An Australian Government Initiative

Regional Development Australia

BARWON SOUTH WEST

Renewable Hydrogen and Energy Investment Opportunity

Mapping study

June 2024

hycel

Deakin University

CERRF
Centre for Regional and Rural Futures

Acknowledgement

We acknowledge the Traditional Owners of the lands and waters on which we live and work, and pay our respects to their Elders past, present and emerging. We acknowledge that we are on traditional lands, including those lands of the Eastern Maar, Gunditjmara, and Wadawurrung people and Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupgalk Nations as well as other Traditional Owner groups in Victoria who are not formally recognised.

We acknowledge the diversity of Aboriginal Victorians, their communities and cultures, the intrinsic connection to Country, the contribution and interest of Aboriginal people and organisations in developing a prosperous region.

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Acronyms

AEMO	Australian Energy Market Operator
ARENA	Australian Renewable Energy Agency
ALC	Australian Lamb Company
BESS	Battery Energy Storage System
BREP	Barwon Renewable Energy Partnership
BSW	Barwon South West
CCGT	Closed Cycle Gas Turbine
CCS	Carbon Capture and Storage
CERRF	Centre for Regional and Rural Futures
DAC	Direct Air Capture
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DEECA	Department of Energy, Environment and Climate Action
DJSIR	Department of Jobs, Skills, Industry and Regions
DLA	Development License Application
EPA	Environment Protection Authority
ESG	Environmental, Social and Governance
EV	Electric Vehicles
FCEB	Fuel Cell Electric Buses
GMA	Groundwater Management Area
GIS	Geographic Information System
GRP	Gross Regional Product
HRS	Hydrogen Refuelling Station
IRENA	International Renewable Energy Agency
ISP	Integrated System Plan
LCOE	Levelised Cost of Electricity
LCOH	Levelised Cost of Hydrogen
LGA	Local Government Area
MOU	Memorandum of Understanding
MSW	Municipal Solid Waste
NEM	National Electricity Market
OCGT	Open Cycle Gas Turbine

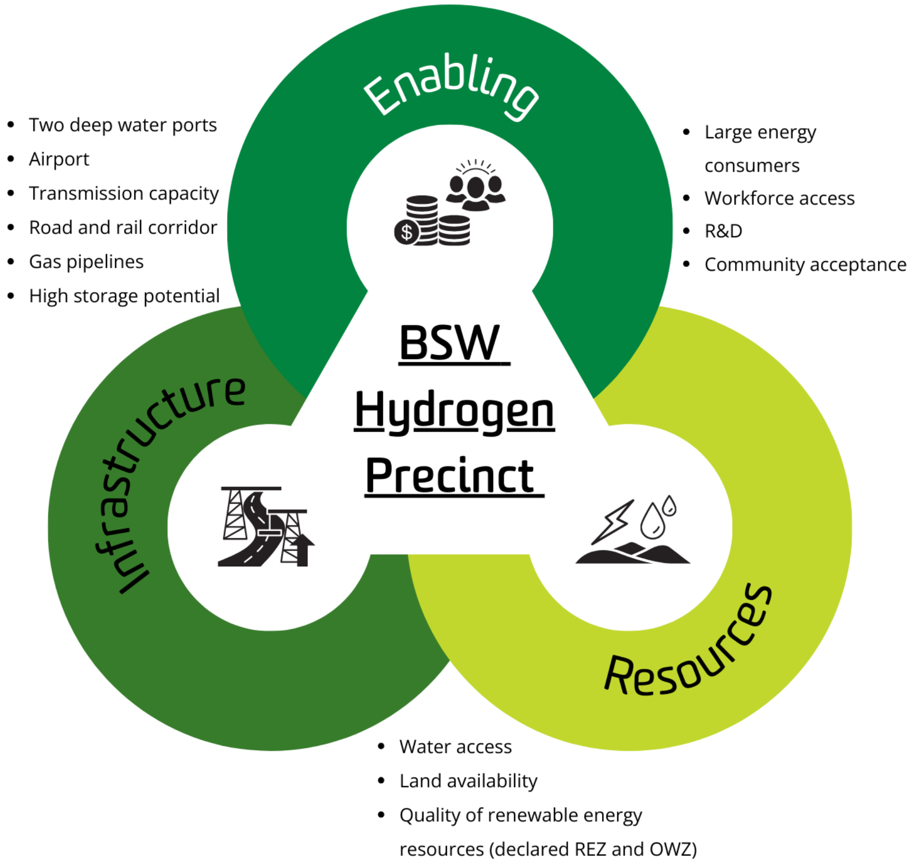
OWZ	Offshore Wind Zone
PPA	Power Purchase Agreement
PV	Photovoltaic
RDA	Regional Development Australia
RDV	Regional Development Victoria
RE	Renewable Energy
RER	Renewable Energy Resources
RET	Renewable Energy Target
REZ	Renewable Energy Zone
RON	Renewable Organics Networks
RRON	Regional Renewable Organics Networks
UHS	Underground Hydrogen Storage

1. Executive Summary

The Barwon South West Renewable Hydrogen and Energy Investment Opportunity project investigated the current state of renewable energy investment in the Barwon South West (BSW) region of Victoria and the opportunities for renewable hydrogen. The project was delivered by Deakin University's Hycel, and Centre for Regional and Rural Futures (CERRF) on behalf of Regional Development Victoria (RDV).

The project found that the BSW region is an ideal location for a hydrogen precinct, with the region possessing the necessary infrastructure, natural resources and enabling factors (economic, social, environmental) to drive investment (see Figure 1). The development of a renewable hydrogen precinct is dependent on the co-location of hydrogen production capability and demand/offtake partners, with constraints such as the availability of high quality water, renewable energy, land, and community acceptance. The BSW region possesses these necessary elements to become a leading hydrogen precinct.

Figure 1. Key factors of BSW as a Hydrogen Precinct



Infrastructure

In terms of infrastructure, the BSW region is equipped with two deep water ports, electricity transmission capacity, gas pipelines, underground storage potential, and is connected by road and rail to the South Australian border and Australia's east coast.

The road and rail connection and diverse regional transport industries (e.g. dairy, forestry) offer a near term opportunity in heavy transport (freight, waste) for hydrogen investment because of identified potential offtake industries. This near-term transport opportunity aligns with modelling by the Hydrogen Council that suggests hydrogen applications such as heavy haul back to base transport and light commercial vehicles are expected to be competitive with fossil fuels in the near term. The production of green chemicals for feedstock and synthetic fuels, and hydrogen as baseline power generation are other mid-term opportunities. The region's two deep water ports offer vital logistics nodes for offshore and onshore wind generation projects, as well as potential for bulk hydrogen or hydrogen derivatives transport in the longer term, along with bunkering opportunities.

Resources

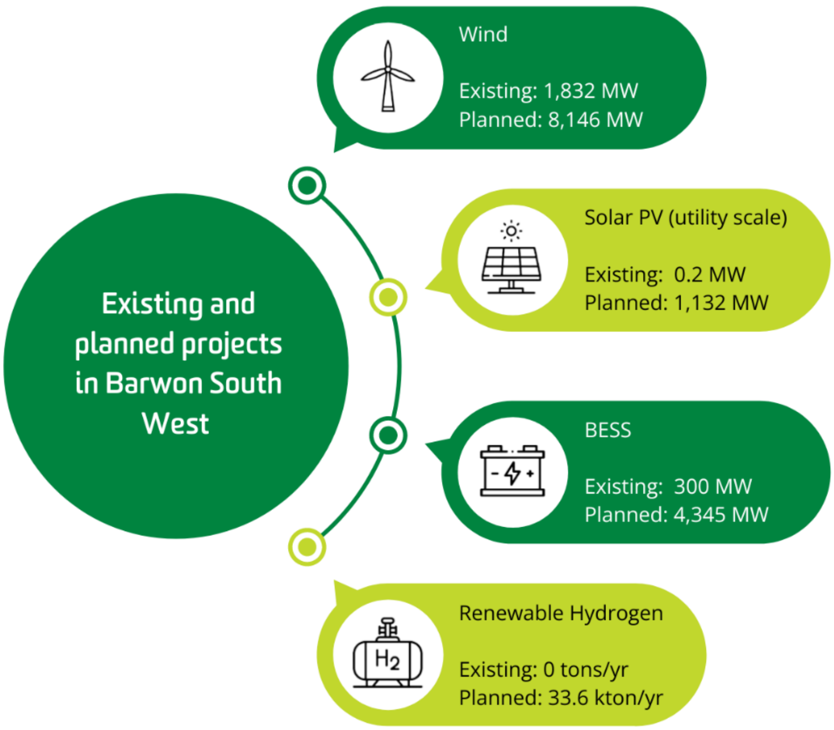
In terms of natural resources, parts of the BSW have been declared a Renewable Energy Zone (REZ) and Offshore Wind Zone (OWZ) by the Australian Energy Market Operator (AEMO) [1] and by The Minister for Climate Change and Energy respectively [2]. Indeed, several renewable energy projects have been announced in the region, as analysed later in this report. Furthermore, there is adequate land and water availability within the region for the development of renewable hydrogen production sites (via electrolysis or other) and refuelling stations (distribution centres). Availability of biomass residues provide bioenergy opportunities, and a source of biogenic carbon dioxide (CO_2) to produce renewable methanol as a derivative of renewable hydrogen.

Enabling Factors

Enabling factors such as the presence of large energy consuming industries within the BSW are coupled with capability for research and development through Deakin's gateway to hydrogen research and education, Hycel, and workforce development through vocational training providers such as South West TAFE. Communities across the BSW region are at various levels of maturity in terms of renewable energy and hydrogen social licence.

Taken together, these three factors, infrastructure, resources and enabling, culminate in the BSW region presenting as a premiere hydrogen precinct. It is important to note that hydrogen is in the emerging stages as an industry so projects such as this report, and other educational and awareness opportunities are required to assist hydrogen sector development.

Figure 2. Impact of planned projects in the renewable energy/hydrogen production capacity of BSW

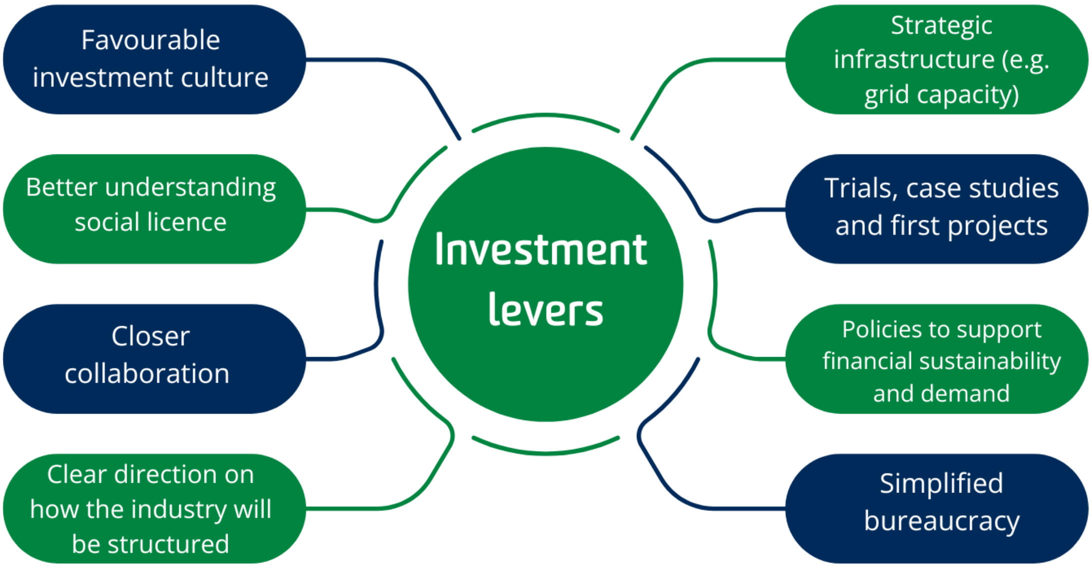


Within the broader renewable energy landscape, projects involving wind, solar and Battery Energy Storage Systems (BESS) are the most prominent throughout the BSW. There is also interest in developing biogas, biosolids, biochar, and biodiesel projects. Figure 2 depicts the significant impact that planned projects would have in the renewable energy/hydrogen production capacity of BSW.

Source: Authors' interpretation

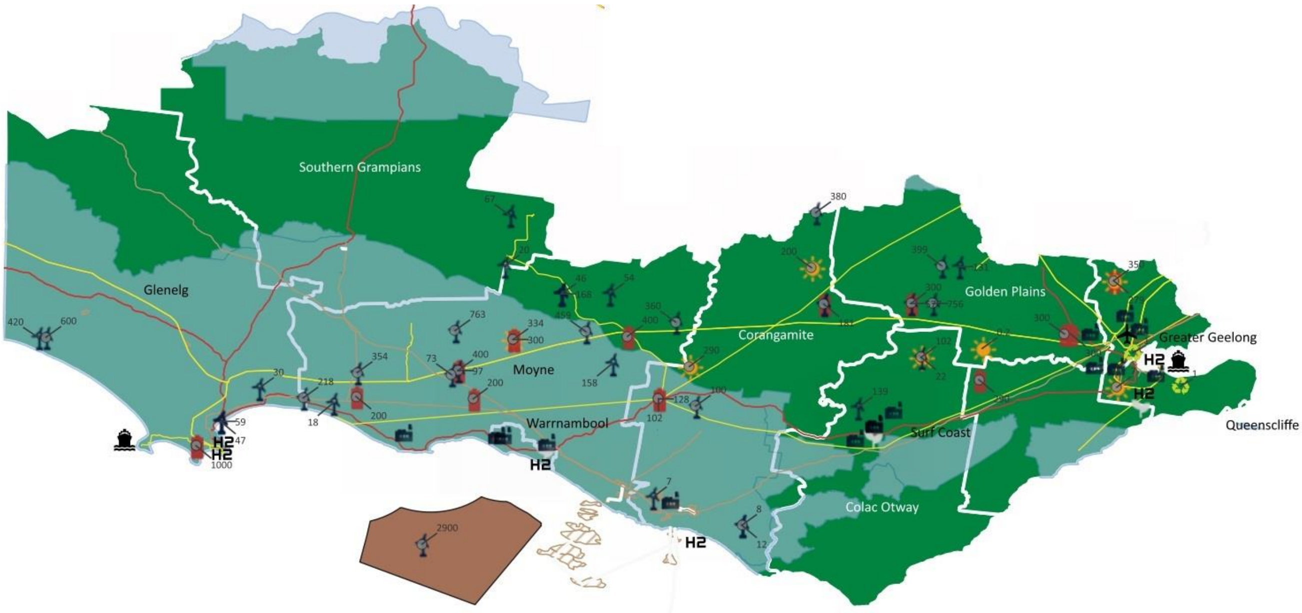
The BSW region is motivated to reduce greenhouse gas emissions to align with council, Victorian and national targets. Cross sector parties, spanning industry to government, are implementing different strategies such as power purchase agreements with renewable energy generators or substituting fossil fuel-based energy with electricity. In the coming years, an increase in the need for sustainable fuels such as hydrogen and its derivatives is expected, especially in hard to abate sectors where the latter strategies are less efficient or unlikely. Producing these fuels locally requires significant investment and policy coordination. There are a variety of levers needed to support confident private investment (depicted in Figure 3).

Figure 3. Needs and requirements of the private sector to confidently invest in the region



1.1 Summary of key findings

Figure 4. GIS visualisation of existing and planned projects and key hydrogen precinct factors of BSW



1.1.1 Barwon South West region as a hydrogen precinct

- Consistent with having areas declared Renewable Energy Zone (REZ) and Offshore Wind Zone (OWZ) by AEMO, significant renewable energy capacity is being planned in most LGAs. Large-scale offshore wind projects are expected in the Southern Ocean, whereas in Moyne, Golden Plains, Corangamite and Glenelg a significant share of onshore wind capacity is expected, similar for solar PV in Moyne, Geelong, Golden Plains and Corangamite, and BESS capacity in Glenelg, Geelong and Moyne.
- Hydrogen production via electrolysis would be the main production pathway, although one project (by HAMR Energy with funding from the Victorian Government Portland Diversification Fund) is also expected to include biomass gasification. Portland is expected to concentrate a large share of the production capacity. Hydrogen demand in this LGA from port operations and large energy consumers could also develop if competitive prices are achieved.
- Geelong has potential to become the main demand centre of the BSW precinct, as a manufacturing hub, and potential demand from airport and port operations. Hydrogen production projects have also been announced (by Viva Energy and Geelong Port with Fortescue Future Industries), yet sourcing power from the grid or other LGAs would be expected.
- Warrnambool and Colac also concentrate several large industries, and a renewable hydrogen project has been announced in the former (by Warrnambool Bus Lines).
- Underground Hydrogen Storage (UHS) and renewable hydrogen production is being assessed at Iona by Lochard Energy, having received ARENA funding for a feasibility study.
- As an agricultural hub, the region consumes a large quantity of fertilisers, which are imported from other regions and from abroad. Geelong is home to Impact Fertilizers and Incitec Pivot. There is an

opportunity to build a local ammonia industry deriving from renewable hydrogen, and subsequently produce fertilisers such as urea.

- Relevant electricity transmission capacity[1], gas pipelines, and proximity to the main freight corridor is widespread across the region. Significant heavy duty operations in the latter provide an opportunity for renewable hydrogen demand.
- Good access to water bodies for sustainable consumption. Notwithstanding, recycled water and desalination projects are being discussed.
- Proximity to Melbourne brings several opportunities. E.g. Viva Energy Australia's proposed pipeline from Altona to Melbourne airport, and HAMR Energy's MOU with Port of Melbourne to explore sustainable maritime fuel bunkering capabilities.

1.1.2 Needs and requirements of the private sector to confidently invest

- Policies to support financial sustainability and foster demand: New technologies involving renewable hydrogen and its derivatives are at present more expensive than fossil fuel alternatives. Coupled with cost reduction expectations produce at present a lack of offtakers. There is a need for government support to bridge the commercial gap in the short to medium term.
- Supporting trials, case studies and first projects: These can be useful to collect information such as timeline to receive regulatory approvals, actual costs and energy needs, supply, resource and infrastructure issues, among other.
- Clear policy direction: Investors currently face uncertainty in whether the sector will be structured as large scale and centralised, or small scale and decentralised. A clear intended direction, consistent and sustained over long periods of time at federal and state level, is needed to materialise investments and avoid the risk of policy moving in a different direction.
- Strategic infrastructure: Electricity transmission capacity, water recycling/desalination, hydrogen refuelling stations (HRS), port bunkering capacity, storage locations, pipelines (adjustments and/or greenfield), among other, to incentivise investments that would not make economic sense as standalone projects. Arguably, the region would benefit from public funding towards this infrastructure (at least partly) to develop other local industries. E.g. agriculture, chemicals manufacturing, among other.
- Simpler bureaucracy: Several stakeholders commented on planning issues and red tape, leading to delays, engagement fatigue and withdrawal of projects.
- Better understanding social licence: Need to approach it holistically within the region to reduce the risk of engagement fatigue. Furthermore, need to ensure community benefit is captured and retained in region. An effective, coordinated, and collaborative approach to social licence was raised as an immediate need.
- Improved collaboration and communication: Investors, suppliers, consumers, regulatory authorities, and other government institutions collaborating more closely would, arguably, speed up the deployment of these technologies. A more formal dialogue between stakeholders and representatives from the relevant bureaucracies is suggested to be initiated as a first step.

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[1] It is anticipated VicGrid's *Victorian Transmission Investment Framework* will include detailed analysis of the BSW transmission network including strategic analysis of planning and development of electricity infrastructure projects.

1.1.3 Obtaining and strengthening social licence

- There is uneven community support across the region for renewable technologies; it is important to understand and respond to the nuances of each community and to recognise that community support may vary from one renewable energy project to another.
- Solar and batteries were raised as known, preferred and attainable sources of energy whereas social licence for wind is uneven. Hydrogen and biochar were raised as known technologies but viewed as future energy projects.
- There is a desire to better articulate, distribute and retain the community benefits across the region.
- A coordinated approach to social licence is needed to prevent community engagement fatigue, with the mechanism to be developed.
- The disconnection between the approval systems, the local experience and the timing of community engagement was raised as issues of concern.

1.2 Recommendations

Relevant Regional Development entities and State Government institutions can provide a leadership role in progressing the following recommendations to enable these investments and maximise their benefits.

1. Enact consistent policy that enables financial sustainability (e.g. addressing the 'green premium') for renewable hydrogen projects.
2. Support the development of essential infrastructure, specifically grid capacity, water planning and distribution infrastructure.
3. Facilitate closer collaboration between investors, government entities, and supply-chain partners.
4. Review the complexity of planning rules to streamline relevant processes and response times.
5. Support communities and proponents to take a holistic approach to renewable hydrogen and energy social licence development and maintenance that is sector based rather than project based so that value is captured in the region.
6. Undertake a comprehensive survey of energy consumption per process of large industries in hard to abate sectors, to better understand potential renewable hydrogen and derivatives demand, strategic infrastructure needs, implementation timeframes, policy requirements and impacts.
7. Support development of a knowledge bank / repository and training to upskill and share information regarding renewable hydrogen and energy developments and decision making. Aggregate ideas and knowledge.

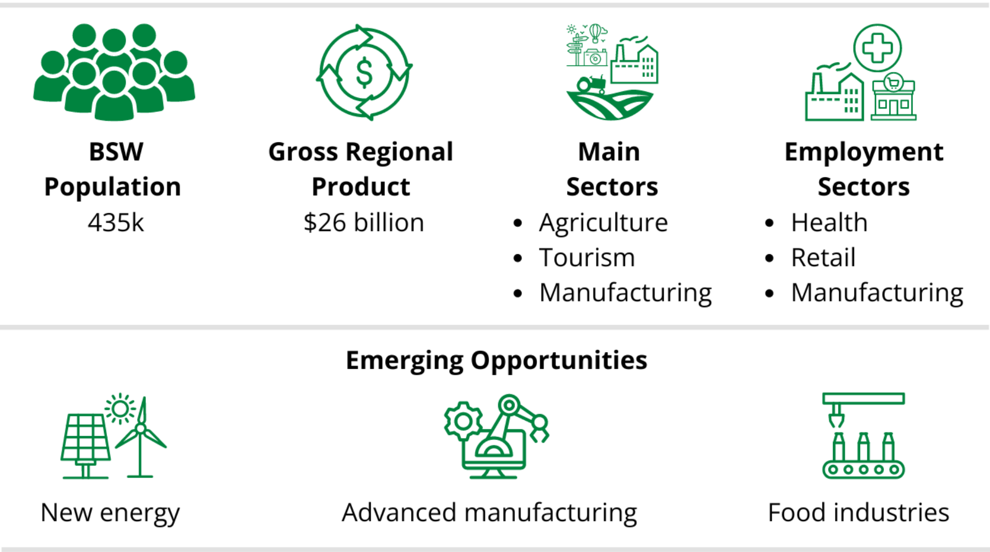
2. Introduction

The Barwon South West Renewable Hydrogen and Energy Investment Opportunity project investigated the current state of renewable energy investment in the BSW region of Victoria and the opportunities for renewable hydrogen. The BSW region, portrayed in the figure below, stretches from Queenscliff at the tip of the Port Phillip Bay Heads in the east to the border of South Australia in the west. It consists of the local government areas (LGAs) of Queenscliff, Greater Geelong, Surf Coast, Golden Plains, Colac Otway, Corangamite, Moyne, Warrnambool City, Southern Grampians, and Glenelg.

Figure 1. Barwon South West Region

Consideration of the relevant Regional Economic Development Strategies (REDS) indicates that Regional Development Australia Barwon South West drives economic development by identifying and advocating for regional priorities and projects. A snapshot of BSW key socioeconomic indicators is provided in Figure 6 [3]. As portrayed, emerging opportunities include development of renewable energy sources (such as wind and solar), advanced manufacturing (e.g. biotechnology), food industries, plantation timber, mineral sands, tourism, and other services.

Figure 6. Snapshot of BSW key socioeconomic indicators



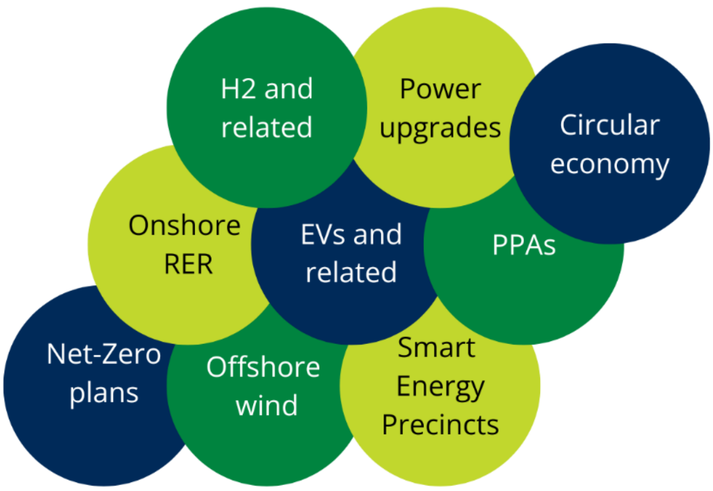
The Australian Energy Market Operator (AEMO) has identified the areas surrounding the main 500 kV transmission line and related infrastructure in BSW as a Renewable Energy Zone (REZ). Furthermore, the Southern Ocean coast, stretching from Port Fairy to Warrnambool was identified as an Offshore Wind Zone (OWZ).

The region has a growing renewable energy sector derived from the combination of wind, solar and emerging bioenergy generation [4]. Furthermore, the region is home to the State's largest battery storage facility [5]. Energy infrastructure upgrades can help improve regional productivity and enhance opportunities for investment and expansion, by reducing electricity supply outages, and encouraging investment in more modern and energy efficient equipment [6].

From a regional circular economy perspective, there is a recognition of the importance of location / co-location of renewable infrastructure near to resource recovery and manufacturing processes to support the facilities to operate at a low cost and low impact to the environment [7].

The initiatives considered for the scope of this project, at either aspirational or feasibility stages, can be grouped as follows:

Figure 7. Energy initiatives



3. Methodology

The methodology implemented in this project was three-fold:

1. Desktop review gathered and analysis publicly available data and reports.
2. Key stakeholder consultation with a focus on planned and potential investments, needs/requirements for investing, enablers, and barriers.
3. Mapping and visualisation to illustrate the energy footprint. Data was sourced from Victorian Government agencies, among other.

A key outcome of the analysis was to map existing and planned renewable hydrogen and renewable energy projects, both public and private, in order to present a regional snapshot.

It is anticipated that this visualisation exercise enhances awareness of opportunities for energy suppliers and users. Its purpose is to be an analytical/technical platform to help convene like-minded entities and communities, initiate the development/enhancement of projects and partnerships, aid relevant industry and government entities in identifying aggregation opportunities.

Furthermore, it aims to help local industries, markets, and communities in accessing ideas, innovations, and research to grow and sustain productive businesses based on renewable energy sources.

This outcome aims to help answer pressing questions such as:

- How might a hydrogen/renewable energy outcome be optimised in the BSW region?
- What do the indicative supply and demand profiles look like for in-region entities to supply or source their energy needs sustainably?

4. Current State of Energy Supply and Demand in the BSW Region

6.1 Supply

6.1.1 Electricity

Almost all existing renewable energy generation and storage capacity in BSW corresponds to wind energy, except for a large-scale BESS, and small solar PV and waste-to-energy generators. In addition, an Open Cycle Gas Turbine (OCGT) operates in the region.

As portrayed in Figure 8, significant expansion of wind, solar and BESS is materialising, with the former expected to remain the main source of renewable energy. Moyne, Golden Plains, Glenelg and Corangamite concentrate 89% of new capacity to be installed (47%, 20%, 12% and 10% respectively).

If planned projects materialise, renewable energy generation capacity is expected to increase from 1,835 MW (plus 300 MW of battery storage – BESS) to 11,113 MW (plus 4,645 MW of BESS)[2].

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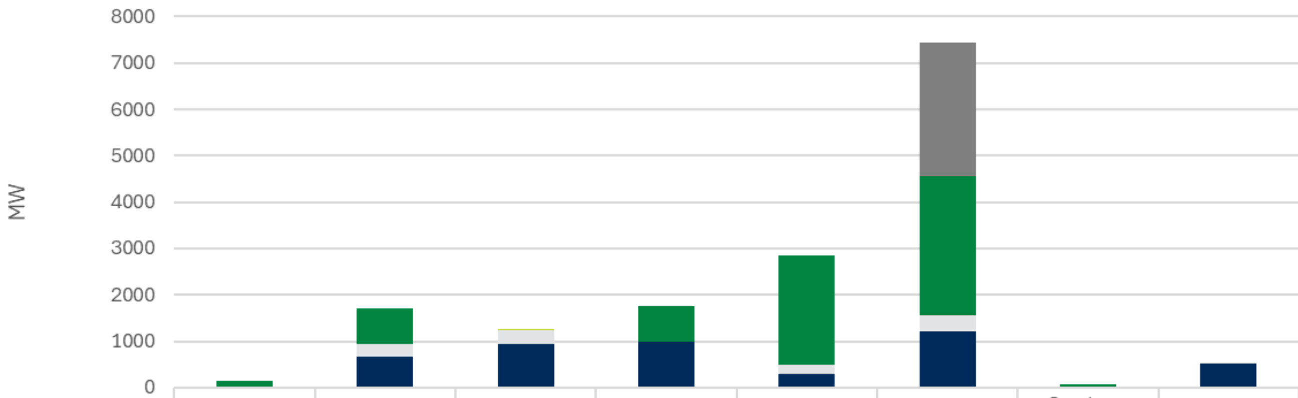
[2] Authors' construction based on NEM generation information as of October 2023 [20].

Figure 8. Existing and planned renewable energy in BSW per source and LGA



	Colac Otway	Corangamite	Geelong	Glenelg	Golden Plains	Moyne	Southern Grampians	Surf Coast
Wind offshore						2900		
Wind onshore	159	757		752	2345	2999	67	
Waste			2					
Solar		290	286		200	334		22
Battery Storage		660	950	1000	300	1216		519

Source: Authors' construction

The region benefits from existing high voltage transmission infrastructure. The 500 kV transmission line links Latrobe Valley areas and the major demand locations of Melbourne and Geelong metropolitan areas to the Portland Aluminium smelter. There is also a transmission line connecting Portland to South Australia via the Heywood interconnector. This high voltage transmission infrastructure provides opportunity for renewable generation to maximise output exported out of the Barwon region.

Notwithstanding, the existing transmission infrastructure in the Victoria South West REZ is estimated to be able to accommodate up to 1,850 MW of generation capacity, and increase to 3,000 MW in 2026-2027 once the Mortlake turn in project is commissioned, according to the AEMO 2024 Integrated System Plan (ISP)[1]. Thus, transmission and generation infrastructure coordination will be required for the planned capacities to be connected to the National Electricity Market (NEM). [8]

Distributed solar power is also a prominent source of renewable energy in the region (reaching approximately 140 MW), and along with wind is the communities preferred technology for renewable generation at present.

6.1.2 Gas

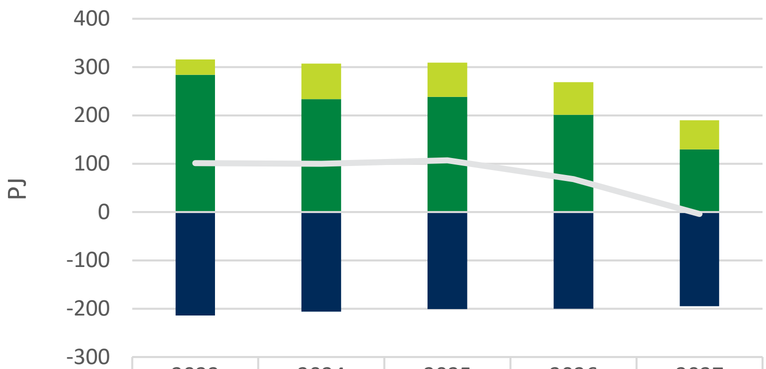
The Western zone (Otway Basin), surrounding Port Campbell, in Corangamite, is the second largest gas production area in Victoria. It is home to four gas processing plants, ten offshore gas production sites, an offshore platform, several gas fields, production pipelines, transmission infrastructure, and an extensive distribution network.

Furthermore, Iona is the largest independent gas storage facility in East Coast of Australia, which can store up to 23.5 PJ of gas underground. In this regard, ARENA funded H2RESTORE a feasibility study by Lochard Energy to store hydrogen underground in this site [9].

Some of the mentioned gas assets can be repurposed to transport and store hydrogen (all infrastructure is privately owned), albeit several complex logistical challenges need to be assessed beforehand. In the case of biogas/biomethane, since it is chemically almost identical to natural gas, the existing gas infrastructure (including end user appliances) could continue to be used without requiring repurposing investments.

Production of natural gas in Port Campbell reached 32 PJ in 2023 (10% of Victoria's output) and is expected to more than double in the coming years (reaching 32% of Victoria's output by 2027), as portrayed in Figure 9.

Figure 9. Natural gas output Victoria



	2023	2024	2025	2026	2027
Total Consumption	-214	-206	-201	-200	-195
Port Campbell	32	73	71	68	60
Gippsland	284	234	238	201	130
Surplus	101	100	107	68	-4

Source: Authors' construction based on [10]

Key points

- Almost all existing clean energy generation capacity in AEMO's database for BSW corresponds to wind energy, except for a large-scale BESS, and small solar PV and waste-to-energy generators.
- According to planned projects, BSW's renewable energy generation capacity is expected to increase from 1,833 MW (plus 300 MW of BESS) to 11,858 MW (plus 5,645 MW of BESS).
- Glenelg, Moyne and Golden Plains concentrate 81% of new capacity to be installed.

6.2 Demand

In this section current electricity and gas demand in the region are portrayed so that a high-level comparison can be made with the current state of energy supply depicted in the previous section.

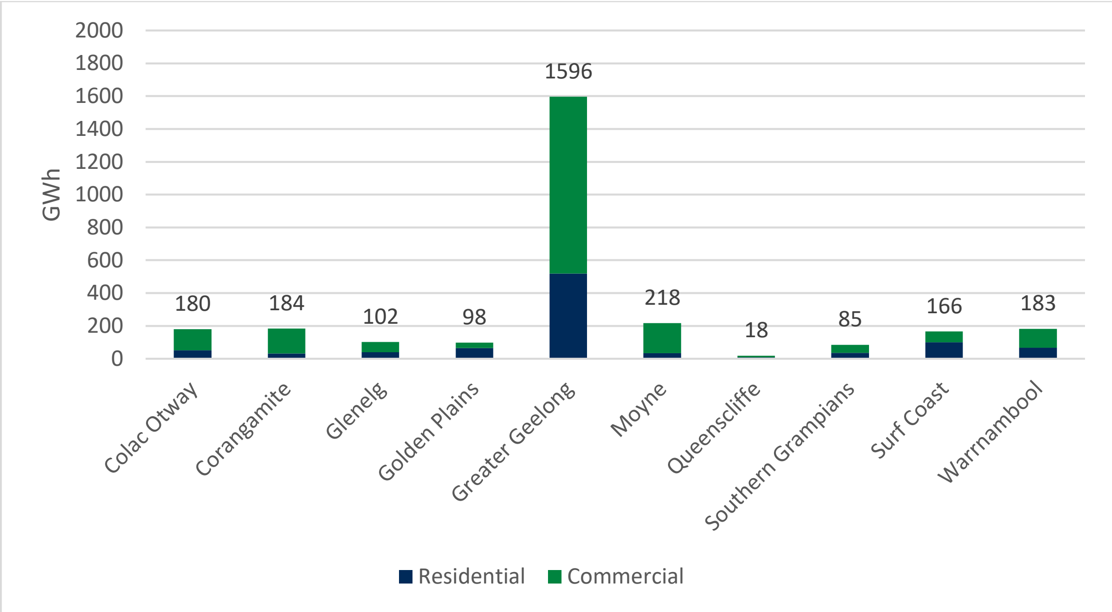
Further research surveying the energy consumption of large industries in hard to abate sectors in BSW is suggested so that the potential demand of renewable hydrogen and derivatives can be assessed. Focus is suggested on industries that consume natural gas as a feedstock, jet fuel at Avalon airport, fuel oil at the ports of Portland and Geelong, diesel by long haul trucks, steel by construction and building companies, fertilisers by the agriculture sector, hydrogenation by the Viva refinery and food industry, methanol by pharmaceuticals, paints and electronics, among other.

6.2.1 Electricity

As portrayed in Figure 10, net metered electricity in the distribution system (Powercor) reached 2,830 GWh in BSW in 2022. Almost half of it (46%) was consumed in Geelong.

In terms of customer categories, commercial tariffs accounted for 66% of this consumption, while residential customers explained the remaining 34%. There are approximately 43,404 commercial customers and 211,500 residential customers as of 2022 in BSW.

Figure 10. Electricity consumption per LGA in BSW as of 2022



Source: Authors' construction based on [11]

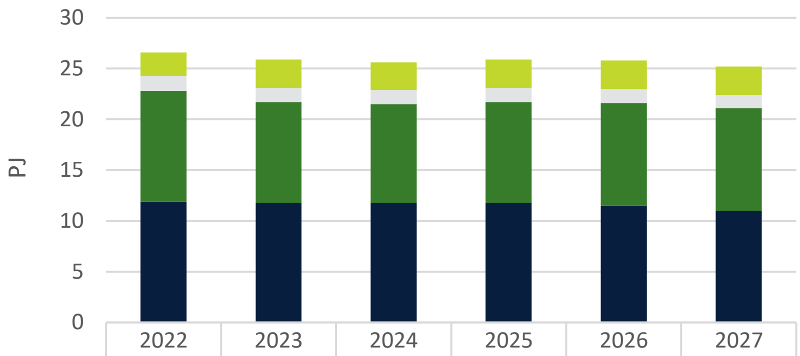
In addition, electricity is demanded by large market participants directly from the transmission system. For example, BSW is home to the largest electricity consumer in Victoria: the Alcoa owned Portland Aluminium Smelter, which consumes between 8% and 10% of Victoria's total electricity consumption[12]. Considering that the latter reached 49,118 GWh in 2022 [13], the smelter is estimated to consume up to 5,000 GWh per year.

6.2.2 Gas

Natural gas consumption reached 27 PJ in 2022 in BSW, of which Geelong demanded 86%. As portrayed in Figure 11 demand is expected to decrease slightly in the coming years.

Approximately half of demand is explained by industrial and large consumers (Tariff D), and half by small commercial and residential consumers.

Figure 11. Natural gas consumption in BSW



	2022	2023	2024	2025	2026	2027
Total	27	26	26	26	26	25
Western Tariff D	2.3	2.8	2.7	2.8	2.8	2.8
Western Tariff V	1.5	1.4	1.4	1.4	1.4	1.3
Geelong Tariff D	10.9	9.9	9.7	9.9	10.1	10.1
Geelong Tariff V	11.9	11.8	11.8	11.8	11.5	11

Note: Tariff D corresponds to industrial and large commercial customers, and Tariff V is small commercial and residential

Source: Authors' construction based on [10]

Key points

- Electricity demand in BSW at distribution level reached 2,830 GWh in 2022, of which Geelong uses almost half (46%). In addition, consumption at the transmission level is significant. Particularly, the Portland Aluminium Smelter, consumes between 3,930 GWh and 4,910 GWh.
- Gas demand as of 2023 is 27 PJ, Geelong concentrating 86%.

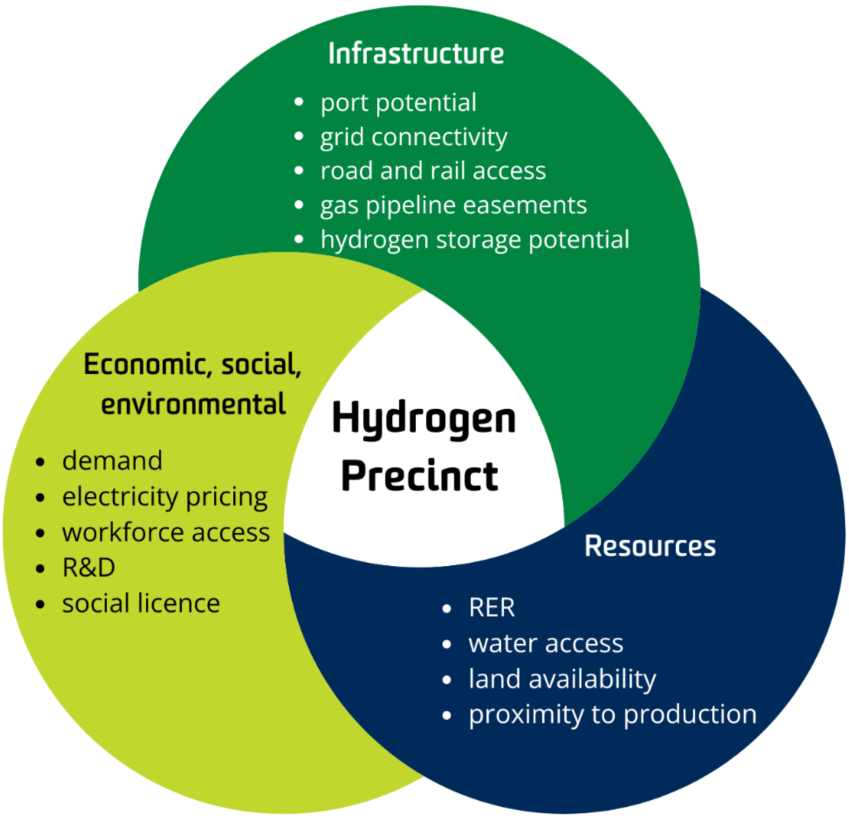
5. Barwon South West as a Hydrogen Precinct

Hydrogen precincts are regions where producers, users, and potential exporters of hydrogen across industrial, transport, export and energy markets are co-located, sharing infrastructure, expertise, and services. Hydrogen precincts are expected to help the hydrogen industry springboard to scale by [14]:

- lowering the cost of production (note the challenge of high labour costs vs overseas precincts),
- encouraging innovation,
- enhancing skills and training efforts.

As portrayed in Figure 12, several factors influence the location choice of a hydrogen precinct [15]:

Figure 12. Key factors of a Hydrogen Precinct



Source: Authors' construction

In

Table **1**, the main factors of BSW as a hydrogen precinct are highlighted. These are further discussed in the subsequent sections of the report.

Table 1. BSW as a hydrogen precinct

Criteria	Factor	Comments
Resources	Renewable energy potential	• South West Renewable Energy Zone (REZ). • Southern Ocean Offshore Wind Zone (OWZ). • High potential for bioenergy (biomass residues). • The BSW Renewable Energy Roadmap [16] suggests one quarter of Victoria's energy can be supplied by BSW.
	Water access	• 8 Groundwater Management Areas. • The largest, South West Limestone, has a Permissible Consumptive Volume of 85,000 ML/yr, extending from Glenelg to the western border of Colac Otway.
	Land availability and topography	• Mostly flat topography. • Large plots of land available.
	Proximity to prospective hydrogen production	• Six renewable hydrogen projects already announced.
Infrastructure	Port potential	• Deep-water ports in Portland and Geelong.
	Grid connectivity	• 500kV transmission line links the Portland Aluminium smelter to major demand nodes in Melbourne and Geelong metropolitan areas and further east to Latrobe Valley. • 275 kV line connects Portland to South Australia (Heywood interconnector).
	Road and rail access	• Princes highway runs across the region, connecting it with Adelaide to the west, and Melbourne and Sydney east. • Railway connection Warrnambool to Geelong (broad gauge), and Portland to Geelong (Western SG line, standard gauge).
	Gas pipeline easements	• Production pipelines from Otway basin and transmission and distribution networks across BSW.
	Hydrogen storage potential	• Iona, largest independent gas storage facility in the East Coast, can store up to 23.5 PJ underground (Lochard feasibility study to store hydrogen).

Economic, social, and environmental	Potential demand	• Geelong, Victoria's largest regional town, is a hub of industry and manufacturing, including a refinery. • Large energy consumers in Geelong, Warrnambool, Colac, and Portland. • Agriculture hub requiring fertilizers. • Proximity to Melbourne.
	Workforce access	• Employment in industries with transferable skills.
	Research and education institutions	• South West TAFE. • The Gordon TAFE. • Deakin University's Hycel Technology Hub, hydrogen research and education centre, operational in Warrnambool. • Deakin University's ManuFutures Tenants: Li-S Energy, Green Li-ion. • Deakin University's Carbon Nexus.
	Community acceptance	• Communities are supportive of hydrogen as a future fuel. • A coordinated approach to building social licence for renewable energy is required.

6. GIS Visualisation

Figure 13 provides GIS visualisation of the existing and planned renewable hydrogen and energy projects mapped and key hydrogen precinct factors of BSW. The visualisation includes renewable energy power generators connected to the NEM (wind, solar, waste, and BESS), other projects and partnerships (not NEM connected), key industry players, electricity transmission lines, gas pipelines, Groundwater Management Areas (GMA), main freight routes, airports, ports, and gas fields as potential locations for underground hydrogen storage. Each layer is disaggregated in Appendix II of this report.

Insights deriving from the mapping exercise and GIS visualisation include:

- Large investments expected in renewable energy capacity, mainly wind energy growing by a factor of 5.4 (large-scale offshore projects expected to reach 2,900 MW in the OWZ, and 5,246 MW planned onshore projects concentrated in Moyne, Golden Plains, Corangamite and Glenelg), complemented with solar PV at a smaller scale (planned projects totalling 1,132 MW).
- Given the intermittency of wind and solar, significant BESS capacity is planned to be deployed (4,345 MW, largest projects are in Glenelg and Geelong of up to 1,000 MW).

- Hydrogen production via electrolysis is the expected main pathway (although one project is considering biomass gasification also). More than 33,600 tons of renewable hydrogen and 300,000 tons of renewable methanol would be produced in the near term if planned projects materialise, requiring approximately 2,000 GWh of electricity per year in electrolysis and compression processes[3]. Ammonia production deriving from renewable hydrogen is planned in Geelong but no estimates on quantities are yet publicly available.
- Underground Hydrogen Storage (UHS) opportunities are being assessed at Iona, the largest underground storage capacity in east Australia. Lochard Energy received funding for a feasibility study at this site.
- Widespread presence of large industrial energy customers. These are particularly clustered in Geelong, Warrnambool and Colac. Furthermore, the region is home to the largest electricity consumer of Victoria: the Portland Aluminium Smelter, accounting for 8 to 10% of the State's demand.
- Two-deep water ports (Portland and Geelong) and the airport (Avalon) also consume significant energy, mostly sourced from fossil fuels. As net zero plans unravel, they could become demand centres for hydrogen derivatives such as methanol, ammonia, and/or other synthetic fuels (e.g. SAF, kerosene, gasoline, and/or others).
- As an agricultural hub, the region consumes a large amount of fertilisers, which are imported from other States and from abroad. The Incitec Pivot and Impact Fertilizers are both located in Geelong. There is an opportunity to build a local ammonia industry, and subsequently produce fertilisers such as Urea.
- BSW proximity to Melbourne brings several opportunities. E.g. Viva refinery's proposed pipeline from Altona to Melbourne airport, and HAMR Energy's MOU with Port of Melbourne to explore bunkering capabilities.
- Relevant electricity transmission capacity (except in Southern Grampians), gas pipelines (except in Southern Grampians and Golden Plains), and proximity to the main road freight corridor.
- Good access to water bodies. Notwithstanding, recycled water and desalination projects are being discussed.
- The manufacturing history aligns with a workforce possessing translatable skills, strong training / education through TAFE and presence of universities and research centres.

Figure 14 portrays further insights from a LGA perspective.

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[3] Considers 60 kWh/kg for hydrogen production and compression. Further electricity demand by processes such as refuelling stations, liquefaction, among other were not considered in the estimate.

Figure 13. GIS visualisation of existing and planned projects and key hydrogen precinct factors of BSW

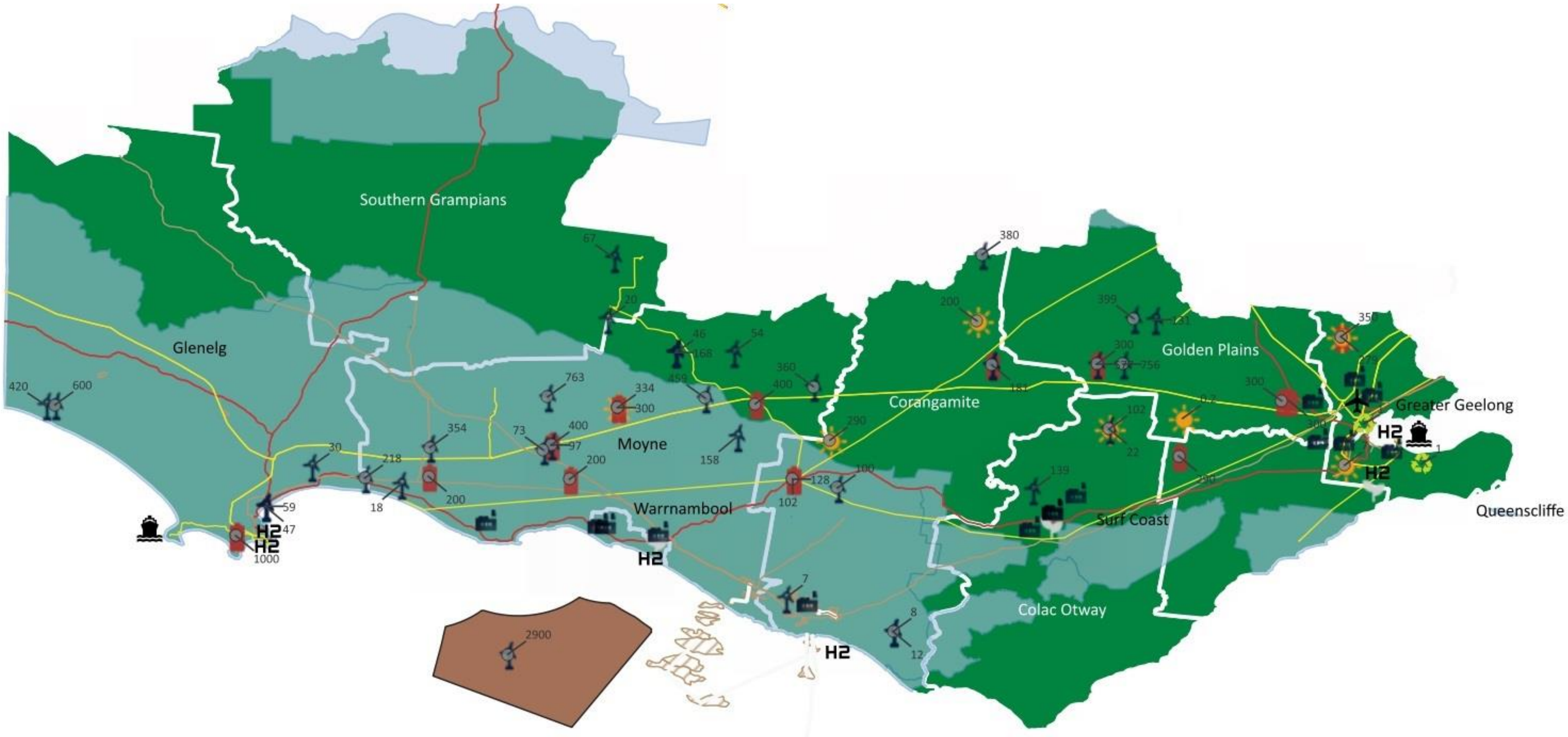


Figure 14. Implications of the investments according to LGA

Geelong

EXPECTED TO BE THE MAIN HYDROGEN DEMAND CENTER

- Hydrogen Demand: large energy consumers (chemicals production, refinery, manufacturing), potential at Avalon airport (SAF), Port of Geelong (ammonia/methanol), Freight corridor (H_2), proximity to Melbourne (airport, port, industries).
- Hydrogen Supply: two projects announced (Geelong Hydrogen Hub expected to produce approximately 1,000 tons/year, Geelong New Energies Service Station Project, expected to produce 365 tons/year.
- Power supply: solar PV and BESS projects operational and planned; H_2 production would require additional capacity or sourcing power from the grid or other LGAs.
- Infrastructure: proximity to 500 kV transmission line, freight corridor, and gas pipelines (connecting west to the Iona Gas Plant and east to the Brooklyn Compressor Station).

Glenelg (Portland)

EXPECTED TO BE THE MAIN HYDROGEN SUPPLY CENTER

- Hydrogen Supply: two large projects announced (Countrywide Hydrogen expected to produce 1600 tons/year and HAMR Energy expected to produce 30,000 tons/year and 300,000 tons of methanol/year). Biogenic carbon availability to produce methanol.
- Hydrogen Demand: potential at Port of Portland (ammonia/methanol), freight corridor (H_2) and large energy consumers.
- Power supply: Wind and BESS projects announced. Potential to generate with biomass residues.
- Water: access to the South West Limestone Groundwater Management Area, the largest in Victoria.
- Infrastructure: proximity to 500 kV transmission line, freight corridor, and gas pipelines (connecting to Allansford and the Aluminium Smelter).

Warrnambool and Colac

LARGE ENERGY CONSUMERS

- Hydrogen Demand: large energy consumers. A hydrogen project has been announced by Warrnambool Bus Lines, which aims to transition its fleet to fuel cell buses (FCEB), producing its own renewable hydrogen and deploying its own distribution center (HRS).
- Water: access to GMAs.
- Infrastructure: proximity to freight corridor, gas pipelines, and Colac to transmission lines.

Moyne, Golden Plains and Corangamite

EXPECTED TO CONCENTRATE MOST POWER CAPACITY

- Power supply: being at the heart of the REZ, they are expected to concentrate a large share of onshore wind, offshore wind (off the coast of Moyne), and BESS capacity.
- Hydrogen underground storage: In Corangamite, Iona could become a large underground hydrogen storage location (current capacity 23.5 PJ).

Source: Authors' construction

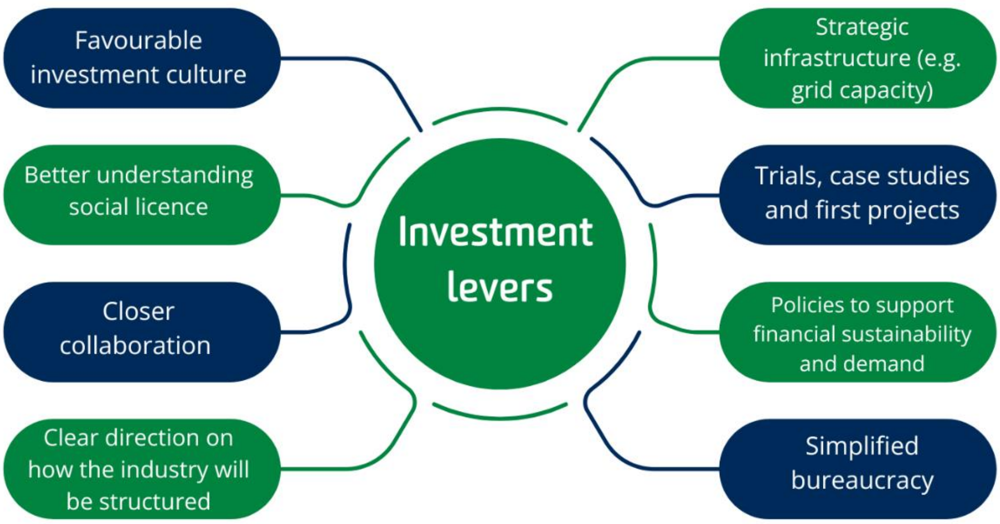
Key points

- Portland is expected to concentrate a large share of renewable hydrogen supply-side projects, and Geelong demand-side projects.
- Warrnambool and Colac concentrate several large energy consumers, with a hydrogen project announced in the former.
- Moyne, Golden Plains and Corangamite are in the heart of the REZ and are expected to concentrate a large share of onshore and offshore power production projects. The latter holds the largest opportunity for large-scale underground hydrogen storage services in East Australia.

7. Needs and Requirements of the Private Sector to confidently invest

Stakeholder consultation with BSW councils, water authorities and industry investigated issues including clean energy goals, energy needs and opportunities, energy investments, energy sources including hydrogen, and barriers for energy investment. Key insights from the stakeholder consultation regarding the needs and requirements of the private sector to confidently invest in renewable hydrogen and energy projects are summarised below and portrayed in Figure 15.

Figure 15. Needs and requirements of the private sector to confidently invest in the region



Source: Authors' construction

9.1 Policies to support financial sustainability and foster demand

Even though the private sector is increasingly incorporating Environmental, Social and Governance (ESG) considerations in its investment decisions, the need to achieve profits remains essential to their financial sustainability. Thus, private investments need a positive return on investment, or at least non-negative, in case ESG impacts are positive.

Wind and solar technologies have reached technology maturity and are currently the cheapest sources of power generation. Thus, they are currently deployed without significant public sector support. New technologies such as hydrogen and its derivatives are a different case, since at present they are more expensive than fossil fuel alternatives. Hence, there is a need for government support to bridge the commercial gap in the short to medium term.

At present, there is a lack of offtake partners willing to commit to buying renewable hydrogen and derivatives long term, since they anticipate a price reduction in the near future. Policies to foster demand would speed up deployment (e.g. targets and mandates).

9.2 Supporting trials, case studies and first projects

Many uncertainties arise when an investor is deciding to deploy a new technology. These range from timeline to receive regulatory approvals, actual costs and energy needs, supply, resource and infrastructure issues, among other.

Trials/case studies can be useful to collect initial information and are thus encouraged. Notwithstanding, trials lack relevant information for an investor to commit to long term investments. For example, a trial might prove that a technology works, but not provide information on maintenance costs, permit requirements and timing, among other.

Some stakeholders argued that supporting first projects would be beneficial to the broader investment community in shedding light to potential challenges not captured by trials. Some large users do not want to be the ‘first adopter’ of new technologies such as hydrogen fuelled machinery, since they want to see it proved first.

9.3 Clear direction

The renewable hydrogen sector is incipient worldwide, different countries/regions encouraging different deployment strategies. Investors currently face uncertainty in whether the sector will be structured as large scale and centralised investments, or small scale and decentralised.

Large scale infrastructure could grow to exporting products to other regions but could be detrimental to small scale decentralised infrastructure. As technology advances, the latter via mobile hydrogen refuellers with electrolysis on site could become significant to remote locations.

A clear intended direction, at federal and state level, is needed to materialise investments and avoid the risk of policy moving in a different direction.

Investors also require consistent policy over long time periods of time to make the large investments required.

9.4 Strategic infrastructure

Wind and solar are mature technologies, but they need transmission capacity if they are to be deployed at the scale needed and commercialised with third parties. Large project developers anticipate a challenge in deploying projects due to transmission capacity bottlenecks in the region.

Other essential infrastructure requirements if the region is to become a hydrogen precinct included water recycling/desalination, hydrogen refuelling stations (HRS), port bunkering capacity, storage locations, pipelines (adjustments and/or greenfield), among other.

A precinct mindset, concentrating essential infrastructure destined to improve regional benefits/prosperity, might incentivise investments that would not make economic sense as standalone projects. E.g. water utilities might invest in water recycling facilities if there is an opportunity to partner for oxygen offtake.

Arguably, BSW would benefit from funding at least partly these investments with public funds at suitable locations, to develop other local industries. E.g. agriculture, chemicals manufacturing, among other.

9.5 Simpler bureaucracy

Several stakeholders commented on planning issues and red tape. Renewable energy projects are facing delays, with some being dropped due to engagement fatigue. This was particularly stressed for offshore wind projects and the use of State land.

Some stakeholders noted that the Renewables Energy (Electricity) Act 2000 has not efficiently eased red tape issues, and that it would be beneficial to formulate a new Act in this regard. It was also noted that the Marine and Coastal Act can impact Electric Vehicle charging projects due to the non-coastal development restriction within 200 meters of the coast.

9.6 Better understanding social licence

There was a noted need to approach social licence holistically within the region to reduce the risk of engagement fatigue. This is vital as renewable energy projects increase in quantity and type. There was also a noted need to ensure community benefit is captured and retained in region. An effective, coordinated, and collaborative approach to social licence was raised as an immediate need.

Further, approaching the ‘value capture’ of renewable technologies, including affordable power for community and industry, high value sustainable jobs and mechanisms for mandating local content requirements were raised as potential actions.

9.7 Improved collaboration and communication

A lack of fluent and efficient communication and collaboration with the parties that will be associated and/or influence the projects was raised as a barrier. Investors, suppliers, consumers, regulatory authorities, and other government institutions collaborating more closely would, arguably, speed up the deployment of these technologies.

To address communication and collaboration issues between parties, and red tape concerns mentioned above, it is suggested that a more formal dialogue between stakeholders and representatives from the relevant bureaucracies be initiated as a first step. That will enable to work out the more specific issues of the relevant parties and what can be done to address those issues in an effective manner.

8. Obtaining and strengthening social licence

The BSW region has had sustained engagement with renewable energy developments, dating back to the first wind tower commissioned at Breamlea in 1987. Since then, there have been a range of wind, solar, battery and hydrogen developments which have engaged in social license programs to varied success and impact.

Federal, State, and peak body reviews into community engagement and social licence best practice approaches have recently been developed or are in development. The Federal Government's 2023 Community Engagement Review [17] indicated the need to improve the engagement process, reduce unnecessary and elongated engagement, implement best practice complaint handling, improve community understanding and identify sustainable benefit sharing. The Victorian Transmission Investment Plan is in development, which has included consultation regarding community benefit sharing mechanisms. The Clean Energy Council has developed best practice approaches to social licence building, including the Best Practice Charter for Renewable Energy Projects [18]. Indigenous engagement in renewable energy infrastructure is extremely important, and mechanisms such as the Hydrogen Headstart Indigenous Engagement fund demonstrate a need to skill Indigenous communities in responding to the transition.

In 2019, extensive consultation regarding renewable energy social licence through the Barwon South West Renewable Energy Roadmap outlined the following:

- **Community support:** there was strong support for the continued development of renewable energy in BSW.
- **Technologies:** wind and solar were known, proven and preferred.
- **Benefit sharing:** community benefit sharing was important to obtain and maintain social license.
- **Strategic approach:** renewable energy planning was viewed as disorganized and not planned strategically.
- **Bureaucracy:** rules and regulations were viewed as complex and a barrier to community involvement.

Consultation with key stakeholders in 2024 revealed the following:

- **Community support:** there was uneven community support across the region, with some communities expressing fatigue and others an eagerness to be involved in piloted renewable energy projects. In some areas there was concern that land would be used to generate renewable energy for metro areas, with little benefit to regional communities. In others there was concern that prime agricultural land would be repurposed from food production to energy production. While this report discusses BSW as a region, it is important when obtaining and strengthening social licence to understand and respond to the nuances of each community and to recognise that community support may vary from one renewable energy project to another. In the case of the lesser known and upcoming energy source, hydrogen, research into community perceptions undertaken by Deakin University in 2021 indicated complex community perceptions. However, of the 76% respondents who were supportive of hydrogen, support was given for the potential of 'clean energy', the opportunity for the region to be energy pioneers and the potential for job creation.
- **Technologies:** solar and batteries were raised as known, preferred and attainable sources of energy. Social licence for wind is uneven across the region and dependent on specific communities, and whether it is on or offshore. Hydrogen and biochar were known technologies but viewed as future

energy sources/projects. For hydrogen, barriers were identified in terms of fuel security and the cost of fleet transition. Hycel's perception research indicates that support for hydrogen is high, but knowledge is low.

- **Benefit sharing:** there has been an uneven benefit sharing experience across the region, dependent on specific council and proponent approaches. Interviews highlighted the desire to deepen the community benefit by focusing on longer term or regional projects that respond to broad community issues, rather than discrete community projects. There was also a desire to articulate the regional value of energy projects. Value was discussed in terms of job creation, articulation of renewable energy pathways, upskilling and addressing areas of regional priority (e.g. educational attainment, housing). The mechanism for benefit sharing was also raised so that communities could gain the most benefit from energy projects.
- **Strategic approach:** a coordinated approach to social licence is needed to prevent community engagement fatigue. It was suggested that the two regions – Great South Coast and G21 – identify a mechanism (e.g. established regional group) to advocate for a coordinated approach to community engagement, benefit sharing and sustainment of social licence. There are established renewable energy groups such as the Barwon South West Climate Alliance, who could act in this manner.
- **Bureaucracy:** the disconnection between the planning approval system, which sits at the State level, and the experience of energy project developments, which is at the local level, was raised as an issue. Timing was also raised, with some energy projects engaging too late with communities to achieve any benefit.

There is an opportunity in the BSW to take a proactive approach to social licence in the energy transition. With increasing volume and complexity of energy projects it is important to strategically consider how to best benefit the region.

Key points

- There is uneven community support across the region for renewable technologies; it is important to understand and respond to the nuances of each community and to recognise that community support may vary from one renewable energy project to another.
- Solar and batteries were raised as known, preferred and attainable sources of energy whereas social licence for wind is uneven. Hydrogen and biochar were raised as known technologies but viewed as future energy projects.
- There is a desire to better articulate, distribute and retain the community benefits across the region.
- A coordinated approach to social licence is needed to prevent community engagement fatigue, with the mechanism to be developed.
- The disconnection between the approval systems, the local experience and the timing of community engagement was raised as issues of concern.

9. Concluding remarks and recommendations

The purpose of this Project was to investigate the current state of renewable hydrogen and renewable energy investment in BSW.

The mapping exercise of existing and planned public and private sector investments suggests that the region expects a significant deployment of projects. Renewable energy generation capacity in BSW would increase from 1,835 MW (plus 300 MW of BESS) at present to 11,113 MW (plus 4,645 MW of BESS) in the near-to-mid-term. Moyne, Golden Plains, Glenelg and Corangamite concentrate 89% of the planned projects mapped (47%, 20%, 12% and 10% respectively).

Renewable hydrogen projects announced are expected to produce more than 33,600 tons/year, and 300,000 tons of methanol/year. Electrolysis is the main expected production pathway, but one project in Portland aims to also produce via biomass gasification.

BSW presents several key factors needed to become a leading hydrogen precinct:

- High quality of renewable energy resources (particularly wind).
- Presence of large industries.
- Two-deep water ports and an airport.
- Baseline infrastructure in terms of electricity transmission, gas pipelines, and proximity to the main freight corridor.
- Access to water bodies.
- Availability of biogenic CO_2 to produce renewable methanol.
- Workforce availability and presence of training / education institutions and universities.
- Land availability.
- Social licence benchmarks.
- Underground Hydrogen Storage potential.
- Consumption of fertilisers.
- Proximity to Melbourne.

Relevant Regional Development entities and State Government institutions can provide a leadership role in progressing the following recommendations to enable these investments and maximise their benefits.

1. Enact consistent policy that enables financial sustainability of renewable hydrogen and derivatives projects (e.g. help bridge the ‘green premium’ vs. fossil fuel alternatives).
2. Support the development of essential infrastructure for the energy transition – specifically grid capacity, water planning, pipelines, and distribution centres, among other.
3. Review the complexity of planning rules to streamline relevant processes and response times.
4. Facilitate closer collaboration between investors, government entities, and supply-chain partners. by initiating a more formal dialogue between them. That will enable to work out the more specific issues of the relevant parties and what can be done to address those issues in an effective manner, including the red tape concerns mentioned above.
5. Support communities and proponents to take a holistic approach to renewable energy and hydrogen social licence development and maintenance that is sector based rather than project based so that value is captured in the region.

6. Undertake a comprehensive survey of the energy consumption per process of industries in hard to abate sectors to better understand strategic infrastructure requirement and implementation timeframes, policy requirements and impacts.
7. Support development of a knowledge bank / repository and training to upskill and share information regarding renewable energy developments and decision making. Aggregate ideas and knowledge.

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Appendix I: Definitions

Bioenergy	Bioenergy is a form of renewable energy generated from the conversion of biomass into heat, electricity, biogas and liquid fuels. Biomass is organic matter derived from forestry, agriculture or waste streams available on a renewable basis. It can also include combustible components of municipal solid waste [19].
Existing project	For power generators, when the following conditions have been met: the individual Generating Unit plant has been commissioned on-site by the EPC / Operator, an “Application for Registration as a Generator in the NEM” has been lodged with AEMO Registrations (which includes that Generating Unit), and Energisation of the relevant Transmission Network Connection Point or Distribution Network Connection Point has been signed-off by AEMO Network Development [20].
Groundwater Management Area (GMA)	Area where groundwater has been intensively developed or has the potential to be. GMAs have boundaries defined for the purposes of setting a PCV for ongoing management [21].
Groundwater Management Area (GMU)	Areas where specific rules are used to manage the resource according to the needs of groundwater users and the environment. There are two types of Groundwater Management Units: Water Supply Protection Areas, and Groundwater Management Areas [21].
Homogeneous Flow Length	Traffic volume information associated with the traffic flow along a link that is representative of all travel along the whole link. A link is a homogeneous segment of a route. An inter-modal facility, where people/freight are transferred from one mode to another, is also a link [22].
Hydrogen precinct	Region where various producers, users, and potential exporters of hydrogen across industrial, transport, export and energy markets are co-located, sharing infrastructure, expertise, and services. Factors influencing hubs site choice include: access to demand, land availability and ownership, port potential (including current capacity, shipping distance and scalability), grid connectivity, road and rail infrastructure access, access to existing gas transmission pipeline easements, water access, economic, social and environmental factors (such as workforce access, weather, safety and other factors), stakeholder and community interest and acceptance, proximity to prospective hydrogen production regions, potential for hydrogen storage, electricity pricing [15].
Nameplate capacity	Maximum continuous output or consumption (in MW), as specified by the manufacturer, or as subsequently modified [20].

Permissible Consumptive Volume (PCV)	Cap set by the Minister for Water. It is the maximum volume of water that can be allocated for consumptive purposes in an area or from a water system over a specified time period. The Minister can declare a PCV by Order published in the Government Gazette for: surface water and groundwater, surface water only, groundwater only. PCVs are imposed to protect the resource and prevent it from being depleted or causing adverse impacts such as: loss of water supply, reduced base flows in rivers and streams, changes to water quality, saline intrusion. A limit on entitlements provides certainty to water users about how much they can extract while also protecting water for the environment. If the PCV is reached and a user wants access to water or to increase their current entitlement volume, they will need to trade a volume of water from another entitlement holder in the area [21].
Planned project	For power generators, when not all conditions of an “Existing Project” have been met.
Renewable energy	Renewable energy is produced using natural resources that are constantly replaced and do not run out. Just as there are many natural sources of energy, there are many renewable energy technologies. Renewable energy types include Solar, Wind, Hydro, Geothermal, Bioenergy, and Ocean energy [23].
Renewable hydrogen	There are different pathways to produce renewable hydrogen. In this document electrolysis using renewable energy is the focus as it is expected to become the prominent production method. It is notwithstanding important to recognise other zero emissions production methods, such as biomethane reforming and biomass gasification. Electrolysis is the process of using electricity to split water into hydrogen and oxygen molecules, using an electrolyser [24].
Renewable methanol	Renewable methanol can be produced using renewable energy and renewable feedstocks via two routes. The first one is Bio-methanol, produced from biomass. Key potential sustainable biomass feedstocks include forestry and agricultural waste and by-products, biogas from landfill, sewage, municipal solid waste (MSW) and black liquor from the pulp and paper industry. The second one is green e-methanol, which is obtained by using CO_2 captured from renewable sources (bioenergy with carbon capture and storage (CCS) and direct air capture (DAC)) and hydrogen produced with renewable energy [25].
Route number	Statewide Route Numbering System (SRNS) class is one of M, A, B or C representing the route classification, and 1-, 2- or 3-digit integer representing the route number [22].
Storage capacity	Derives from multiplying nameplate capacity and storage duration. The latter is the amount of time that storage can discharge at capacity before being depleted. E.g., a 1 MW battery with 4 MWh of storage capacity has 4 hours of storage duration [26].

Appendix II: GIS layers

4.2.1. Battery energy storage systems

Figure 16. BESS existing and planned projects

Source: Authors' construction

Table 2. BESS existing and planned projects

LGA	Status	Nameplate Capacity (MW)	Storage Capacity (MWh)	Site Name	Owner
Geelong	Existing	300	450	Victorian Big Battery	Victorian Big Battery Pty Ltd
Corangamite	Planned	60	120	Berrybank 1 BESS - Storage - KCI	Global Power Generation Australia Pty Ltd
Corangamite	Planned	200	400	Dalvui BESS	Tilt Renewables Australia Pty Ltd
Surf Coast	Planned	290	550	Gnarwarre BESS Facility	ACEnergy Pty Ltd
Golden Plains	Planned	300	600	Golden Plains BESS	Tag Energy Australia P/L
Corangamite	Planned	400		Haunted Gully BESS - KCI	Vena Energy Services (Australia) Pty

Moyne	Planned	400		Hawkesdale BESS - Storage - KCI	Envervest Pty Ltd
Geelong	Planned	350	770	Little River BESS	ACEnergy Pty Ltd
Moyne	Planned	300	600	Mortlake Battery	BORAL
Moyne	Planned	316.08	600	Mortlake Energy Hub	brightnightpower_NR
Glenelg	Planned	1000	2000	Pacific Green Energy Park	Pacific Green
Moyne	Planned	200	400	Tarrone BESS - Storage - KCI	Global Power Generation Australia Pty Ltd
Surf Coast	Planned	127.6	220	Terang Battery Energy Storage System	Acenergy Pty Ltd
Surf Coast	Planned	101.5	200	Terang BESS	frv_NR
Geelong	Planned	300	1200	Victorian Big Battery 2	Neoen Australia Pty Ltd

Source: Authors' construction based on [20]

Key points

- There is 1 existing BESS in the region (Victorian Big Battery in Geelong) with 450 MWh storage capacity, and 15 planned projects.
- Projects are dispersed in several LGAs excluding Southern Grampians and Colac Otway.
- Largest projects are in Glenelg and Geelong, ranging between 1200 MWh and 2000 MWh of storage capacity.

4.2.2. Solar photovoltaic power generation

Figure 17. Solar PV existing and planned projects

Source: Authors' construction based on [20]

Table 3. Solar PV existing and planned projects

LGA	Status	Technology Type	Nameplate Capacity (MW)	Site Name	Owner
Geelong	Existing	Solar PV - Fixed	0.2	Cedar Meats Solar Geelong	Cedar Meats
Geelong	Planned	Solar PV - Single axis tracking	7.25	Deakin University Renewable Energy Microgrid	Deakin university & AusNet Services Ltd
Corangamite	Planned	Solar PV - Fixed	290	Bookaar Solar Farm	Infinergy Australia Pty ltd
Surf Coast	Planned	Solar PV - Fixed	22	Inverleigh Solar Farm	TBA
Geelong	Planned	Solar PV - Fixed	279	Little River Solar Farm - KCI	Clean Technology Partners
Moyne	Planned	Solar PV - Single axis tracking	330	Mortlake Energy Hub	BrightNight Power
Golden Plains	Planned	Solar PV - Fixed	200	Willowvale Solar Farm - KCI	Elgin Energy Pty Ltd

Source: Authors' construction based on [20]

Key points

- There is 1 existing small solar PV farm in Geelong (Cedar Meats), and 6 mid to large scale planned projects.
- The largest planned projects are in Moyne, Corangamite, Geelong, and Golden Plains. Their capacity ranges between 200 and 334 MW.

4.2.3. Waste-to-energy power generation

Figure 18. Waste-to-energy existing and planned projects

Source: Authors' construction based on [20]

Table 4. Waste/biomass existing and planned projects

LGA	Status	Technology Type	Nameplate Capacity (MW)	Site Name	Owner
Geelong	Existing	Reciprocating Engine - Spark ignition	1	Corio	EDL LFG Vic Pty Ltd
Geelong	Existing	Reciprocating Engine - Spark ignition	1.06	Drysdale	LMS_NR

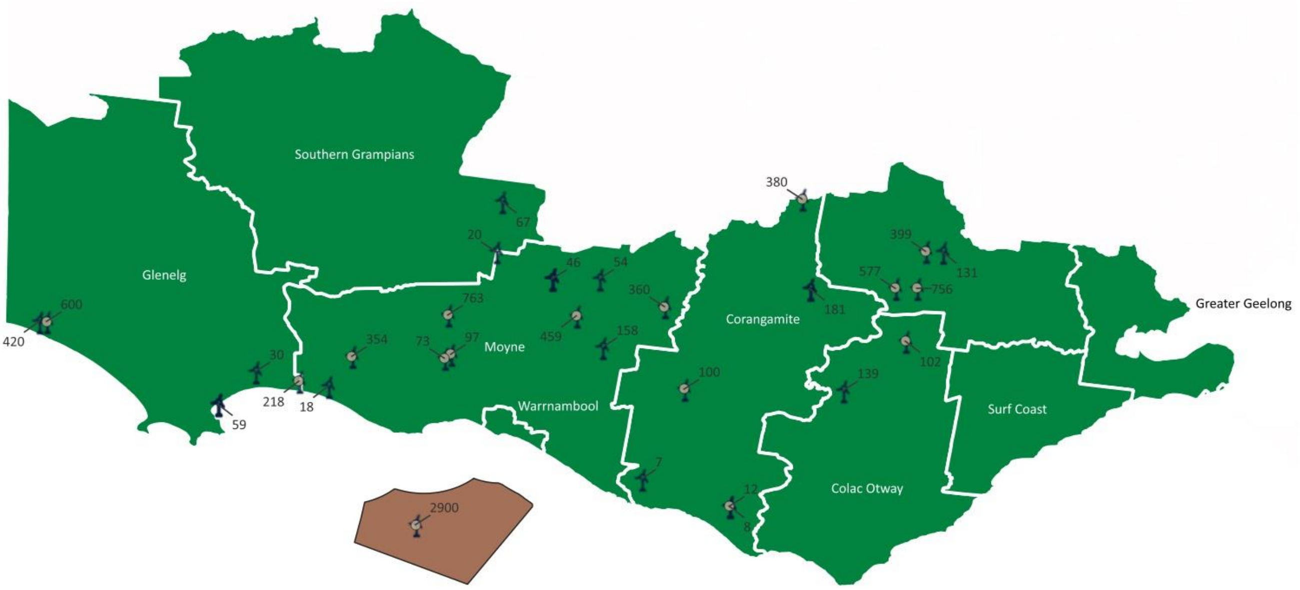
Source: Authors' construction based on [20]

Key points

- There are only 2 existing small waste-to-energy power generation plants operating in the region. Both are located in Geelong (Corio and Drysdale) producing biogas from landfill waste, each with a capacity of approximately 1 MW.
- Significant biomass/bioenergy potential as highlighted in the BSW renewable energy roadmap: 1.35 million tons of residues are produced (of which 75% are plantation, straw/chaff, and sawmill).

4.2.4. Wind

Figure 19. Wind existing and planned projects



Source: Authors' construction based on [20]

Table 5. Wind existing and planned projects

LGA	Status	Technology Type	Nameplate Capacity (MW)	Site Name	Owner
Corangamite	Existing	Onshore	109.2	Berrybank Wind Farm	Berrybank Development Pty ltd
Corangamite	Existing	Onshore	180.6	Berrybank Wind Farm	Berrybank Development Pty ltd
Moyne	Existing	Onshore	18.2	Codrington Wind Farm	Energy Pacific (Vic) Pty Ltd
Moyne	Existing	Onshore	168	Dundonnell Wind Farm	Tilt Renewables

Moyne	Existing	Onshore	46.2	Dundonnell Wind Farm	Tilt Renewables
Moyne	Existing	Onshore	121.8	Dundonnell Wind Farm	Tilt Renewables
Colac Otway	Existing	Onshore	12	Ferguson Wind Farm	Ferguson Wind Farm Pty Ltd
Moyne	Existing	Onshore	420	Macarthur Wind Farm	Macarthur Wind Farm Pty Ltd and Meridian Wind Macarthur Pty Ltd
Moyne	Existing	Onshore	157.5	Mortlake South Wind Farm	Mortlake South Wind Farm Pty Ltd
Moyne	Existing	Onshore	19.5	Mortons Lane Wind Farm	Mortons Lane Windfarm Pty Ltd
Colac Otway	Existing	Onshore	138.6	Mt Gellibrand Wind Farm	ACCIONA Energy
Golden Plains	Existing	Onshore	131.2	Mt Mercer Wind Farm	Mt Mercer Windfarm Pty Ltd
Southern Grampians	Existing	Onshore	67.2	Oaklands Hill Wind Farm	Oaklands Hill Wind farm pty ltd
Glenelg	Existing	Onshore	45.1	Portland Wind Farm	Pacific Hydro Portland Wind Farm Pty Ltd
Glenelg	Existing	Onshore	47.15	Portland Wind Farm	Pacific Hydro Portland Wind Farm Pty Ltd
Glenelg	Existing	Onshore	59.45	Portland Wind Farm	Pacific Hydro Portland Wind Farm Pty Ltd
Moyne	Existing	Onshore	54	Salt Creek Wind Farm	Salt Creek Wind Farm Pty Ltd
Corangamite	Existing	Onshore	7.2	Timboon West Wind Farm	Timboon West Wind Farm Pty Ltd
Moyne	Existing	Onshore	30	Yambuk	Energy Pacific Vic Pty Ltd
Corangamite	Project	Onshore	360	Darlington Wind Farm - GPG	globalpower-generation_NR
Colac Otway	Project	Onshore	8	Ferguson South Wind Farm	Ferguson Wind Farm Pty Ltd

Golden Plains	Project	Onshore	756.4	Golden Plains Wind Farm East	TagEnergy Golden Plains Investments Pty Ltd
Golden Plains	Project	Onshore	576.6	Golden Plains Wind Farm West	WestWind Energy
Moyne	Project	Onshore	96.6	Hawkesdale Wind Farm	Hawkesdale Asset Pty Ltd as trustee for Hawkesdale Asset Trust
Moyne	Project	Onshore	763	Hexham	Wind Prospect WA Pty Ltd
Golden Plains	Project	Onshore	102	Inverleigh Wind Farm	Inverleigh Wind Farm Pty Ltd
Glenelg	Project	Onshore	600	Kentbruck Green Power Hub	Neoen Australia Pty Ltd
Golden Plains	Project	Onshore	399	Meredith Wind Farm - KCI	Acciona Energy Global Australia
Golden Plains	Project	Onshore	380	Moreton Hill Wind Farm	Moreton Hill Wind Farm Nominees Pty Ltd
Moyne	Project	Onshore	459	Mount Fyans	Woolnorth Wind Farm Holding
Moyne	Project	Onshore	218.4	Ryan Corner Wind Farm	Ryan Corner Development Pty Ltd
Corangamite	Project	Onshore	100	Naroghid	Alinta Energy Retail Sales Pty Ltd
Moyne	Project	Onshore	354	Willatook	Wind Prospect WA Pty Ltd
Moyne	Project	Onshore	73	Woolsthorpe Wind Farm	Woolsthorpe Wind Farm Pty Ltd
Moyne	Project	Offshore	2900	Expected capacity as announced.	

Source: Authors' construction based on [20]

Key points

- Existing wind energy capacity reaches 1833 MW (19 farms), while planned investments total 8,146 MW. Capacity is thus expected to grow by a factor of 5.4 if planned projects materialise.
- Existing projects are onshore, and their capacity ranges between 7.2 MW and 420 MW.
- Planned projects are mostly large scale. Large offshore projects are expected off the coast of Moyne, with a total capacity of 2,900 MW.

4.2.5. Other clean energy projects

Figure 20. Other clean energy existing and planned projects

Source: Authors' construction

Table 6. Other clean energy existing and planned projects

LGA	Status	Proponent	Project Name	Fuel	Expected power production (GWh)	Other output
Colac	Planned	Barwon Water	The Colac Renewable Organics Network (Colac RON)	Waste	5.5	Biochar
Geelong	Planned	Barwon Water	The Regional RON at Black Rock (RRON)	Waste	16.7	Biochar
Warrnambool	Planned	Saputo Dairy Australia Pty Ltd	Allansford cheese and whey plant	Waste	35.5*	

*Authors' estimate based on an announced capacity of 4.5 MW, assuming 90% utilization factor.

Source: Author's construction

4.2.6. Key industry players

Figure 21. Key industry players

Source: Authors' construction

Table 7. Key industry players

LGA	Name	Sector
Otway	Boggy Creek Facility (BOC group)	Oil and gas
Geelong	Little Creatures Brewery	Brewery
Colac	Bulla (Connor St)	Dairy
Colac	Bulla (Forest St)	Dairy
Warrnambool	Great Ocean Ingredients	Food processing
Colac	Associated Kiln Driers	Softwood sawmilling
Colac	Australian Lamb	Meat production
Geelong	Turosi	Food solutions group
Geelong	MC Herd Property Limited	Meat and food processing
Warrnambool	Midfield Protein Solutions	Protein extraction facility
Geelong	Chemring Australia	Countermeasures manufacturing facility
Geelong	Fulton Hogan Industries	Asphalt plant
Warrnambool	Futon Hogan Industries	Asphalt plant
Moyne	Sun pharmaceutical industries	Pharmaceutical
Geelong	Godfrey Hirst	Carpet manufacturing

Source: Authors' construction based on information sent by DEECA

4.2.7. Ports and Airports

Figure 22. Ports and airports

Source: Authors' construction

Table 8. Ports and airports

LGA	Type	Name
Geelong	Airport	Avalon Airport
Glenelg	Port	Port of Portland
Geelong	Port	Geelong Port

Source: Authors' construction

Key points

- There are two deep-water ports in BSW (Geelong and Portland), which could demand H_2 derivatives and provide bunkeringin the future.
- Avalon airport could become a demand for Sustainable Aviation Fuels (e.g. produced via renewable methanol route).
- Proximity to Melbourne airport (Tullamarine) and Port of Melbourne (E.g. Viva refinery proposed pipeline to Tullamarine, and HAMR Energy's MOU with Port of Melbourne to explore bunkering capabilities).

4.2.8. Renewable Hydrogen Projects

Figure 23. Renewable Hydrogen existing and planned projects

Source: Authors' construction

Table 9. Hydrogen existing and planned projects

LGA	Status	Project Name	Main proponent	Production method	Capacity Electrolyser (MW)	H2 ton/y	Derivatives ton/y	End use
Glenelg	Planned	Hydrogen Portland Project	Countrywide Hydrogen	Electrolysis	10	1,600		Stage 1: Mobility/gas, Stage 2: Ammonia export
Glenelg	Planned	Portland Renewable Fuels	HAMR Energy	Electrolysis/ Gasification	220	30,000	300,000 methanol	Maritime
Warrnambool	Planned	Warrnambool Hydrogen Mobility Project	Warrnambool Bus Lines	Electrolysis	1	128*		Mobility
Geelong	Planned	Geelong Hydrogen Hub	Geelong Port, Fortescue Future Industries	Electrolysis	7*	913*	Ammonia	Export

Geelong	Planned	Geelong New Energies	Viva Energy	Electrolysis	2.5	365		Mobility
Corangamite	Planned	H2RESTORE	Lochard Energy	Electrolysis and Storage	2-5	256 – 639*		Stage 1: Grid firming, Stage 2: Derivatives

*Authors' estimate assuming 0.35 ton/MW/day.

Source: Authors' construction based on CSIRO Hydrogen Map and desktop research. Link: https://www.csiro.au/hydrogen-map

Key points

- There are 6 announced hydrogen projects in the region, concentrated in Portland, Geelong, Warrnambool and Corangamite.
- All projects involve electrolysis (one hybrid with gasification), and target different end uses, including mobility, gas blending, and export.

4.2.9. Electricity transmission lines

Figure 24. Electricity transmission lines

Source: Authors' construction

Table 10. Electricity transmission lines

Line	Capacity (kV)
Heywood Terminal to Portland Aluminium	500
Tarrone Terminal to Heywood Terminal	500
Tarrone Terminal to McArthur Zone	500
Moorabool Terminal to Tarrone Terminal	500
Cape Bridgewater Substation to Cape Nelson North Tee	66
Cape Nelson South Substation to Cape Nelson South Tee	66
Cape Sir William Grant Wind Farm Tee to Cape Nelson South Tee	66
Heywood Terminal to South East	275
McArthur Wind Farm to McArthur Zone Substation	66
Terang Terminal to Yambuk-Codrington Wind Farms	66
Terang Terminal to Oakland Hills Wind Farm Tee	66
Terang Terminal to Oakland Hills Wind Farm	66
Terang Terminal to Ballarat Terminal	220
Terang Terminal to Moorabool Terminal	220
Anglesea Power Station to Point Henry	220
Point Henry to Geelong Terminal	220
Geelong Terminal to Moorabool Terminal	220
Moorabool Terminal to Ballarat Terminal	220
Elaine to Mt Mercer	132
Wyndham Power Station to Geelong Terminal	66
Deer Park to Geelong Terminal	220
Moorabool Terminal to Sydenham Terminal	500

Source: Authors' construction based on DATA VIC as of January 2024. Link: https://discover.data.vic.gov.au/dataset/vicmap-infrastructure-power-line

Key points

- The region has widespread high voltage transmission connectivity, with a 500 kV line connecting it with major demand centres (e.g. Melbourne).
- Notwithstanding, transmission and generation coordination will be required to successfully deploy planned projects.

4.2.10. Freight routes

Figure 25. Freight routes

Source: Authors' construction

Table 11. Freight routes

Route Number	Road name	Homogeneous Flow Length (kms)	Volume of trucks (thousands/year)
A1	PRINCES HIGHWAY	742	21,231
A10	CORIO-WAURN PONDS ROAD	40	60,464
A200	HENTY HIGHWAY	452	5,692
A300	MIDLAND HIGHWAY	88	9,125
M1	PRINCES FREEWAY WEST	98	46,921

Source: Authors' construction based on Department of Transport Open Data Hub as of January 2024. Link: https://vicroadsopendata-vicroadsmaps.opendata.arcgis.com/datasets/vicroadsmaps::traffic-volume/about

Key points

- Key interstate freight corridor runs across the region.
- High potential of H_2 demand by Princes Highway mobility as heavy duty transports pursues decarbonisation strategies.

4.2.11. Gas fields

Figure 26. Gas fields

Source: Authors' construction

Table 12. Gas fields

Type	Site
Onshore	Iona
Onshore	Wallaby Creek
Onshore	North Paaratte
Onshore	Mylor
Onshore	Fenton Creek
Onshore	Penryn
Onshore	McIntee
Onshore	Tregony
Onshore	Dunbar
Onshore	Skull Creek
Onshore	Wild Dog Road
Onshore	Croft
Onshore	Seamer
Offshore	Enterprise
Offshore	Minerva
Onshore	Speculant
Offshore	Halldale
Offshore	Black Watch
Onshore	Martha
Offshore	Pecten East
Offshore	Netherby
Offshore	Henry
Offshore	Casino
Offshore	Labella
Offshore	Geographe

Offshore	Thylacine

Source: Authors' construction based on [27]

Key points

- Depleted gas fields in the Otway Basin (surrounding Port Campbell, in Corangamite) offer a unique opportunity for geological H_2 storage.
- Iona, operated by Lochard Energy, is the largest provider of storage services to the East Coast gas market, with a capacity of 23.5 PJ (Injection capacity 155 TJ/d and Withdrawal 500 TJ/d).

4.2.12. Gas pipelines

Figure 27. Gas pipelines

Source: Authors' construction

Table 13. Gas pipelines

Type	Diam (mm)	Pressure (kilopascals)	Depth (m)	Length (km)	Pipeline	Company
Onshore	200	2760		15.8	Portland City Gate to Portland Smelter	Ausnet Gas Services
Onshore	150	9890		100.4	Allansford to Portland	APA VTS Australia (Operations)
Onshore	150	9890		54.6	Codrington to Hamilton	APA VTS Australia (Operations)
Onshore	200,350,450	15360	2000	267.6	Iona Gas Plant to South Australia border	South East Australia Gas
Onshore	200	15300, 22000		33	Halladale, Black Watch and Speculant well site to Otway Gas Plant	Beach Energy (Operations)
Onshore	150	9890		27.7	Curdievale to Cobden	APA VTS Australia (Operations)
Onshore	150	9890		33.3	Paaratte to Allansford	APA VTS Australia (Operations)
Onshore	80,100, 450,500	7390, 10200		143.84	Iona to Lara	APA VTS Australia (Operations)
Onshore	80,200, 250	2760		17	Fyansford to Waurn Ponds	Ausnet Gas Services
Onshore	50,80,100,200,250,300	2760		24.5	Corio to Belmont and Point Henry	Ausnet Gas Services
Onshore	500	10200	700	57.98	Brooklyn Compressor Station to Lara City Gate	APA VTS Australia (Operations)
Offshore	250	16800		5.3	3 Nautical mile limit to shore near Port Campbell National Park	Woodside Energy (Victoria)

Source: Authors' construction based on DATA VIC as of January 2024. Link: https://discover.data.vic.gov.au/dataset/gas-and-fuel-pipelines-warning-75-complete

Key points

- There is significant gas pipeline capacity due to exports to other regions. The operating pressure ranges between 2.7 and 22 megapascals and the diameter between 80 and 500 mm.
- Some pipelines can be repurposed to transport/store biogas/biomethane or H_2, however logistical challenges need to be properly assessed.

4.2.13. Groundwater Management Areas

Figure 28. Groundwater management areas

Source: Authors' construction

Table 14. Groundwater management areas

Groundwater Catchment	Depth to water table (m)	Water table salinity (mg/L)	Groundwater Management Unit (GMU)	Depth below surface (m)	Permissible Consumptive Volume (PCV) (ML/yr)
Glenelg	5 - 10	501 - 1000	1) SOUTH WEST LIMESTONE GMA 2) GLENELG WSPA	1) N/A 2) ALL	1) 85000 2) 33262
Portland	5 - 10	1001 - 3500	1) SOUTH WEST LIMESTONE GMA 2) CONDAH WSPA 3) PORTLAND GMA	1) N/A 2) 70 - 200 3) >200	1) 85000 2) 7475 3) 7795
Hopkins - Corangamite	< 5	501 - 1000	1) SOUTH WEST LIMESTONE GMA 2) GLENORMISTON GMA 3) PAARATTE GMA 4) COLONGULAC GMA 5) NEWLINGROOK GMA 6) PAARATTE GMA 7) GELLIBRAND 8) GERANGAMETE GMA	1) N/A 2) 0-60 3) >120 4) 0-60 5) ALL 6) >120 7) ALL 8) >60	1) 85000 2) 2698 3) 4606 4) 4695 5) 1977 6) 4606 7) N/A 8) 20000
Otway Torquay	10 - 20	1001 - 3500	JAN JUC GMA	ALL	39250

Source: Authors' construction based on DATA VIC as of January 2024. Link: https://discover.data.vic.gov.au/dataset/groundwater-management-areas

Key points

- There are 8 Groundwater Management Areas in BSW.
- The largest is South West Limestone, with a Permissible Consumptive Volume of 85,000 ML/yr, extending from Glenelg to the western border of Colac Otway.