hydrogen production and use is predicted to expand rapidly, and early action would maximise Gippsland's contribution.

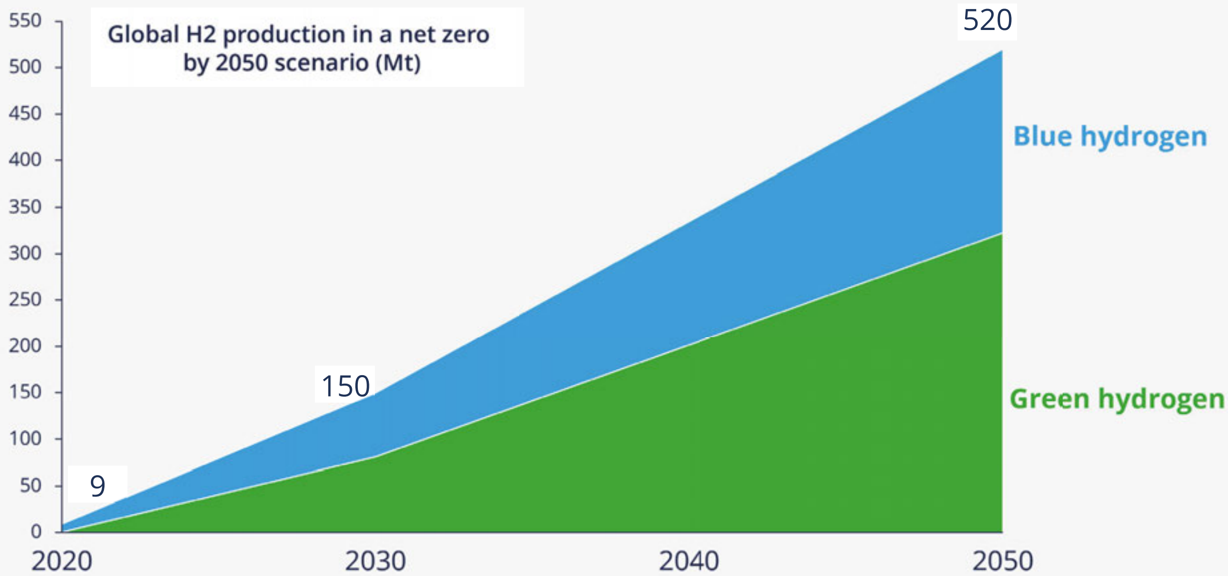
The region will benefit from new jobs, infrastructure, and domestic and international investment – and Victoria and Australia will gain a stable, local supply of important resources including hydrogen, ammonia and urea – at a time of geopolitical tension and heightened energy insecurity.

2.3 Gippsland has two pathways to clean hydrogen

Of the many ways in which hydrogen can be made, a small number produce no or low emissions: 'green' hydrogen from electrolysis of water using renewable power, and 'blue' hydrogen from lignite (using gasification or pyrolysis) or natural gas (using steam reforming), both with carbon capture and storage. Gippsland is unusually well endowed to produce both blue and green hydrogen.

Modelling of global energy futures generally finds that green hydrogen will make the larger contribution to a net zero energy mix in 2050, with blue hydrogen comprising a large minority share. The figure below shows IEA modelling[15] of the size and composition of hydrogen production globally.

GREEN AND BLUE HYDROGEN PRODUCTION FORECAST (INTERNATIONAL), 2020-2050



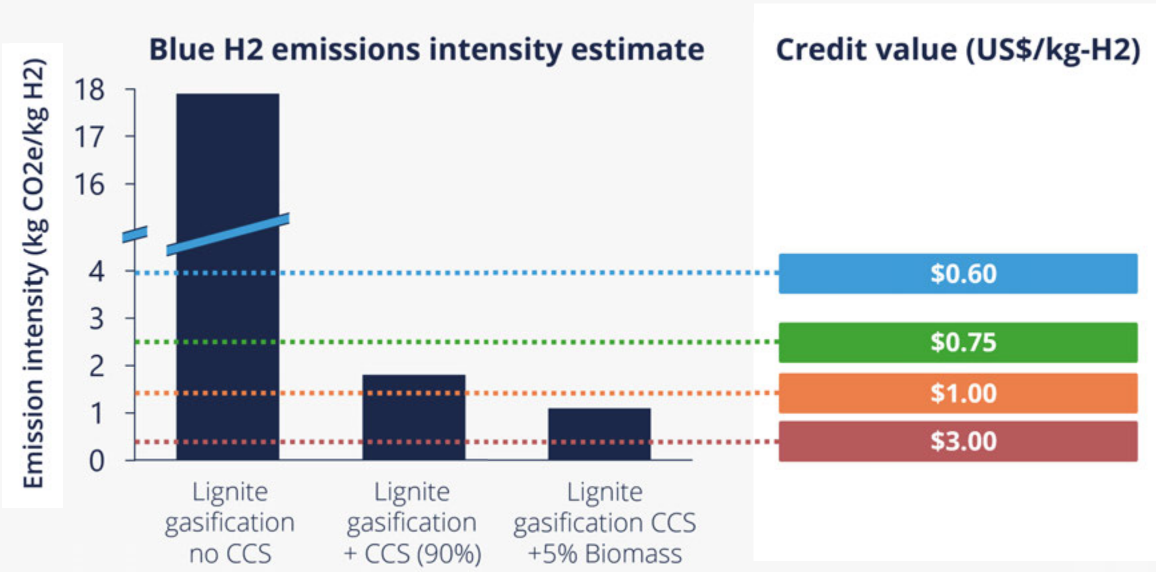
Gippsland is unusual in having the potential to produce both varieties of hydrogen. However, its prospects to be an early-mover are strongest with blue hydrogen using lignite and carbon storage. Mining capacity is already available to support production at scale and will grow as coal-fired power declines further. Making blue hydrogen from Bass Strait gas is unlikely to be commercially attractive because reserves are forecast to decline sharply and investment in major new supplies is not expected.

Residual carbon emissions from blue hydrogen production will be low compared to unabated fossil fuel use and has the potential to be neutralised by blending biomass with lignite. The process by which lignite is gasified can be extended to make ammonia[16] and in turn urea[17] and other chemicals.

International policy shows that demand for hydrogen is increasingly unlikely to be determined by the production pathway. For example, the United States' Inflation Reduction Act (IRA) has specified a declining lifecycle emissions intensity benchmark which can be met by blue or green hydrogen, to achieve eligibility under its Clean Hydrogen Production Tax Credit. Higher tax credits are available for producers of hydrogen with lower emissions. The maximum emissions threshold is expected to decrease over time.

Echoing the trend from the US, Germany, and Norway, recently agreed to developing a blue hydrogen supply chain.[18] The figure below shows that blue hydrogen produced from lignite is likely to fall under the IRA thresholds, indicating the potential for competitiveness in the global hydrogen marketplace.

CLEAN HYDROGEN PRODUCTION TAX CREDIT IN THE IRA AND POSSIBLE BLUE HYDROGEN PROCESS EMISSIONS[19]



Estimates of future clean hydrogen costs are uncertain. Most suggest that blue hydrogen is now cheaper than green, but that green hydrogen will become competitive with blue over time, although forecast costs are uncertain and do not take account of local factors.

> Gippsland has longer-term prospects as a green hydrogen producer using its offshore wind resources complemented with onshore renewable power imported through the grid.

For now, the best use of renewable electricity from Gippsland is to displace coal-fired power and supply increased electrification, including from the expected take-up of electric vehicles, heat pumps and other technologies. Around the mid-2030s, the cost of offshore wind power, onshore renewables and electrolysis is expected to have fallen, so that an emerging surplus of renewable power can be used to make green Gippsland hydrogen competitive, particularly for domestic use. However, preparatory action should be taken now to enable a commercial green hydrogen industry once a surplus of renewable energy generation is achieved.

2.4 Gippsland hydrogen can meet domestic and export demand

Growing clean hydrogen supply and demand is a 'chicken and egg' challenge. Investment in scaling up and lowering the cost of hydrogen requires a large and long-term source of demand. However, building that demand by deploying hydrogen use technologies at sufficient scale, requires a low-cost and abundant source of fuel. Demand and supply will need to be scaled up together from mostly uncommercial starting points, so subsidies and regulation will be needed to close the commercial gap in the early stages.

Gippsland's earliest opportunities to supply domestic demand would come if existing uses of grey hydrogen convert to blue hydrogen and derivatives, through some combination of industry choice and government mandate.

Chemical derivatives of blue hydrogen are an important opportunity for Gippsland, particularly if global prices for natural gas remain high and the growing interest in improving self-sufficiency in strategically important commodities, is sustained. In 2020 Australia imported $77m of ammonia (mostly from Saudi Arabia and Malaysia[20]) and $615m of urea (mostly from the Middle East, Southeast Asia and China[21]).

Ammonia and urea prices increased between 2020 and early 2022,[22] and again with Russia's invasion of Ukraine[23], linked to gas price rises. Urea made from blue hydrogen is becoming competitive with imports, is less carbon intensive, and will have a more stable supply. The Latrobe Valley can be a large, secure, and competitive source of this vital agricultural input.

Demand for clean hydrogen in new uses is likely to grow fastest overseas in the first instance, as use technologies are made and sold in the larger manufacturing economies of East Asia, Europe and North America. While Australia should follow fast in importing those technologies, early demand in the northern hemisphere will open early export opportunities for Gippsland blue hydrogen through the 2020s, particularly in East Asian economies with limited energy resources.

In the longer run, Gippsland hydrogen's competitiveness in energy export markets may be challenged by locations with large and low-cost combinations of wind and solar. However, the export potential of urea and other hydrogen derivatives for non-energy uses should be durable, and Gippsland hydrogen will be competitive over imports for many domestic uses, because imports will incur extra conversion and transport costs when supplying Victorian demand.

This means a diversified approach will maximise the benefits to Gippsland. This entails meeting both domestic and export demand, meeting demand for both hydrogen and its derivatives, and supplying both energy and non-energy uses.

Gippsland will also be a source of hydrogen demand. Although Gippsland will export hydrogen to Victoria and beyond, local demand should grow as existing industries convert to hydrogen from oil and gas. New industries could be attracted to the region, leveraging the production industry, to create a multi-user industry.

Gippsland users of hydrogen may include:

Freight/heavy and long-distance transport: Hydrogen is expected to be used in fuel cells or reciprocating engines to replace diesel in heavy transport vehicles such as trucks, trains and ships.

Agriculture: Hydrogen can be used to power heavy farm machinery. Farms may, in future, have the capacity to produce small quantities of hydrogen on-farm from solar at times of peak production.

Manufacturing: Clean hydrogen can be used to replace high energy density fuels used for heating in industrial processes (e.g. pulp and paper production and dairy processing). Hydrogen and carbon dioxide (from blue hydrogen production) can also be made into ammonia then urea, providing a domestic source of nitrogen fertiliser for Gippsland farms.

Grid firming: There is potential to use hydrogen to produce electricity when unusual conditions produce a shortfall of renewable and storage output relative to demand.

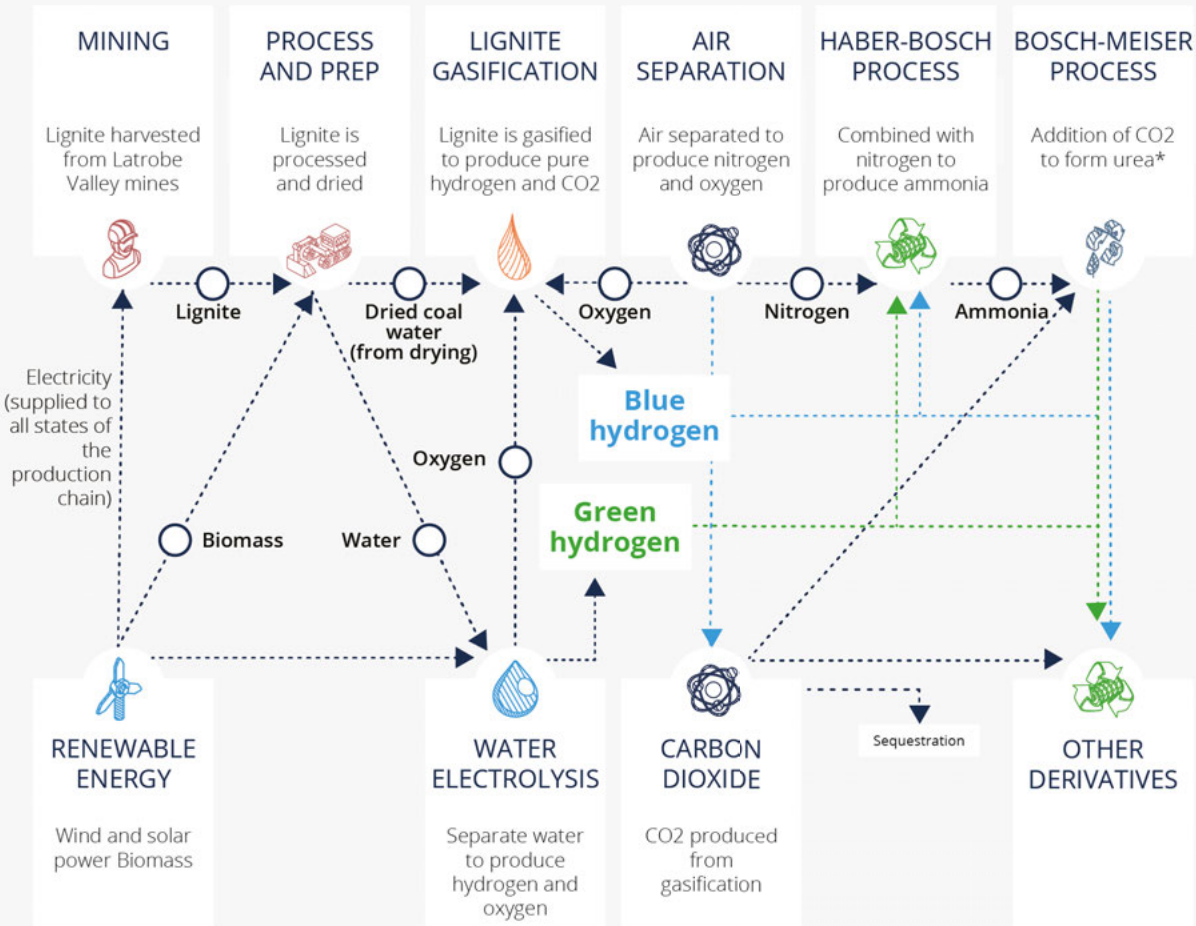
2.5 Gippsland can make both blue and green hydrogen

There are potential synergies that would increase the viability of blue and green hydrogen production in Gippsland, once green hydrogen can be produced in commercial quantities.

- Green hydrogen can utilise infrastructure for blue hydrogen, including pipelines and ports, the development of which is being planned as part of the commercialisation of the Hydrogen Energy Supply Chain project.
- Blue hydrogen can provide a strategic reserve for green hydrogen to better match hydrogen supply to demand, because blue hydrogen production does not fluctuate with weather. This would reduce the volume and cost of green hydrogen storage for meeting seasonal supply-demand imbalances.[24] Lignite is a hydrogen store in itself, and blue hydrogen production can be controlled, so warrants consideration as a backup to green hydrogen over the longer-term.
- Green hydrogen can be added to blue hydrogen to improve the productivity of chemical manufacture. This would increase the utilisation of nitrogen from air separation and carbon dioxide from lignite gasification, in producing chemicals such as ammonia and urea. It can also reduce the volume of carbon dioxide that has to be permanently stored.
- Green hydrogen can also provide oxygen for gasification. This would reduce the use of oxygen from air separation units that also provide oxygen for gasification, so research would be needed to establish an optimal production process.

Gippsland's renewable power output can also provide clean energy for clean hydrogen production, for example the air separation, gasification, and compression stages of the process. Electrolysers can help secure power supplies by providing essential services to the power grid (i.e. flexing their demand).

INDICATIVE PROCESS FLOW FOR THE PRODUCTION OF HYDROGEN, AMMONIA AND UREA[25]



2.6 A Gippsland hydrogen industry will benefit other sectors

Intensive horticulture can use some of the carbon dioxide that is a by-product of blue hydrogen production to promote plant growth in controlled environments.

The establishment of a carbon storage industry to support blue hydrogen production can serve other abatement uses for which renewable energy is not a solution, including sequestering emissions that are already vented to atmosphere, including from natural gas production at Longford and cement manufacturing.

Hydrogen used to produce fertilisers may replace imported urea made from fossil fuels. This could provide security of supply for Victoria's agricultural industry and potentially stabilise costs.

Products from lignite processing (e.g. drying and pyrolysis) may also be used in advanced materials for vehicles, batteries and other applications, including activated carbons, carbon fibre, blended fertilisers, biostimulants, fine chemical manufacturing or for soil conditioning in agriculture.

2.7 Action is needed to grow a Gippsland hydrogen industry

Government and corporate action is required, here and overseas, to build demand for clean hydrogen and derivatives such as ammonia and urea, to supply the required finance, and support investment in the region.

Social licence is a significant factor in the growth of a clean hydrogen industry. Blue hydrogen attracts concern because it continues the use of finite fossil fuels and relies on carbon storage which is also a finite resource (although with significant potential in Gippsland) and has developed more slowly than expected. Renewable electricity for making green hydrogen attracts criticism of the transmission infrastructure needed to convey it, from landowners and communities. Gippsland has a history as a major energy industry, but community support for new technologies must still be developed.

Opposition to both forms of hydrogen production will need to be proactively addressed by early engagement and the sharing of benefits with affected landowners and communities. There is an important role for government and developers to maximise the social licence of a clean hydrogen industry in Gippsland. Any community engagement should follow the Victorian government's guidelines and the six principles for public engagement[26]. In addition, best practice guidance for benefit sharing from renewable energy projects has been developed and should be followed where possible[27].

Integrated processes for gasifying lignite, and using and storing the carbon dioxide stream, are under development but will require support to become commercially viable. Assurance and support may be needed to increase investment from the finance sector in zero carbon applications of lignite.

A large-scale carbon storage service is also needed, for which the Gippsland Basin remains Australia's most prospective location, using Bass Strait's depleted oil and gas fields and saline aquifers. Studies have shown that the Gippsland Basin has extremely high potential storage capacity in the tens of gigatonnes, but no project has yet achieved a commercial scale.[28] CarbonNet's commercialisation needs to be expedited, and ExxonMobil's investigation of a Southeast Australia CCS hub deserves continued support.

A more fundamental issue is that lignite and carbon storage are more finite resources than renewable energy, which uses minerals to make generation equipment but requires no fuel once it has been built. While Victoria's lignite and carbon storage resources are large, directing their use to lower-volume, higher-value applications is most consistent with sustainability objectives.

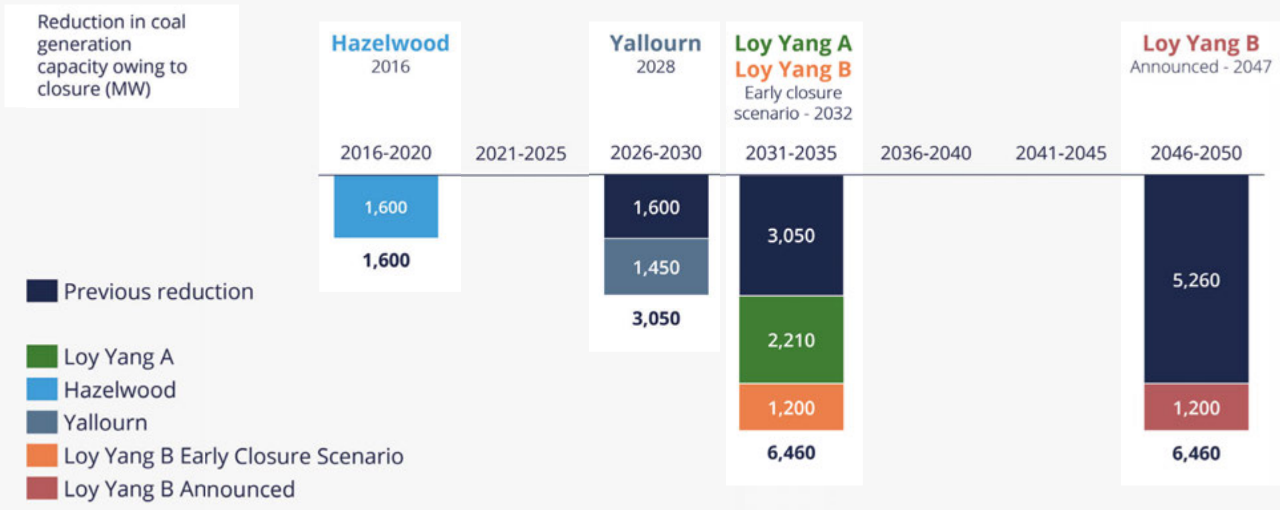
This plan would achieve that aim. Lignite is mined at the rate of about 30 million tonnes per year to produce 100 PJ of power at Loy Yang A and B in the Latrobe Valley. By contrast, a hydrogen industry producing 250,000 tonnes or 31 PJ of hydrogen per year would consume only 4.2 million tonnes of lignite. Water consumption could fall from 102.5 GL per year for power generation when all power stations were in operation, to 23 GL per year for that level of hydrogen production.

Water supply will be an important input to hydrogen production. The availability of water for blue hydrogen production should benefit from reduced demand for cooling water in coal-fired power generation, though there will be competition from other uses including mine rehabilitation. Desalination using renewable power and recovery of entrained water in lignite would lower demands for river water. Green hydrogen production located on the Gippsland coast would minimise electricity transmission costs and take advantage of the low cost of moving hydrogen in pipelines. The water demand of electrolysers (including for cooling) can also be met through desalination, possibly by expanding the existing Wonthaggi plant or building new facilities.

This overview suggests that commercial-scale blue hydrogen should attract investment from now, whereas green hydrogen should be demonstrated early, to take advantage of commercial opportunities as supply grows and costs fall, building on the establishment of blue hydrogen. Research should begin into the combined use of blue and green hydrogen that realise synergies and make full use of Gippsland's diverse resources.

The expected closure of coal-fired power stations will make lignite available for blue hydrogen production and increase the use of renewable power to supply electricity use. The figure below shows the expected closure of coal-fired power in Victoria based on publicly announced closure dates and an early closure scenario.

REDUCTION IN LIGNITE-FIRED GENERATION CAPACITY, 2016-2050



SOURCE: publicly announced closure dates of Victorian coal-fired power stations, accurate at march 2023

Electrification of various oil and gas uses will lead to a significant increase in demand for electricity. The planned closures of coal-fired power stations – especially under an early closure scenario forecast by AEMO[29] – will decrease supply at the same time. Current renewable energy targets may prove insufficient to meet electricity end-use demand, let alone facilitate large-scale green hydrogen production. Concerted action is needed to provide enough renewable electricity supply to meet this challenge and build an electricity surplus for green hydrogen production.

2.8 Government action can bring these opportunities to life

The emerging clean hydrogen industry will require strong and sustained action from governments and investors to reach its potential. This is true world-wide, and Gippsland's advantages make it a priority for support.

The preconditions for industry growth are diverse. Key inputs need to be available (lignite, carbon storage, renewable power, water, land and finance). Demand needs to be built here and overseas. Industries which make and use hydrogen need to be attracted. Paths to market need to be provided through ports, pipelines, road and rail. Workforce capacity needs to be grown, and social licence needs to be built. This will require new policies, regulations, subsidies, programs and investment commitments.

Governments should start work now on a five-year plan

Government action should be focused on these tasks, in coordination with the private sector. A taskforce of the Australian, Victorian and local governments should be established immediately to deliver the action plan below over the next five years.

Establish a commercial-scale blue hydrogen industry with the following actions

- Provide financial support which complements the Japanese Government's Green Innovation Fund grant to secure commercialisation of the HESC, subject to final studies.
- Provide the HESC with access to lignite and water.
- Use financial and regulatory support to attract investment in a large-scale, multi-user carbon storage service under the Bass Strait of five million tonnes per year.
- Facilitate enough demand for hydrogen and derivatives (for domestic use and export) to underpin production, including investments in new Gippsland hydrogen-using industries such as ammonia and urea production.
- Prepare a Hydrogen Infrastructure Plan (as a subset of the Master Plans recommended in Gippsland's Clean Energy Future) to support the transport of hydrogen and derivatives to domestic users and export markets, by pipeline, road, rail and ports.
    - An early focus should be on a trunk hydrogen pipeline from the Latrobe Valley to industrial centres in Melbourne.

Diversify and grow Gippsland's hydrogen industry with the following actions

- Develop and fully implement a comprehensive Gippsland hydrogen roadmap to develop all viable sources and supply diverse uses, to increase economic security and lower emissions.
- Develop demonstration fleets of trucks, buses and hydrogen-fuelled passenger trains, a trial 'hydrogen town' and supporting local businesses to use clean hydrogen.
- Partner with industry to establish an independent Gippsland Clean Energy Centre within the region. This function would be embedded within industry, facilitating a practice of excellence in better supported industry and community engagement and coordination that accelerates and expands the current work to facilitate the growth of Gippsland's clean energy opportunities across each of the emerging clean energy industries. This work would be central in connecting and coordinating the actions of industry and business, community and regional stakeholders as well as local, state and federal governments and their agencies.
- Encourage superannuation funds and banks to support commercially viable net zero-compatible uses of lignite, including the production of blue hydrogen.

Grow community benefits and support with the following actions

- Ensure meaningful consultation and collaboration with key stakeholder groups, including local Traditional Owners, to build social licence.
- Identify the next generation of clean energy employees by developing and implementing a Gippsland workforce transition and development plan that identifies local jobs from clean energy investments in the region and just transition for current coal workers and service businesses (from 2023).
- Invest in and support skills and training opportunities locally, including through TAFE Gippsland and Federation University.

Lay foundations for a commercial-scale green hydrogen industry with the following actions

- Support the establishment of a green hydrogen demonstration plant to supplement blue hydrogen supply – at least one MW-scale electrolyser (by 2024) and seek investment in commercial-scale green hydrogen production as soon as is feasible.
- Commission detailed investigations of the potential long-run synergies between blue and green hydrogen investments and Gippsland's potential to become a 'hydrogen hub' of co-located industries for making and using hydrogen, derivatives and by-products.
- Prioritise the implementation of the state's offshore wind strategy to ensure ample supply of renewable energy for future green hydrogen production.

Endnotes

1 Grey hydrogen is made from natural gas without CCS.

2 Australian Government Department of Industry, Science, Energy and Resources, Energy Consumption, available at: https://www.energy.gov.au/data/energy-consumption

3 European Commission 2020, A hydrogen strategy for a climate-neutral Europe

4 Adapted from Energy Transition Committee, "Making the Hydrogen Economy Possible", April 2021

5 Brown coal or lignite is distinguished from black coal by its different properties and future economic potential.

6 Victorian Government Earth Resources, Coal

7 AEMO (2021), Victorian Gas Planning Report, https://aemo.com.au/-/media/files/gas/national_planning_and_forecasting/vgpr/2021/2021-victorian-gas-planning-report.pdf?la=en

8 Carbon Storage Taskforce (2009), National Carbon Mapping and Infrastructure Plan – Australia

9 Australian Government Department of Agriculture, Water and the Environment (2018), Regional Profile for the Latrobe Region, https://www.awe.gov.au/abares/research-topics/aboutmyregion/vic-latrobe - forestry-sector

10 METI, Basic Policies for Green Innovation Fund (summary), https://www.meti.go.jp/english/press/2021/pdf/0312_002a.pdf

11 See https://green-innovation.nedo.go.jp/en/ for a list of projects

12 NEDO, Large-scale Hydrogen Supply Chain Establishment, https://green-innovation.nedo.go.jp/en/project/hydrogen-supply-chain/

13 University of Technology Sydney (2020), Renewable Energy Employment in Australia, p 7

14 Road infrastructure was excluded for visual readability due to the prevalence of many major roads in the region. Distances, locations, sizes and proportions are not to scale and based on estimates drawn from publicly available maps of the region's resources.

15 International Energy Agency (2021), Net Zero by 2050 – A Roadmap for the Global Energy Sector https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

16 Ammonia can be made from hydrogen using nitrogen from the same air separation units that supply oxygen for brown coal gasification.

17 Urea can be made from ammonia using some of the carbon dioxide captured from brown coal gasification.

18 Government of Norway, 2023, Joint Statement – Germany – Norway – Hydrogen, https://www.regjeringen.no/en/whatsnew/dep/smk/press-releases/2023/closer-cooperation-between-norway-and-germany-to-develop-green-industry/joint-statement-germany-norway-hydrogen/id2958105/

19 Gasification emissions sourced from Global CCS Institute, 2021: (https://www.globalccsinstitute.com/wp-content/uploads/2021/10/2021-Global-Status-of-CCS-Report_Global_CCS_Institute.pdf); Biomass emissions sourced from Kim et al. 2017: https://www.sciencedirect.com/science/article/abs/pii/S1164556317303278

20 Observatory of Economic Complexity 2020, Ammonia in Australia, 2020, available at: https://oec.world/en/profile/bilateral-product/ammonia/reporter/aus

21 Observatory of Economic Complexity 2020, Urea, including aqueous solution, 2020, available at: https://oec.world/en/profile/bilateral-product/urea-including-aqueous-solution-in-packs-10-kg/reporter/aus

22 S&P Global (2021), Global ammonia prices surge on European natural gas cost push

23 The Conversation (2022), Russia's war with Ukraine risks fresh pressure on fertiliser prices

24 Although inter-seasonal supply could be secured by storing hydrogen at scale, trading it nationally and globally, and managing demand, storage options do not appear to be plentiful, long-distance transport incurs conversion costs, and demand management is limited by its economic and social impacts.

25 Renewable energy can be used to power most aspects of the process; biomass can be blended with coal to achieve net zero emissions. CO2 can be sourced from coal gasification to produce urea from both blue and green hydrogen, and other hydrogen derivatives..

26 Victorian Government, Public Engagement Hub, available at: https://www.vic.gov.au/public-engagement-hub

27 Renewable energy alliance (2019), A guide to benefit sharing options for renewable energy projects

28 Geoscience Australia, Gippsland Basin CO2 Storage Project, available at: https://www.ga.gov.au/about/projects/resources/gippsland-basin-co2-storage#:~:text=Overall%2C%20the%20offshore%20Gippsland%20Basin,high%20porosity%20of%20the%20unit

29 ABC (2021), Early exit for coal as National Electricity Market prepares for renewable future

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