dsquared

Department of Planning, Industry and Environment

A Regional Approach to Sustainability in the Illawarra Shoalhaven

Sustainability Plan

D Squared Consulting Pty Ltd
Trading as dsquared
ACN 159 612 067
ABN 38 159 612 067

Suite 5, 241 Pirie Street
Adelaide SA 5000
T: 0488 220 022
E: jacob@dsquaredconsulting.com.au
W: www.dsquaredconsulting.com.au

Project Number: 2190

Issue	Date	Change	Checked	Approved
-	16/06/20	Draft issue for page turn workshop	JP	PD
01	22/06/20	First issue	JP	PD
02	14/07/20	Final issue incorporating feedback and comments	JP	PD

Our vision is to think beyond the square.

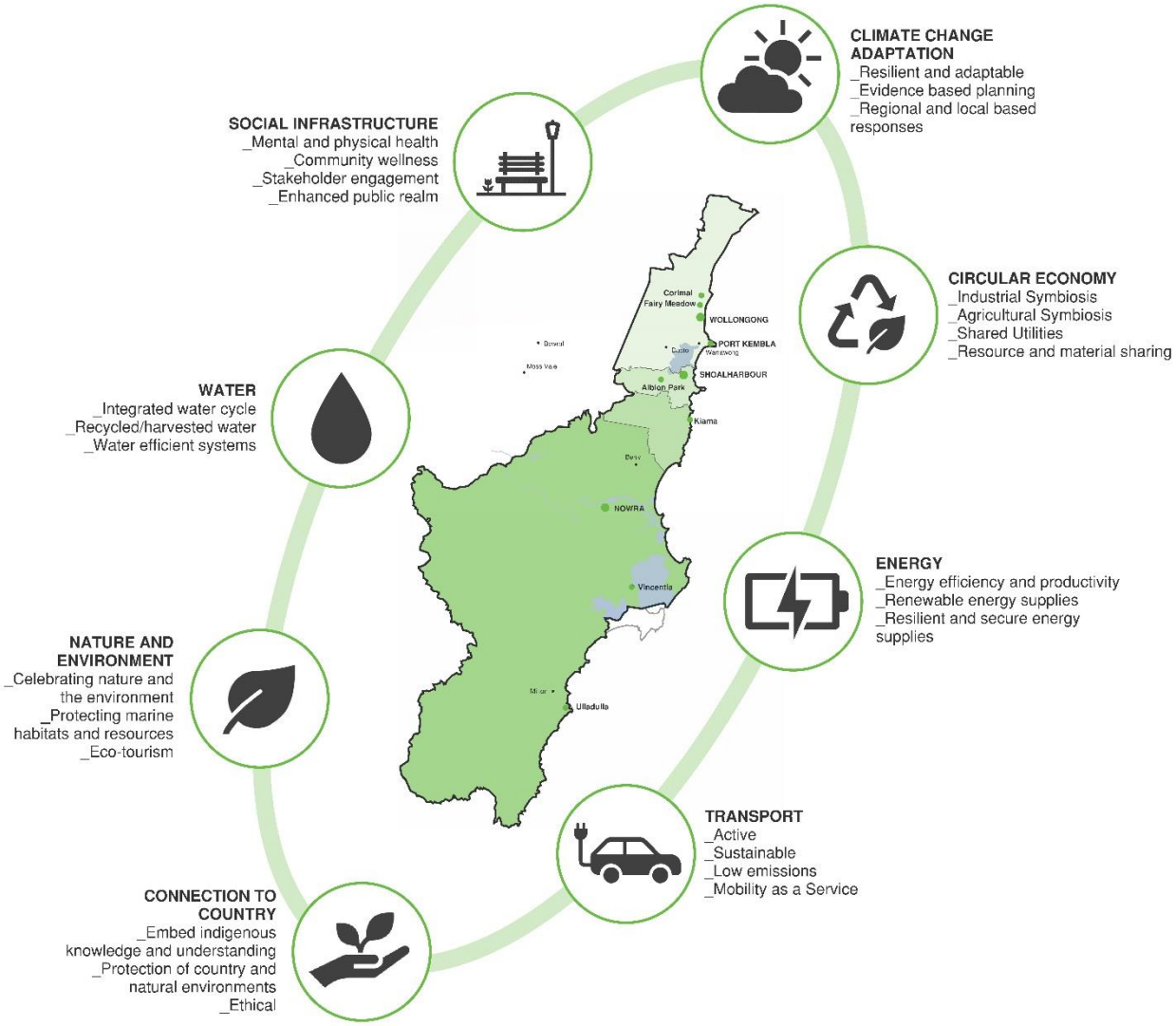
Our mission is to reduce the impact on the environment of our client's actions by providing innovative solutions, challenging perceived thinking, and pushing the boundaries of achievement whilst using all resources in a sustainable way.

We confirm that all work has been undertaken in accordance with our ISO 9001 accredited quality management system.

Contents

This Sustainability Plan (the Plan) for A Regional Approach to Sustainability in the Illawarra Shoalhaven has been developed to embed sustainability into the 2020 update of the Illawarra Shoalhaven Regional Plan. It is intended to provide a snapshot of the region and identify priority actions and collaborative opportunities that could be embedded into the Regional Plan, while considering the region's successes and challenges, climate change impacts and how sustainability can drive a more connected, innovative and diverse community in line with the Regional Plan's key themes.

The Plan was developed with the following key topics (refer below) providing a framework for reviewing the region and has assessed Local Government Areas (LGAs), Major and Minor Centres and specific precincts and sites that can assist in embedding sustainability into the Regional Plan. It is recommended that the below is used to continue to explore sustainability opportunities that have both been identified in this Plan and additional opportunities that may become apparent as part of stakeholder engagement.



To ensure that sustainability was fully embedded, a Line of Sight planning methodology was utilised to review the region, with international megatrends down to specific site initiatives reviewed and the United Nations Sustainable Development Goals incorporated, to align the plan with international, national and state strategies and goals for sustainable development.

The Plan has identified a wide range of opportunities which can be implemented from a regional, LGA and precinct level perspective which can be maximised by implementing a collaborative framework across the LGAs. The following key initiatives will require a collaborative approach across the LGAs with multiple stakeholders playing a facilitation role and the Regional Plan providing a framework.

Topic	Initiative	Summary
Hydrogen		
	Hydrogen Supply Chain Analysis	Maximising hydrogen opportunities by creating a holistic supply chain strategy which leverages industrial, transport and agricultural sectors to underwrite demand in the short term and position the region for potential international demand in the longer term.
Circular Economy and Industrial Symbiosis		
	Industrial Symbiosis	Undertaking a feasibility study into creating an industrial symbiosis model across major industrial areas which uses circular economy principles to maximise efficiencies, share resources and materials, reduce operating costs and improve environmental outcomes.
Emissions		
CO_2	**Emissions Inventory**	Investigate the procurement of a regional carbon emissions inventory across the Local Government Areas to allow effective monitoring and to track emissions reduction initiatives.
Renewable Energy and Energy Efficiency		
	Energy Efficiency and Productivity	Facilitating energy efficiency improvements by utilising existing grants and programs to drive energy productivity measures.
	Renewable Energy Agreements	Investigate the procurement of a regional renewable energy contract which aggregates the energy demand of the local councils, major industry and commercial operators to negotiate a competitive renewable energy supply contract while significantly reducing emissions.
	Solar PV Systems	Facilitating an increase in rooftop solar photovoltaic (PV) system penetration in the region by utilising the region's existing solar resources and large amounts of residential growth, industrial areas and car import yards.
	Energy Storage	Facilitating and increasing the uptake of energy storage systems (battery, thermal, pumped hydro, biogenic gas) to maximise renewable energy potential, while supporting energy security and increasing resilience particularly in the southern area of the region.
	Virtual Power Plant Extension	Creating a Virtual Power Plant that interconnects and extends existing VPPs proposed for the region across residential, commercial, industrial and agricultural sectors, to maximise opportunities for distributed renewable energy.

	Demand Management	Maximising all of the above opportunities, as part of a VPP model, to take advantage of the recently announced Wholesale Demand Response rule change due to be implemented in October 2021.
Transport		
	Integrated Transport Model	Continue to maximise sustainable transport options by integrating electric and hydrogen powered vehicles and refuelling (charging) infrastructure, supporting increased active and public transport options and facilitating Mobility-as-a-Service (MaaS) solutions to decrease private vehicle use and transition to low and zero emission transport.
	EV and Hydrogen Vehicles	Supporting the uptake of electric and hydrogen vehicles by updating procurement policies to support low and zero emission vehicles, continuing trials of low emission vehicles and providing information to the public on the benefits.
	EV and Hydrogen Refuelling Stations	Development of a regional electric and hydrogen fuelling network strategy to facilitate the transition to low and zero emission transport, increase resilience and support the hydrogen supply chain
Water		
	Fully Integrated Water Cycle	Diversifying water supplies across region and improving water efficiency by implementing a fully integrated water supply which incorporates wastewater capture and water recycling, harvested stormwater, Water Sensitive Urban Design (WSUD) and water efficiency programs.
	Wollongong Wastewater and Water Recycling Plant	Investigate recycled water capacity and maximise existing opportunities to increase biogas generation which will assist in powering the recycled water plant, supplying recycled water to the region and increase opportunities to inject biogas into the natural gas network.
General		
	Procurement Policies	A regional approach to sustainable procurement should be implemented with a strong focus on local and recycled content to underwrite demand and increase circular economy opportunities.
	Sustainability Focus Group	Create a focus group and/or workshop the sustainability plan with key stakeholders to integrate sustainability into the Regional Plan.

The above initiatives will require a collaborative approach with a range of stakeholders identified in this Plan. These opportunities are based on a review of the region and additional stakeholder engagement will be required to explore and test the ideas with relevant government agencies, local councils, industry and educational institutions.

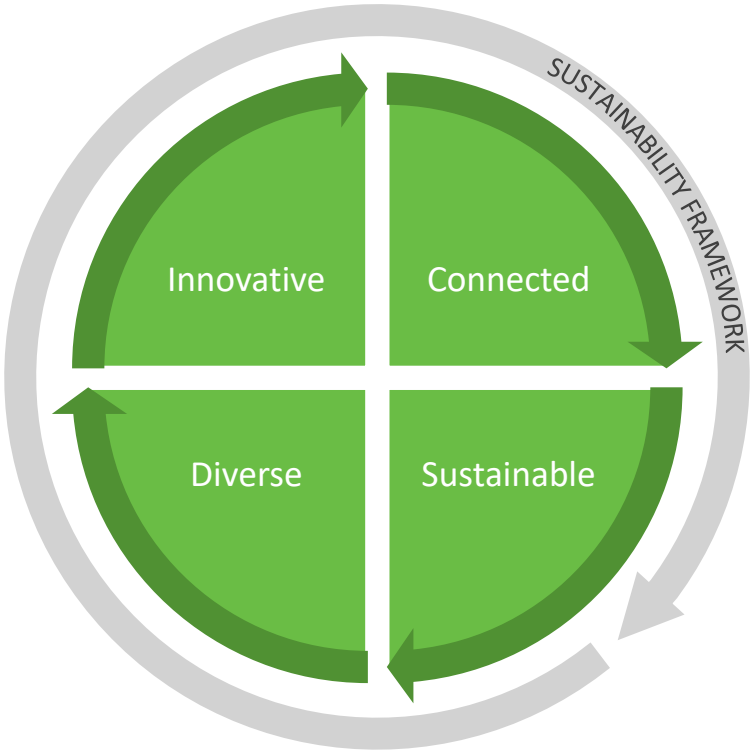
1 Introduction

1.1 Sustainability Plan

This Sustainability Plan (the Plan) for A Regional Approach to Sustainability in the Illawarra Shoalhaven has been developed to embed sustainability into the 2020 update of the Illawarra Shoalhaven Regional Plan. It is intended to complement the Regional Plan and incorporates national, state and regional specific policies, strategies, plans and targets and aims to create a holistic sustainability plan for the Illawarra Shoalhaven region.

1.2 Regional Plan Vision

As part of consultation undertaken by the Department of Planning, Industry and Environment (DPIE), a sustainable region has been identified as one of four key themes to be integrated into the Regional Plan as per the below (refer below). The vision and the key themes have been referenced throughout the development of this Plan. Although sustainability has been identified as its own theme, it is integral to all of the themes with opportunities to leverage sustainability to drive a more connected, innovative and diverse community.



The narrative for the Sustainable theme is as follows:

- A precinct sustainability framework will drive **energy efficiency, emissions reduction, and enable a circular economy approach** to drive sustainability and resource efficiency.
- Public open spaces, beaches and **environmental values** drives healthy and active communities.
- New release areas will be designed and located to meet the needs of communities, encompass walking and cycling networks, energy efficiency, and social inclusion to promote **community wellbeing and environmental sustainability.**
- **Community resilience** is prioritised so that the region can better understand, plan for and respond to natural hazards and major disruptions.

The narrative is supported by the following spatial drivers which have been used to inform this Plan:

- Metro Centres of Wollongong, Shellharbour City and Nowra
- Blue and Green grid
- Hydrogen Hub at Port Kembla
- Regional Release Areas at West Lake Illawarra and Nowra Bomaderry
- Industrial Precincts
- High Environmental Value land and coastal areas
- Sydney drinking water catchments

1.3 Sustainability Principles

Further to vision, narrative and spatial drivers, the following sustainability principles have been used to develop this Plan, employing a triple bottom line approach supported by a circular economy framework.

1.4 Sustainability Topics

The following key sustainability topics have been analysed against the above principles for the region to ensure this Plan provides a holistic sustainability outcome.

- Climate resilience and adaptation
- Emissions reduction
- Resource optimisation
- Transport and mobility

2 Regional Sustainability on a Page

The Illawarra Shoalhaven region provides a unique opportunity to balance regional growth and emissions intensive industry and agriculture with innovative and collaborative initiatives that improve environmental, social and economic performance. This Sustainability Plan has been developed to outline sustainability opportunities within a collaborative framework and has considered the topics outlined in the below Regional Sustainability on a Page diagram (refer Figure 1).

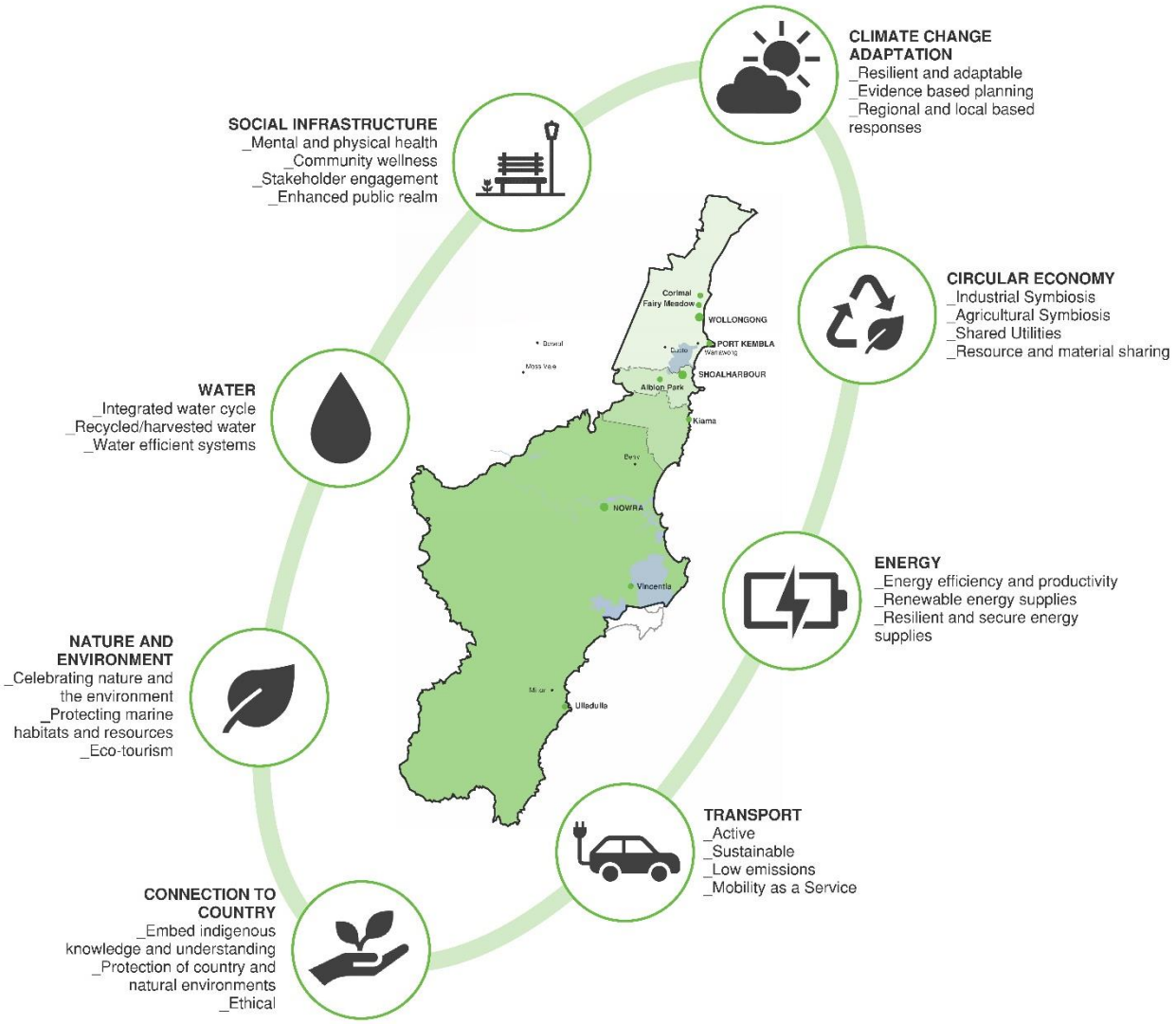


Figure 1: Regional Sustainability on a Page

3 Policies, Strategies and Plans

3.1 Introduction

A review of key international, national, state, regional and location specific policies, strategies, plans and targets has been undertaken to ensure this Plan is aligned with both local and broader priorities. This ensures that the Plan does not incorporate priorities that are already being addressed through alternative programs and that the region can focus on local projects that will provide the greatest benefit.

The review has been undertaken in line with the NSW Planning Line of Sight process (refer Figure 2).

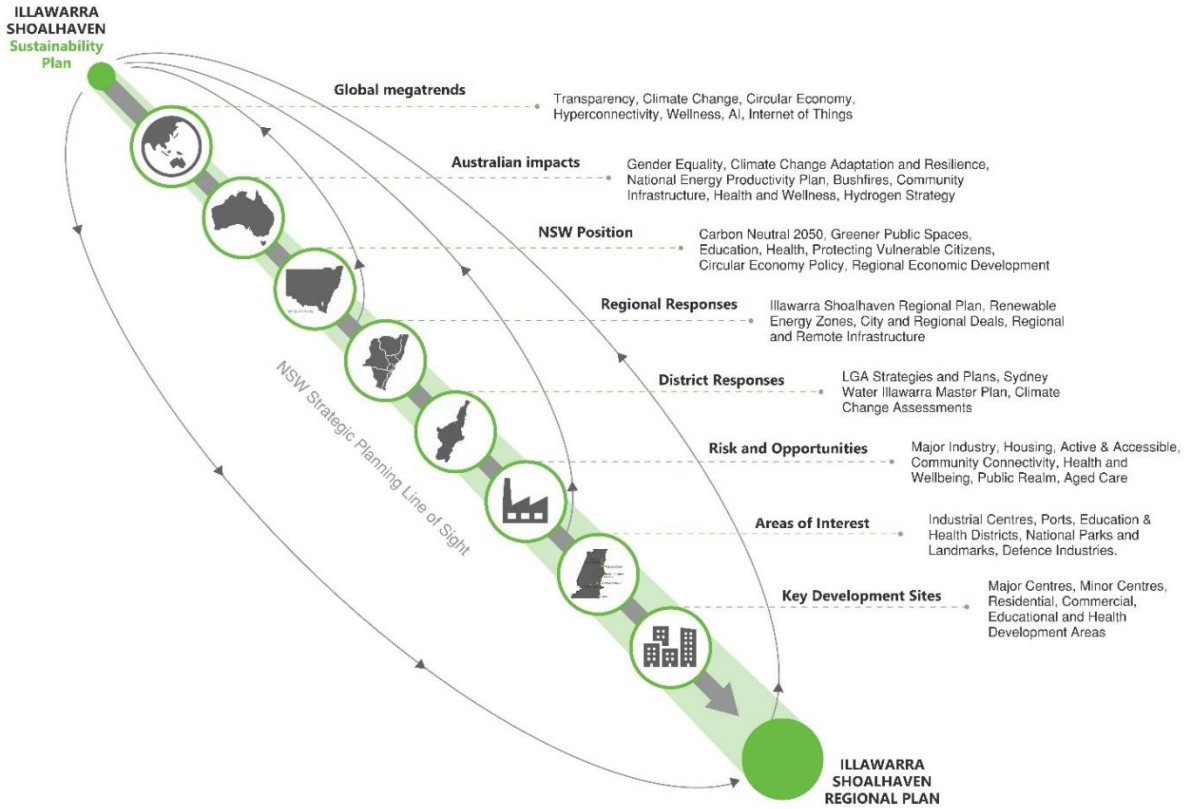


Figure 2: Line of Sight Diagram

3.2 International

Concerns over climate change impact are increasingly on the agenda for governments and organisations. The Intergovernmental Panel on Climate Change (IPCC) has stated that by 2030 global emissions must be down by at least 45% from 2010 levels to keep global temperature from rising by no more than 1.5°C. This is relevant to the region as the Australian Government has committed to emission reductions as part of the Paris Agreement signed in 2016).

The UN Sustainable Development Goals also provide priorities which should be integrated into strategies, plans and targets that aim to improve sustainability in the region. The UN Sustainable Developments Goals have been referenced in each topic where applicable and topics relevant to this plan have been outlined in Figure 3.

Figure 3: UN Sustainable Development Goals

3.3 National

At a national level there are a range of strategies and plans which directly relate to the region and can be used as a high level ESD framework. At the highest-level Australia's COP21 Paris agreement Commitments include a target to reduce emissions by 26-28% on 2005 levels by 2030. As per section 4.3, the largest sectors that will need to implement efficiencies to reach this target are stationary energy, transport and agriculture. Due to the region being heavily reliant on all three of these sectors it is critical that the Regional Plan is aligned with this target. Additional strategies and plans include the National Climate Resilience and Adaptation Strategy, National Energy Productivity Plan 2015–2030 and Smart Cities Plan.

3.4 State

In line with international and national priorities, the NSW Government have implemented strategies and plans to reduce environmental impacts including the NSW Climate Change Policy Framework, NSW Local Land Services: Future Climate Impacts and NSW EPA Circular Economy Policy Statement: Too Good to Waste and NSW Net Zero Plan Stage 1: 2020-2030.

3.5 Region

The region and LGAs have had extensive environmental, climate change and infrastructure studies undertaken which have been utilised to inform this Plan and identify high priorities for the region and are referenced where directly relevant.

4 Context Analysis

4.1 Introduction

An analysis of opportunities and constraints at a regional and, where relevant, state level has been undertaken to ensure that any ESD initiatives are considered in the context existing priorities and projects. A review of emissions, resource optimisations, energy, water, waste, transport, green and blue infrastructure, community and social infrastructure, and connection to country has been undertaken and used to inform the development of this Plan.

4.2 Region

Figure 4: Local Government Areas

The Illawarra-Shoalhaven region (the region) encompasses four Local Government Areas (LGAs) of Kiama, Shellharbour, Shoalhaven and Wollongong (refer Figure 4).

The region is on the eastern seaboard of NSW approximately 160km south of Sydney. Its topography includes mountainous terrain, flat coastal areas, bays, inlets, lakes and rivers. It enjoys a temperate climate which, combined with the natural attractions, creates a perfect tourism offering for nearby city dwellers.

The region generates more than $16B in GRP, making it the third largest economic contributor to regional NSW growth. Important economic value add comes from construction, health care and social assistance, manufacturing, retail, education and tourism. These businesses are also some of the most affected by the COVID 2019 pandemic but the business mix in the area has meant that they are relatively protected from major negative effects with a 2.2% decrease (economic output) projected. This equates to approximately $95M for the region.

Manufacturing has been encouraged through the provision of inexpensive, high quality industrial land and proactive councils, resulting in good product and service quality and strong export performance for items like yachts, chemicals, building products and food.

Wollongong is a major hub of the area with many people working within the CBD as well as at the University of Wollongong campuses, which are also well connected to TAFE NSW.

By 2050 the population of the Illawarra-Shoalhaven is projected to be around half a million people. In 2016 the population was 393,204, comprising 5.3% of NSW population.

The NSW regional plan builds on the region's existing economic strengths, and identifies the following priority growth sectors:

- tourism;
- health, disability and aged care;
- ICT/knowledge services;
- education and training;
- aviation, defence and advanced manufacturing; and
- freight and logistics.

The plan identifies Port Kembla as an international trade gateway with the potential to expand industrial activity by providing well-located and well-serviced industrial land and strengthening the economic self-determination of Aboriginal communities.

With over 50% of the workforce having achieved tertiary education, the region's economy is moving away from traditional manufacturing and mining to focus on knowledge intensive industries attracting global talent and investment.

4.2.1 Illawarra Shoalhaven Joint Organisation

The Illawarra Shoalhaven Joint Organisation (ISJO) aims to drive collaboration and advocacy in the region and is one of the key collaborative strengths of the region. The ISJO is critical to the success of driving the Sustainability and Regional Plan and ensuring a coordinated approach to addressing regional risks and opportunities such as climate change resilience. Initiatives being implemented by the ISJO have been referenced throughout this Plan and it is recommended the ISJO continue to be supported with funding support and resources.

4.2.2 Cities Power Partnership

All four councils are participants in the Cities Power Partnership which aims to take action on climate change and is providing a platform for collaborative projects and knowledge sharing. The following pledges have been made by the councils:

Table 1: Cities Power Partnership Pledges

Council	Renewable Energy	Battery Storage	Energy Efficiency	Methane Gas Capture from Landfill	Sustainable Transport	Behaviour Change	EV Charging
Wollongong							
Shellharbour							
Kiama							
Shoalhaven							

Wollongong City Council has also committed to taking action on climate change by maintaining a membership with the Global Covenant of Mayors for Climate and Energy. As a result, the council is required to collate a more comprehensive carbon emissions inventory in line with reporting requirements.

Following the 2019/20 bushfires across NSW, a joint statement from Cities Power Partnership councils regarding the impact of climate change on bushfire fire-weather has also been signed by the Shoalhaven City Council Mayor. Over 80% of the Shoalhaven region was burnt and over 300 buildings were impacted by fire during the 2019/20 fires.

4.3 Emissions

In line with the NSW Government commitment to carbon neutrality by 2050, the region's emissions will need to be decoupled from productivity and support a transition to low carbon, high performing economy. The latest State and Territory Greenhouse Gas Inventories 2017 for NSW shows an 18.2% decrease from 2005 to 2017. However, NSW contributes approximately one quarter of Australia's total GHG emissions and will be key to meeting Australia's COP21 emissions reduction target. The main contributor for NSW's emissions was stationary energy (electricity generation) due to the high percentage of electricity being generated by coal power stations.

NSW's 2017 emissions are as follows (Figure 5 - includes Land Use, Land Use Change and Forestry (LULUCF) activity reductions of -10%):

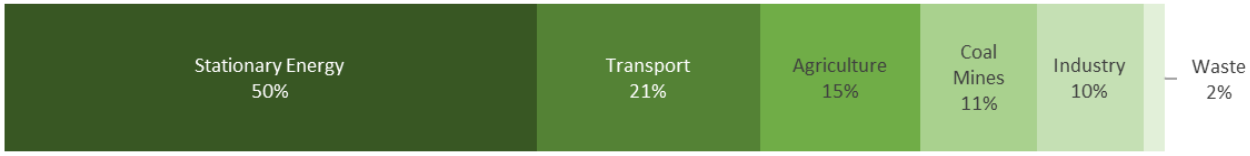


Figure 5: NSW 2017 Emissions breakdown

With over 70% of emissions associated with stationary energy and transport, which are a significant component of the region, emission reduction measures to improve efficiencies and support the transition to low carbon transport alternatives should be a priority. In particular supporting existing industry and businesses and the community to become more efficient and to reduce their emissions will require targeted and ongoing support resources.

The NSW Government have set a net-zero emissions target by 2050 which will only be possible with energy efficiency improvements, a significant increase and integration of renewable energy into NSW's electricity supply, supported by energy storage (battery storage, pumped hydro, thermal storage, etc.), alternative renewable fuels (hydrogen), the transition to low emission transport (electric vehicles and hydrogen cell vehicles) and improving agricultural practices.

The Illawarra Shoalhaven region's emissions differ from the state average emissions due to having a higher proportion of energy intensive industrial processes such as steelworks and manufacturing, along with significant growth in the residential dwellings (Refer Figure 6 for a breakdown of the region's emissions). The data presented is average emissions from the Snapshot community climate tool which is currently in Beta testing and should be used as a guide only. The data highlights that energy and transport are a high priority and will be a key focus in this Plan.

Figure 6: Illawarra Shoalhaven 2017 Emissions Breakdown

The total emissions have also been calculated per LGA to identify priority areas to implement emissions reduction initiatives that will have the greatest impact (refer Figure 7). The below data is based on publicly available state level data which has been applied to the relevant LGAs. It should be noted that this is a high-level analysis which has been used to determine priority emission sources which can provide the most benefit if targeted.

These figures will differ from science-derived greenhouse gas emission budgets and targets which are specifically developed for a council or region. For example, Wollongong City Council have engaged a specialist consultant to develop a carbon emissions inventory which will differ to the below, however these inventories are still expected to identify similar priority emission sources e.g. industry in Wollongong is still expected to be a significant component to the emissions inventory.

It is recommended that a consistent emissions boundary and accounting process is implemented across the LGAs through a collaborative project to develop an emissions account, identify priorities and track progression over time.

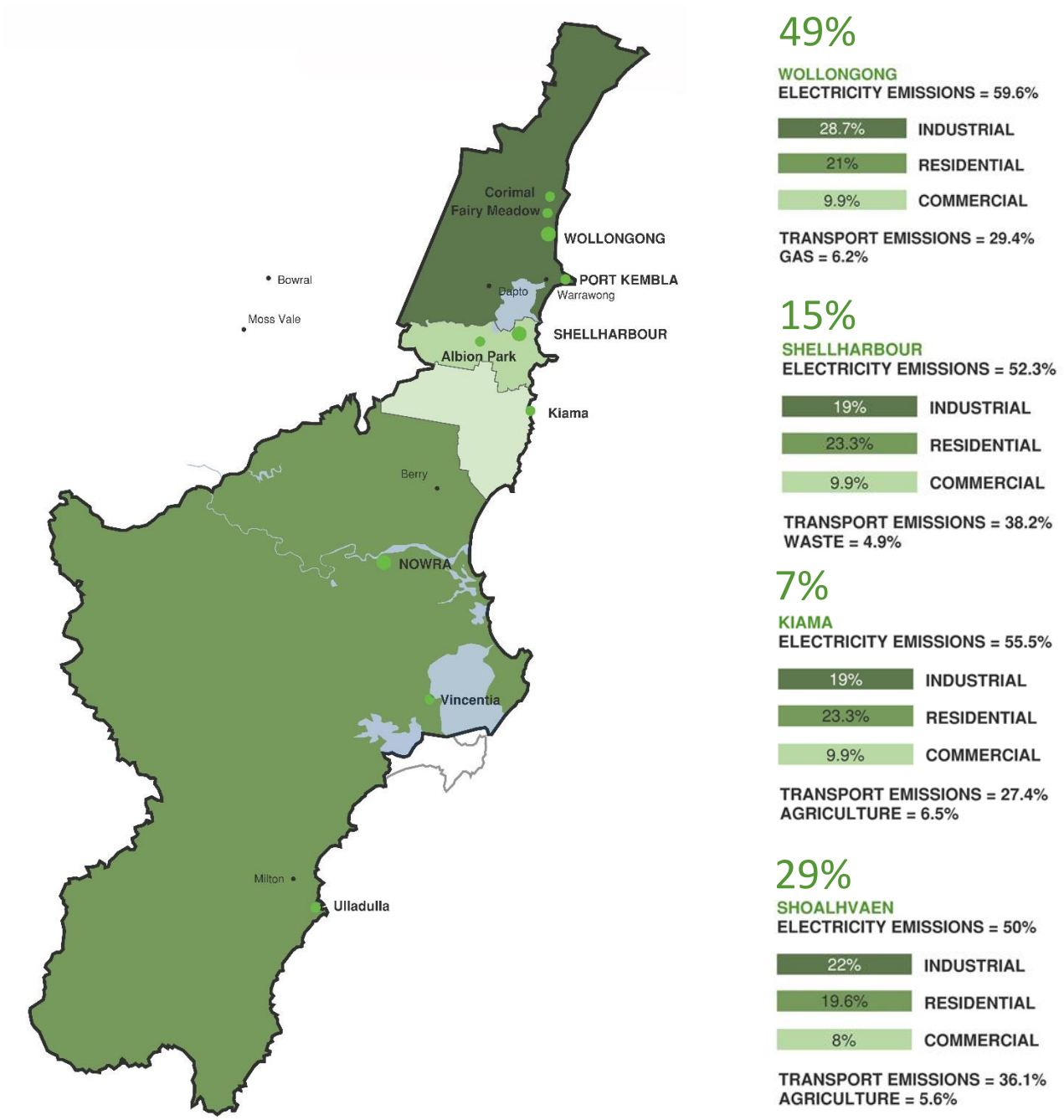


Figure 7: LGA Emissions

4.4 Climate Change

The Illawarra Shoalhaven region (the region) is in New South Wales, Australia which is located in the CSIRO Climate Change zone defined as the "Southern Slopes (Victoria East) sub-cluster (Refer Figure 8).

Figure 8: CSIRO Climate Change Regions Map. Source: CCIA Technical Report 2015

The region encompasses four Local Government Areas (LGAs) of Kiama, Shellharbour, Shoalhaven and Wollongong (refer Figure 4) and is captured under the NSW Shoalhaven and Illawarra Enabling Regional Adaptation document which outlines seven regional systems which are particularly vulnerable to climate change including:

- Satellite settlements
- Transport
- Emergency management
- Energy
- Food
- Industrial transformation
- Water

The four LGAs have developed individual climate change assessments, strategies and plans which focus on local climate change risks that the councils will need to address however collaborative responses have also been identified and are in various stages of planning and delivery. In addition, the Shoalhaven Illawarra Enabling Regional Adaptation (SIERA) project has been established to build local knowledge on understanding climate risks and enable regional responses to be implemented based on local knowledge and expertise.

The ISJO and outcomes being created by the SIERA project are critical to the success of driving climate change resilience and adaptation as part of a regional response. One of the key constraints to the climate change adaptation planning and strategies is that each of the council's plans have been commissioned individually and at various stages with some dating back over 10 years. Since this time a large number of relevant resources and guides have been released and it is recommended that climate change adaptation plans, strategies and action plans are updated to align with the regional adaptation plan and the latest data sources and resources used to create a detailed response for each LGA. This includes work undertaken by the Institute of Public Works Engineering Australasia and *Practice Note 12.1: Climate Change Impacts on the Useful Life of Infrastructure* which is directly applicable to the LGAs.

4.4.1 Climate Risk Assessments and Adaptation Plans

The CCIA Technical Reports, Shoalhaven and Illawarra Enabling Regional Adaptation document and local council climate change assessments, strategies and plans have already undertaken a comprehensive review of climate data and projections. The suite of data and reports, projects underway and priorities identified have been reviewed and integrated into this report to provide a holistic plan to embed climate change risks and mitigation strategies into this Plan and the Regional Plan.

The below diagram outlines the key risks identified and outlines the solutions being proposed throughout this Plan to mitigate the impacts of climate change (refer figure 9).

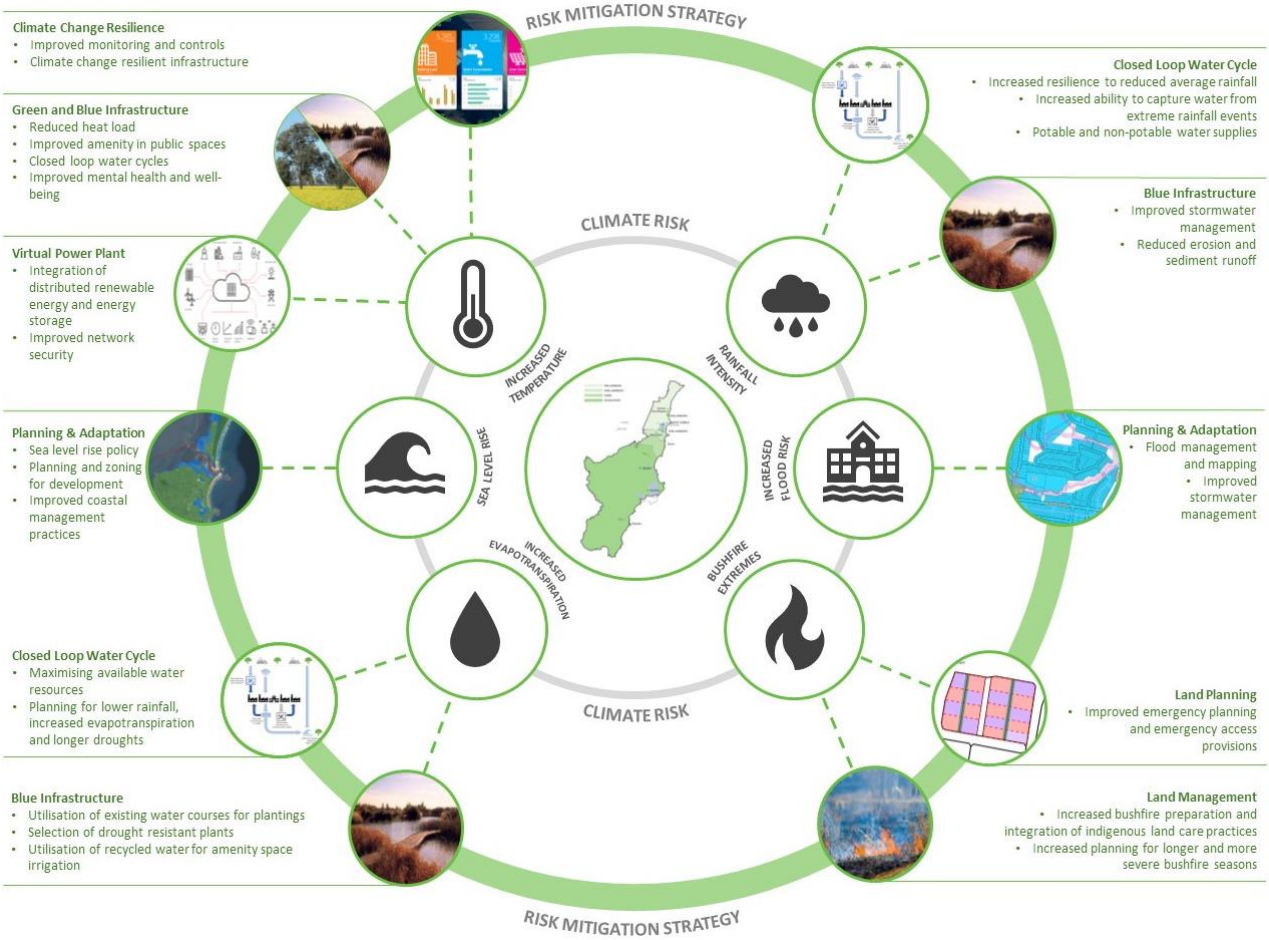


Figure 9: Climate Change Risks and Strategies

In addition, a climate change impact summary is incorporated into each section of this plan to ensure each topic considers climate change and links proposed solutions to the relevant risks. Refer to xx for further information on the climate risk assessment process.

5 Energy

The region is connected to the National Electricity Market (NEM) with major transmission lines (330kV) running through Wollongong and Robertson to Goulburn and further south through Kangaroo Valley and across to Canberra (refer purple lines in Figure 10 below). 132kV lines also service metropolitan areas, with smaller transmission and distribution lines servicing the remainder of the region.

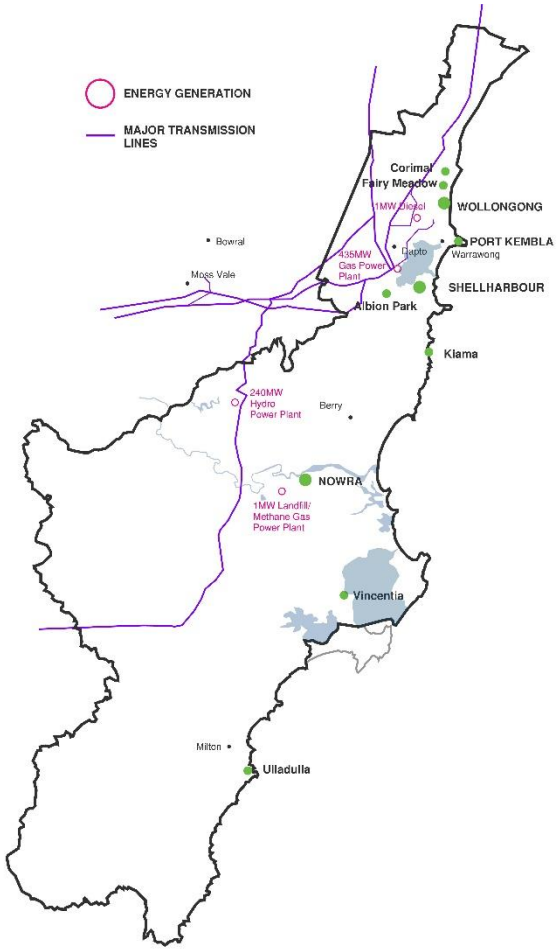


Figure 10: Transmission Network and Major Generation

The largest energy generation asset in the region is the Tallawarra 435MW combined cycle gas fired power plant located at Lake Illawarra operated by Energy Australia. Energy Australia are currently developing a 300MW expansion of the Tallawarra power plant which will have the capacity to supply an additional 60,000 homes in the region. The upgrade will likely increase stationary energy emissions in the region; however, this will depend on demand and wholesale energy markets. For example, the emissions of the plant decreased by 35% from 2017/18 to 2018/19 prior to the plant upgrade which demonstrates the variability of demand and the market.

In addition, Origin Energy operate the 240MW Shoalhaven Hydro Pump Storage power plant located in the Kangaroo Valley. This plant was identified for expansion as part of the NSW Hydrogen Roadmap and has a planned 235MW upgrade proposed which has been shortlisted for capital funding as part of the NSW Emerging Energy Program. The upgrade is expected to increase renewable energy storage capacity in the region which will assist in offsetting increased emissions due to regional growth and the expansion of the Tallawarra power plant. There are also a number of smaller generation assets including a 1MW landfill gas (methane) power plant outside of Nowra and a 1MW diesel generator in Wollongong.

The planned expansion of the Tallawarra gas and Shoalhaven hydro power plants is expected to increase generation capacity and resilience to support the expected growth in the region. Additional projects are also in planning stages including a landfill (methane) gas power plant located Whytes Gully and additional pumped hydro projects which are still in development.

The Australian Energy Market Operator's 2018 Integrated System Plan (ISP) identified that although system strength (reliability) is currently stable through to the end of the 2020s, system strength may begin to weaken towards the end of the 2030s with transmission and sub-stations reaching capacity. This is likely due to increased growth in the region and sub-stations reaching capacity, higher percentages of renewable energy entering the NEM and ageing infrastructure. In addition, interconnectivity upgrades have been identified in the AEMO National Transmission Network Development Plan 2018 (NTNDP) for the region take advantage of increased renewable energy generation in adjacent regions. System strength to support increased renewable energy in the NEM, and in particular in the Illawarra Shoalhaven, will need to be considered as part of longer-term planning.

The NSW Electricity Strategy has also identified network capacity as a potential constraint and is incorporating transmission network upgrades as part of strategies and plans to maximise REZs in the adjacent region, along with strengthening interconnection to South Australia (SA) to take advantage of the high percentage of renewables in the SA grid.

A recent example of the region's growth impacting electricity infrastructure was a need to upgrade Dapto sub-station operated by Endeavour Energy (distribution network operator) to facilitate residential growth in the Dapto area. As an alternative to upgrading the capacity of the sub-station and to offset capital expenditure, Endeavour Energy has instead installed a 1.1MWh battery energy storage system to provide additional capacity for 600 homes by managing peak demand events and increasing grid reliability through frequency control and voltage management services. Similar opportunities to utilise renewable energy systems coupled with energy storage is outlined in Section 5.

In addition, the recently approved 'wholesale demand response' rule change by the Australian Energy Market Commission (AEMC), approved for implementation in October 2021, may be a significant opportunity for the region if a coordinated and collaborative approach is taken to implement demand management systems across major industry and commercial operators.

5.1 Energy Efficiency & Productivity

As a result of the high proportion of industry in the region, along the current and projected residential growth, energy efficiency and productivity are expected to be a significant opportunity to both reduce emissions and costs while supporting national and state strategies and priorities. This includes the National Energy Productivity Plan to improve energy productivity by 40% between 2015 and 2030, and the NSW Electricity Strategy Energy Security Safeguard energy efficiency scheme which aims to reduce consumption of gas and electricity from the wholesale market.

Improving energy efficiency provides a wide range of benefits including reducing consumption and costs for users, electricity network demand (improving grid stability) and emissions associated with stationary energy generation.

5.1.1 Residential

Both existing and new residential developments are expected to have significant opportunities for energy efficiency improvements which will reduce consumption, emissions and household electricity costs. With over 20% of Australia's electricity consumption being associated with the residential sector, improving the energy efficiency of new developments and upgrading existing housing stock should be a priority.

Existing programs such as the NSW Energy Savings Scheme (ESS) and the National Construction Code (NCC) Section J requirements are already targeting energy efficiency and have been achieving energy efficiency improvements. In addition, the COAG Energy Council's Trajectory for Low Energy Buildings has identified that the energy efficiency requirements in the NCC should be increased from 2022 which are expected to continue to improve the efficiency for new residential developments.

However, the Australian Sustainable Built Environment Council (ASBEC) has identified that on average, existing dwellings in Australia have a NatHERS equivalent rating of 1.7, compared to 6.1 for new homes. This identifies that existing older dwellings in the region would be comparatively inefficient and that energy efficiency upgrades may be a large opportunity for the region. In addition, the CSIRO Australian Housing Data portal, which tracks NatHERS energy ratings across Australia, has identified that on average NSW homes are achieving a slightly below average NatHERS rating with 6 Stars versus the national average of 6.2. Although minor, 6 Stars is the minimum NCC compliance requirement which indicates new residential housing in NSW has room for improvement.

In addition, the CSIRO and ASBEC have also undertaken studies of both existing and new housing and identified that air tightness performance (air permeability or infiltration) in households can significantly exceed assumptions in NatHERS modelling and as a result, the 6 Star rating may not be accurate. On average, households that have appropriate building sealing and are well constructed should achieve a rate of 10 air changes per hour (ACH) at 50 Pascals, however households in Sydney achieve an average 18.3 ACH @ 50 Pascals which indicates energy performance would be reduced. Build quality and sealing should be considered as part of local construction industry engagement with the University of Wollongong potentially playing a role in providing expertise and input.

The NSW Electricity Strategy has also incorporated a new Energy Security Target and Safeguard program which has recently closed for consultation and incorporates reforms for the ESS. As a result, it is recommended the local councils monitor the outcome of this review and ensure that any opportunities to support energy efficiency in residential developments are maximised.

Additional energy efficiency opportunities are also present including:

- Incorporating improved passive design and energy efficiency requirements in planning rules and building approvals above NCC and BASIX requirements OR developing guidelines specific to the region to support improved design in residential developments.
- Developing a sustainability grant scheme to support energy efficiency upgrades of existing residential buildings. This could target older buildings where average performance is lower.
- Developing a comprehensive energy efficiency program for low income households to assist with living costs while improving resilience.
- Advocating for and supporting the increased energy efficiency requirements outlined for the 2022 NCC improvements by engaging with building industry in the region. It is expected that the construction industry will push back on the proposed changes unless demand for more efficient homes increases.
- Identifying residential areas that could be classified as a sustainable housing hub or demonstration development, targeting a minimum 7 Stars NatHERS rating.

5.1.2 Industrial

To enable energy efficiency to be maximised at existing industrial properties, it is recommended that the DPIE Sustainability Advantage program is promoted to allow organisations to gain support and insights into improving energy and water efficiency, reducing remissions and identifying funding opportunities for audits and implementing improvements. It is recommended a collaborative approach is utilised to enable the sharing of knowledge and experience between organisations and joint funding opportunities.

In addition, electricity distribution operators and retailers, such as Endeavour Energy, often run energy efficiency and peak demand management grant programs to support improved capacity in the network, reduce capital costs associated with network upgrades and as a corporate social responsibility initiative. It is recommended that collaborative opportunities targeting industrial and commercial energy efficiency is pursued in the region and operators such as Endeavour Energy contacted to identify potential opportunities.

5.1.3 Commercial

Building Upgrade Finance (BUF) programs also provide an opportunity for building owners to implement energy efficiency upgrades which is a benefit both to the owner through improved assets and marketability (e.g. the ability to market an energy efficiency building and support a NABERS rating) and to the tenant who typically pays for utilities. It is recommended that the local councils investigate BUF eligibility and a targeted program developed to provide information on BUF to commercial organisations in the region.

Improving energy efficiency and productivity will also facilitate the installation of renewable energy systems which will be designed to match efficient operations instead of installing larger systems to cover inefficient systems. This can reduce the size of the renewable energy systems and capital required and can also form part of the BUF program. A final opportunity is to integrate energy efficiency and productivity with industrial symbiosis analyses outlined in the Section 12 and demand management systems as per Section 5.2 below.

5.2 Demand Management

In addition to energy efficiency and productivity, peak demand management is a key opportunity to reduce both operating costs for organisations and assist in improving network stability and reliability. Peak demand tariffs (kVA) are often a significant component of commercial and industrial electricity bills and implementing demand management technologies or scheduling plant and equipment outside of peak demand periods can reduce electricity costs significantly. In addition, reducing peak demand can decrease reliance on fossil fuel powered gas plants (peaking plants) which typically increase generation or come online during peak demand periods.

Peak demand management opportunities include:

- Upgrading older plant and equipment with more efficient systems that have a lower peak electricity demand.
- Scheduling a staggered start-up for energy intensive equipment to flatten peak demand.
- Shifting operations with a high peak demand to off-peak periods when tariffs are lower e.g. changing production scheduling to run energy intensive equipment outside of peak periods.
- Implementing demand management systems which monitor and automatically load shed or shift based on a set schedule e.g. air conditioning temperature set points are automatically altered by 1-2 degrees or air conditioning compressors cycled during peak demand events.
- Energy storage systems (e.g. battery or thermal storage) are charged during off-peak periods and discharged during peak periods when tariffs are higher.
- Utilising hydrogen electrolysers for grid stability services including peak demand management and frequency control.

The recent AEMC wholesale demand response rule change presents a significant opportunity for industrial and commercial businesses to implement demand management systems that will enable them to participate in demand response markets. This could be a combined energy efficiency and demand response upgrade that will reduce operating costs and emissions and open up new revenue streams.

5.3 Social Licence to Operate

It should be noted that the largest energy source in the region (Tallawarra gas power plant) is a fossil fuel-based supply which would be increasing emissions for the region, NSW and Australia. Coupled with the planned expansion which will further increase emissions, this should be considered in the larger perspective of public opinion and the power plants social licence to operate.

The recently released Technology Investment Roadmap Discussion Paper by the Australian Government has identified natural gas as a significant player in a transition to lower emissions and therefore the gas plants social licence to operate is not expected to be an issue in the near future. However, opposition to the gas power plant including emissions, smog and its impact on Lake Illawarra's water quality and biodiversity are already a concern for members of the community and should be considered.

Although natural gas is increasingly becoming a transition fuel with significantly lower emissions compared to ageing coal-based power plants, it is still a fossil fuel-based supply. As a result, the Tallawarra gas powered plant will need to maintain its social licence to operate as NSW works towards net zero emissions. To offset some of the emissions, there is a plan to blend hydrogen produced at Port Kembla into the natural gas supply to the power station with a 10% blend possible for the existing facility and 15% for the upgraded facility. This will assist in maintaining a social licence to operate however >85% of the gas plants supply will still be from fossil fuels.

5.4 Energy Implementation Guide

It is recommended energy efficiency and productivity is targeted as a high priority to reduce operating costs, emissions and network demand and should be implemented prior to large scale renewable energy.

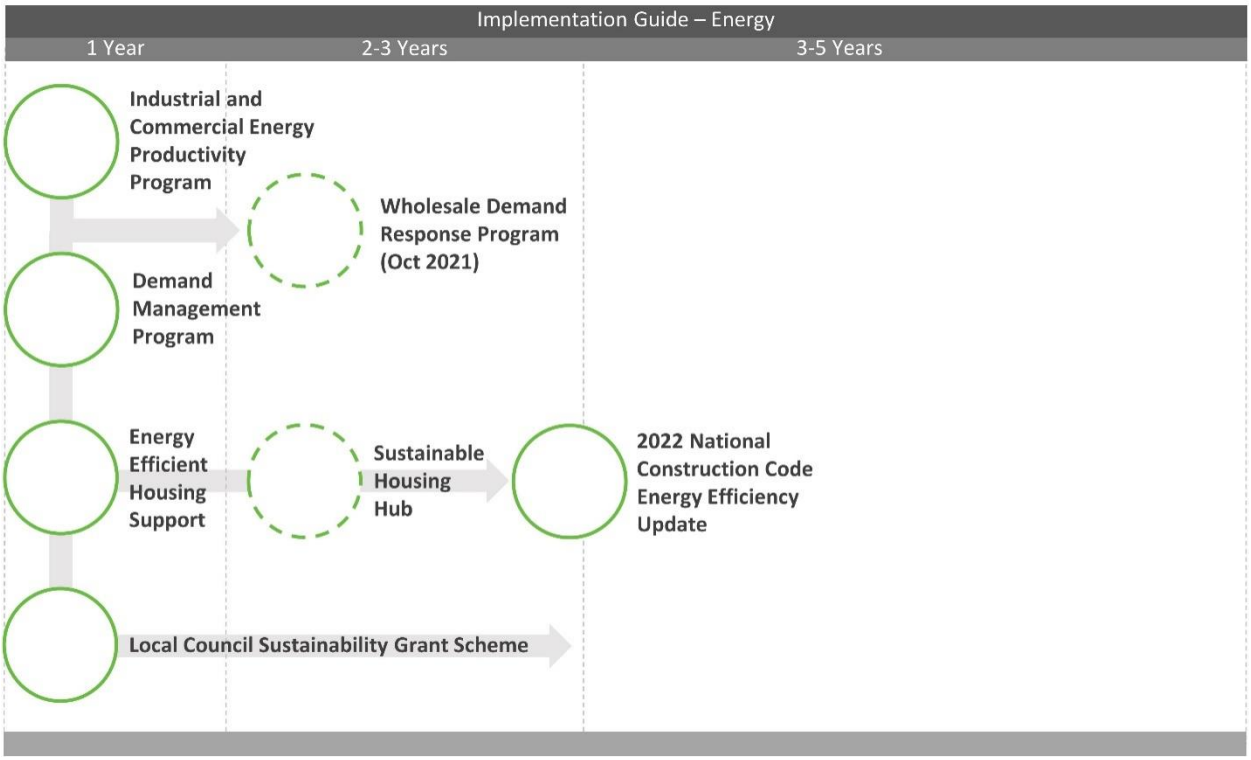


Figure 11: Energy Implementation Guide

5.5 Climate Change Impact

A number of climate change risks have the potential to impact energy supplies in the region as per Table 2 below.

Table 2: Climate change risks for energy

Climate Change Risks		Impact	Risk Rating
	Increased Temperature	Increased energy demand and likelihood of network capacity being exceeded with potential brown/black-outs.	**M**
	Harsher Fire-weather	More frequent and intense bushfires are likely to disrupt utility supplies.	**H**

	**Increased Rainfall Variability and Evaporation**	Reduced capacity of hydro power plants, resulting in potential reduced generation capacity in the region.	**L**
	**Sea level rise**	Increased sea levels have the potential to impact utility supplies however major infrastructure has likely incorporated this risk in facility designs. Sea level rise is not expected to impact major facilities such as the Tallawarra Gas Power Plant.	**L**
	**All of the above**	The combination of climate change risks in the region has the potential of reducing the life of transport infrastructure with additional capital required to maintain, upgrade and replace infrastructure due to increased climate change design requirements.	**H**

6 Renewable Energy

In line with the NSW Government's commitment to the Net Zero Plan and the NSW Electricity Strategy, there is a focus on increasing the uptake and integration of renewable energy into the NSW electricity supply, supported by improved energy efficiency and productivity and energy storage solutions (e.g. firmed renewable energy solutions). As part of the AEMO ISP and NSW Government's Electricity Strategy, Renewable Energy Zones (REZs) have been identified based on the available solar and wind resources. This has led to the NSW Government implementing the Central-West REZ pilot project to the North West of Sydney and additional opportunities being identified for the New England and South-West Energy Zones (refer figure 13).

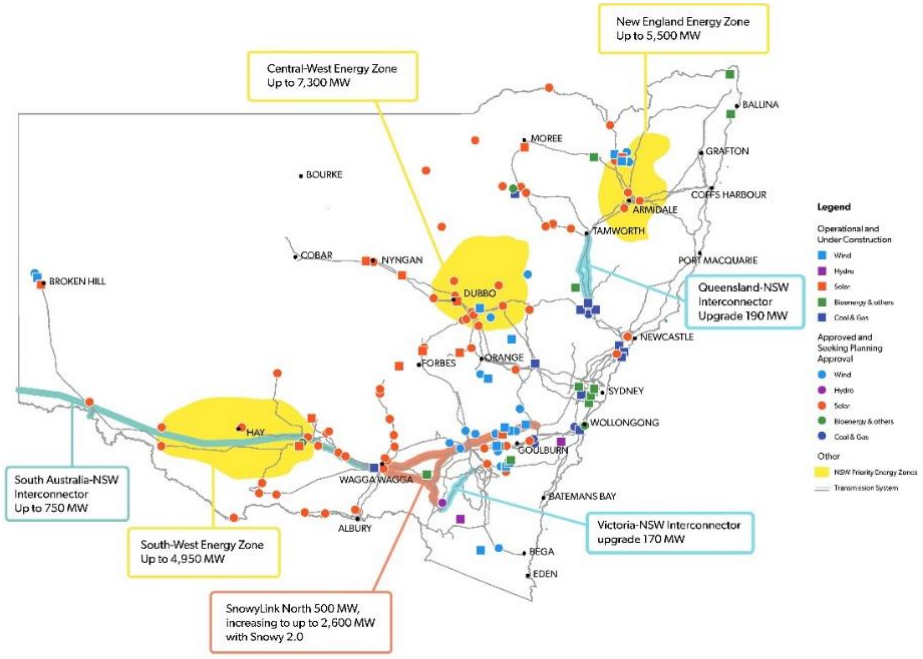


Figure 12: Renewable Energy Zones and Transmission Network Upgrades

The closest identified REZ in the ISP is in the adjacent Southern NSW Tablelands region (refer figure 14 – region 11) which is part of the South Eastern and Tablelands Regional Plan area. This region has large wind resources and also incorporates hydro power plants as part of the Snowy Hydro scheme and therefore has an increased focus on large scale renewable energy as a core strategy to grow the region.

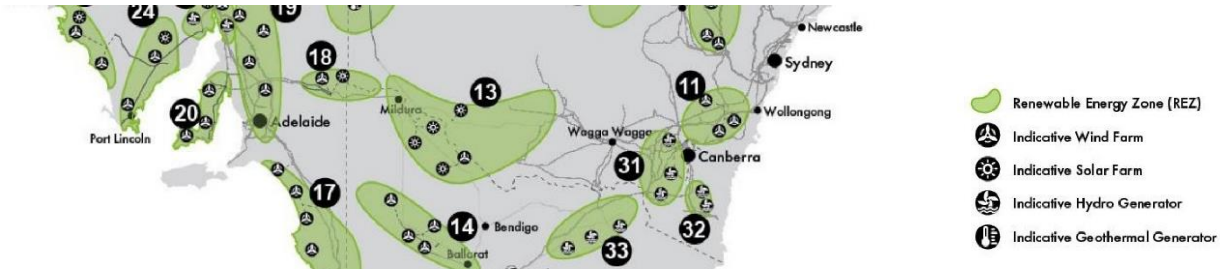


Figure 13: Renewable Energy Zones (AEMO ISP)

Due to existing REZs being in development and the relatively low levels of wind and solar resources in the Illawarra Shoalhaven region compared to the REZs, large scale renewable energy such as wind and solar farms (>10MW) are unlikely to be a priority. However, solar resources are more than sufficient for the installation of distributed smaller scale solar PV systems (refer to Section 6.1 below). As a result, a focus has been placed on integrating distributed renewable energy coupled with energy storage into the region which is outlined in Section 6.1 below.

6.1 Solar Photovoltaic (PV) Systems

Solar radiation resources in the region are outlined in Figure 15 and although solar resources are greater in regions to the west and north west, which are being targeted as part of the REZs, solar resources are sufficient to support deployment of large scale distributed renewable energy in the region.

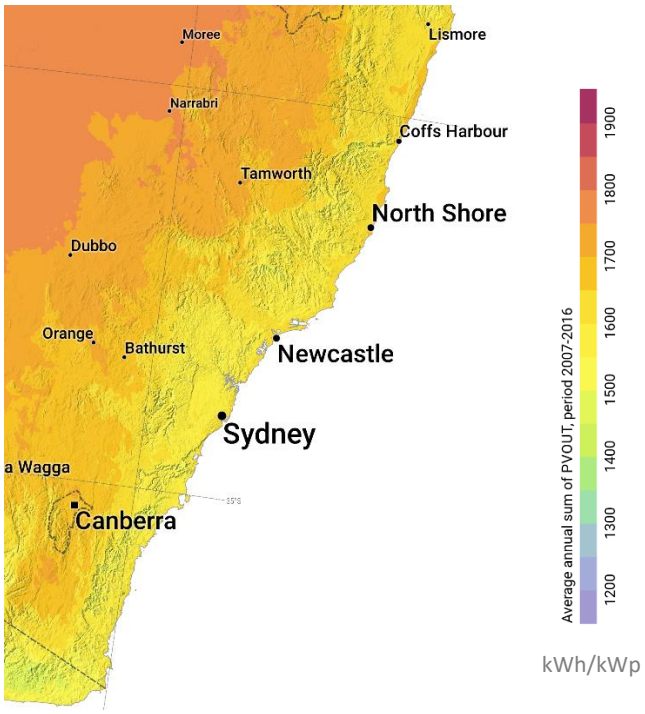


Figure 14: Solar PV Potential (kWh/kWp)

In line with the rest of NSW, solar has been increasing in the region for both residential and more recently commercial solar PV systems. Based on data from the Clean Energy Regulator (CER) and the Australian PV Institute (APVI) Solar PV Status map, the uptake of solar PV per dwelling is lower than the state average with the exception of Kiama (refer table 3). This is further supported by the 2017/18 BASIX summary which identified that the inclusion of solar PV on new residential dwellings was lower in Wollongong and Shellharbour compared to Kiama and Shoalhaven (refer Table 3 and Figure 16). This may be due to the increased energy security issues experience to the south of the region and the types of dwellings being constructed. Total estimated solar PV system capacity in the region is approximately 124MW.

Table 3: Rooftop Solar PV Penetration

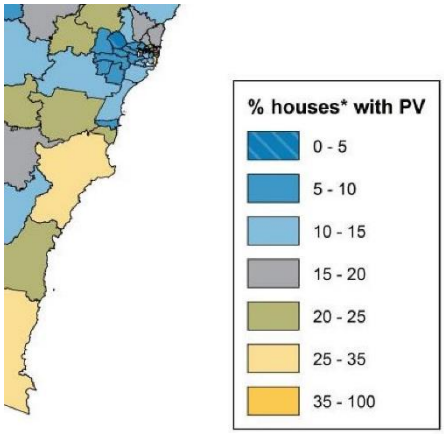


Figure 15: BASIX Solar PV Penetration

Region	Region Rooftop Solar Penetration	BASIX Solar Penetration (New Residential)
State	20.4%	14%
Wollongong	16.6%	10-15%
Shellharbour	18.8%	5-10%
Kiama	21.3%	20-25%
Shoalhaven	18.8%	25-35%

This presents an opportunity for additional solar PV to be integrated into the region however will require careful planning due to the potential network constraints identified in Section 5 and additional challenges introduced when large amounts of behind-the-meter solar PV is installed from a monitoring and control perspective. In particular, AEMO's recent Renewable Energy Integration report (April 2020) outlines a number of additional controls which should be considered as part of planning for distributed renewable energy systems.

It is recommended that distributed solar PV systems are supported across the region to increase solar PV penetration in line with state averages, with a target to increase above average when coupled with monitoring and energy storage systems. If the region were to increase

In particular, there is an opportunity to maximise solar PV on large industrial sites and import car parks which are currently underutilised for solar PV. These systems could provide both renewable energy to the businesses while also facilitating a Virtual Power Plant (VPP – refer to Section 8) and supplying renewable energy to other organisations that are unable to install the same capacity of solar.

For example, there is approximately 150 hectares of industrial land at Unanderra in the below satellite image (refer figure 17 and 18). If a 30% land utilisation factor is used and it is assumed that 70% of this area is capable of installing solar PV, this equates to approximately 30 hectares or 30,000m^2 of roof space which has the potential to facilitate the following for rooftop solar PV. Structural capacity, building orientation, roof angle and the age and condition of electrical systems will need to be confirmed.

Table 4: Rooftop Solar PV Assumptions

Metric	Total
kW / m2	1kW / 5.7m^2
Typical Generation per kW	1,500kWh / Yr
Rooftop Area	315,000
Rooftop Solar PV Capacity	55.3MW
Annual Generation	74,605 MWh
Emissions Reduction t CO2-e (Scope 2 & 3)	7,105

Figure 16: Industrial Area Unanderra

Figure 17: Industrial Area Unanderra

The following opportunities are also present at industrial parks across the region to facilitate increased renewables.

Flinders Industrial Estate

Metric	Total
Rooftop Area	477,750
Rooftop Solar PV Capacity	83.8MW
Annual Generation	125,724 MWh
Emissions Reduction t CO2-e (Scope 2 & 3)	113,151

Figure 18: Flinders Industrial Estate

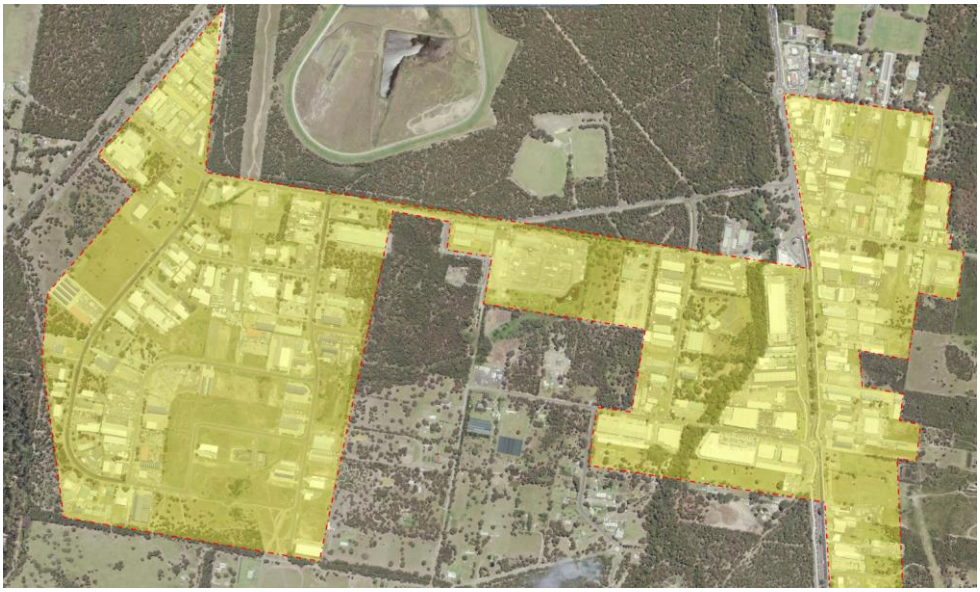


Figure 19: Flinders Industrial Estate Area

Woollamia Industrial Estate

Metric	Total
Rooftop Area	31,500
Rooftop Solar PV Capacity	5.5MW
Annual Generation	8,289MWh
Emissions Reduction t CO2-e (Scope 2 & 3)	7,461

Figure 20: Woollamia Industrial Estate

Figure 21: Woollamia Industrial Estate Area

Albatross Aviation Technology Park

Metric	Total
Rooftop Area	33,600
Rooftop Solar PV Capacity	5.9MW
Annual Generation	8,842MWh
Emissions Reduction t CO2-e (Scope 2 & 3)	7,958

Figure 22: Albatross Aviation Technology Park

Figure 23: Albatross Aviation Technology Park Area

A second example is to install solar PV over the car import yards which would provide both protection for the vehicles and a revenue source with the following potential identified for car storage yards in the suburb of Kembla Grange (refer figure 25 and 26). The analysis is based on 70% of the car yard space being utilised for a ground mounted solar PV system. A detailed feasibility study will be required to confirm spatial arrangements taking into account spacing between cars and the structural span of ground mounted solar panels.

Metric	Total
Area m^2	560,000
Ground Mount Solar PV Capacity (MW)	98.2
Annual Generation (MWh)	147,368
Emissions Reduction t CO_2-e (Scope 2 & 3)	132,632

Figure 24: Car Import Yard Kembla Grange

Figure 25: Car Import Yard Kembla Grange_2

It is recommended that industrial organisations are supported in installing large scale solar PV as part of a coordinated approach to integrating renewable energy in the region. The above examples have the potential of installing approximately 250MW of solar PV with an annual generation of over 150GWh and an emissions reduction of approximately 130,000 tonnes of CO_2-e. This is equivalent to 5% of total electricity emissions for the region. However, these systems will need to carefully consider network capacity, the impact of intermittent renewable energy on the grid (frequency and voltage) and how to integrate energy storage to support the grid and wider region.

In addition, continued promotion of rooftop solar PV for commercial and residential properties is also recommended to increase the penetration of rooftop solar in the region which is currently lower than the state average. The Energy NSW Solar for Low Income Households and Building Upgrade Finance programs should be investigated to increase the share of solar PV while reducing costs for low income households and businesses.

6.2 Wind Energy

In line with the AEMO ISP and Renewable Energy Zones (REZs) identified by the NSW Government, wind resources are currently located to the west of the region and increased wind generation is being targeted by the South East and Tablelands Regional Plan. In addition, offshore wind resources are available in the region however increased wind resources are available further south.

Sydney Water and the Ports Authority have previously investigated the feasibility of implementing wind turbines adjacent to the Wollongong wastewater treatment plant however due to high capital costs and lower wind resources than expected, the project has not proceeded. However, wind turbines of this size may be an opportunity when coupled with alternative energy solutions such as a hydrogen electrolyser to provide a renewable energy supply for the generation of green hydrogen. Refer to Section 7.4 for further information.

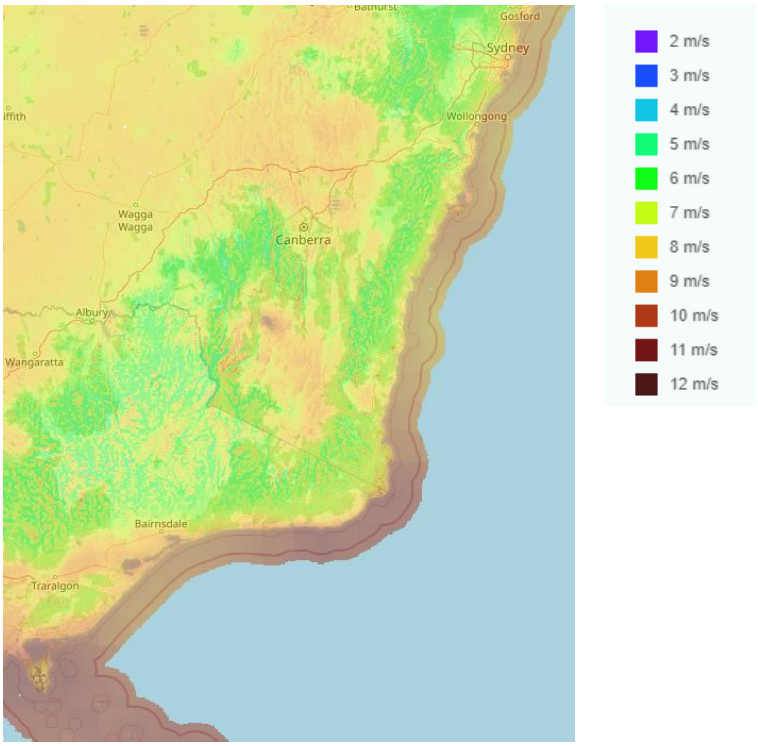


Figure 26: Wind Energy Resources

6.3 Wave Energy

An analysis of wave energy resources has been undertaken and identified that even in the event that a commercially viable wave energy system is developed, wave resources in the region are not supportive of wave energy generation with the southern and western coastlines providing a far stronger opportunity (refer figure 28). As a result, wave energy for the region has not been considered further.

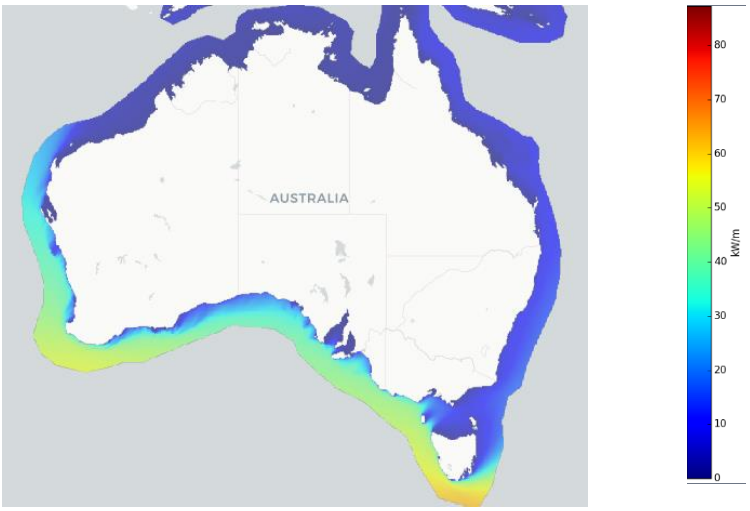


Figure 27: Wave energy resources

6.4 Renewable Energy Contracts & Procurement

To take advantage of the REZs, renewable energy resources in the adjacent regions and the typically lower cost of renewables, it is recommended a regional approach to procuring renewable energy as part of across government electricity contracting is pursued. There are a number of procurement options for integrating renewable energy including:

- **Power Purchase Agreements (PPA):** A PPA is a direct agreement with an energy generator such as wind and solar farms where a discounted rate can be secured by committing to purchasing a set volume of energy per annum. For example, Westpac entered into a PPA with Spark Infrastructure to source 45% of its electricity from the Bomen Solar Farm in Wagga Wagga which was recently completed. There are a number of PPA structures which will need to be considered and it is recommended a procurement specialist in electricity contracts and PPAs is engaged if pursued.
- **100% Renewables Expression of Interest:** An alternative to pursuing a PPA is to open an Expression of Interest (EOI) with the aim of procuring 100% renewables which allows the market to respond with innovative options. This could be expanded to include additional options such as energy efficiency improvements (Energy Performance Contracts – EPCs), demand controls and response, Virtual Power Plants (refer to Section 8) and new forms of energy generation that could locate in the region if a contract is secured.
- **Green Power:** A more traditional approach is to enter into standard electricity contracts with an electricity retailer with 100% Green Power included. Green Power will be an added cost to standard electricity rates however recent commercial contracts have demonstrated that it is possible to secure Green Power without a significant cost impact. For example, recently negotiated electricity contracts have a reducing electricity rate over the next 3 years and although Green Power resulted in a higher price per kWh in the first year, by the second year the rate had reduced below current electricity prices. As a result, the total cost of electricity does not increase over the life of the contract.

- **Capital Funding:** A final option that some councils around Australia are electing to pursue is utilising council land to install a solar PV farm with sufficient energy to supply the council's operations and reduce electricity emissions to zero. Although this option requires a large capital investment, a joint solar PV farm between the 4 councils may provide an economically viable solution which does not require a long-term agreement with a private operator. In addition, the solar farm could be oversized with the aim of providing renewable energy to private organisations in the region as a strategy to reduce emissions in a coordinated way. In this case the councils would need to become an authorised electricity retailer to sell excess electricity to organisations.

To enable sufficient buying power and demand, there may also be an opportunity to enter into a joint agreement where a state or regional level organisation, such as NSW Government or the Local Government NSW, develop a regional procurement approach for energy which is open to both councils and select private organisations that have significant electrical demand and emissions. For example, a cross regional energy contract that aggregates the demand from the councils, major industry and commercial operations would have sufficient demand to underwrite a large-scale energy procurement initiative. The energy contract could also be used to facilitate a Virtual Power Plant (VPP) model as per Section 8. Further investigation into how to separate entities within the contract will be required to ensure that there are appropriate governance structures and controls and that any debt is appropriately allocated to responsible organisations.

Another option to assist in reducing the electricity rate, securing renewable energy and providing certainty to both the councils and the renewable energy providers is to enter into longer term agreements. Longer term agreements are becoming more common place and provide greater price certainty for organisations with longer term planning possible or renewable energy companies.

It is recommended that a strategic cross regional approach to energy management and renewable energy procurement is implemented with a lead organisation taking responsibility for acting on behalf of the councils, major industry and commercial organisations.

6.5 Key Renewable Energy Initiatives

A coordinated approach to increasing renewables in the region should be undertaken for residential, commercial and industrial properties. As a result, all areas should be supported for solar PV however a potential opportunity for previously proposed wind turbines adjacent to the Wollongong wastewater treatment plant was also identified which, when coupled with the potential hydrogen electrolyser, may now be viable.

LGA	Centre	Residential Solar PV	Commercial & Industrial Solar PV	Wind
Wollongong	Corrimal			
	Wollongong			Port of Port Kembla
	West Lake Illawarra			

	Dapto		Car import storage areas	
Shellharbour	Shellharbour			
Kiama	Kiama			
Shoalhaven	Nowra-Bomaderry			
	Ulladulla			

6.6 Renewable Energy Implementation Guide

It is recommended renewable energy is targeted as a high priority however large-scale integration will require planning and ensure grid stability is not negatively impacted. As a result, renewable energy should be deployed alongside energy storage (refer Section 7), supported by a monitoring system such as a Virtual Power Plant (VPP – Refer Section 8).

The following implementation guide has been developed with potential timeframes for implementing large scale renewable energy projects (refer Figure 29).

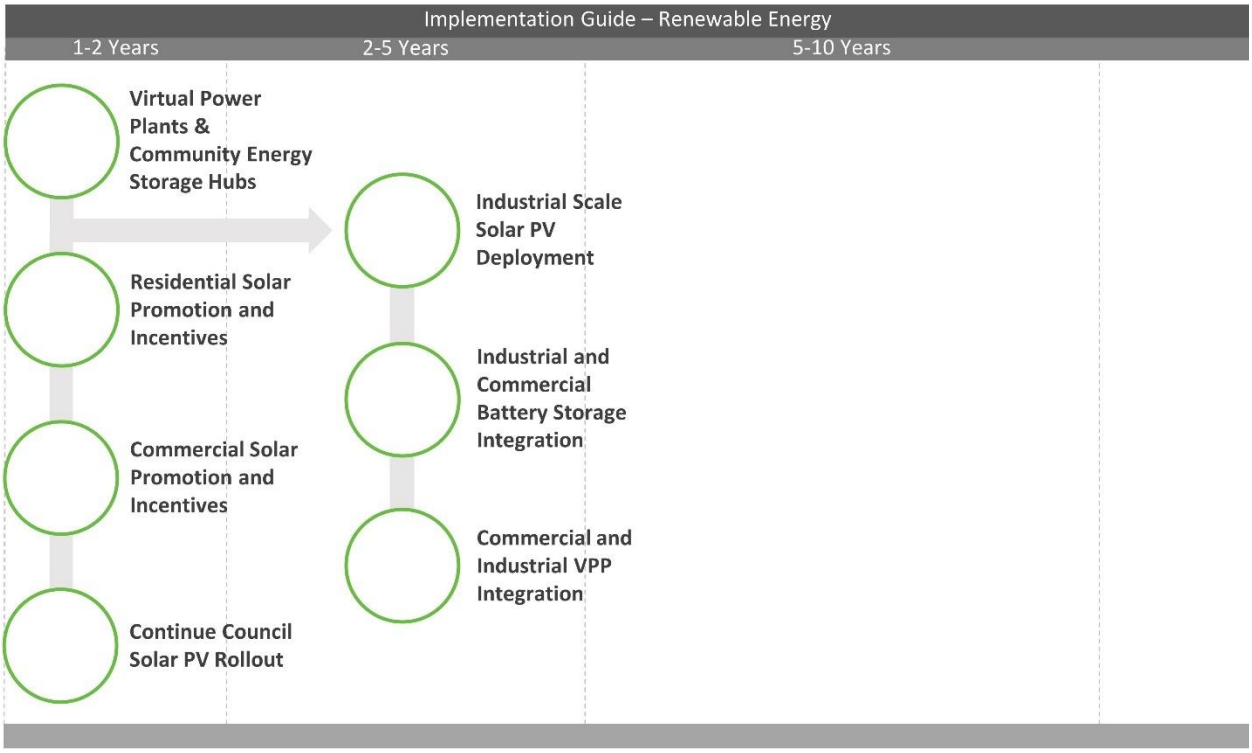


Figure 28: Renewable Energy Implementation Guide

6.7 Climate Change Impact

A number of climate change risks have the potential to impact renewable energy in the region as per Table 5 below.

Table 5: Climate change risks for renewable energy

Climate Change Risks		Impact	Risk Rating
	**Increased solar radiation**	Increased solar radiation for the region has been projected which will result in a minor increase in the productivity of solar PV systems.	N/A
	**Minor increase in mean wind speed**	Minor increases in mean wind projected for the southern region of the sub-clusters however minimal impact on wind resources for the Illawarra Shoalhaven.	**L**
	**Increased rainfall variability, evaporation and longer periods of drought**	Reduced capacity of hydro power plants, resulting in potential reduced generation capacity in the region.	**L**
	**Increased sea surface temperatures and more acidic oceans**	No impact on wave energy resources projected.	N/A

7 Energy Storage

As a simple definition, energy storage is the capture of energy generated at one point in time for use at a later time. The energy can be generated from both renewable and non-renewable sources and can be used to:

- support increased renewable energy integration by smoothing the intermittent nature of renewables (e.g. voltage and frequency control);
- reduce operating costs by storing energy during off-peak periods and discharging during peak periods;
- manage peak demand at a customer and network level;
- access alternative energy markets such as Frequency Control Ancillary Services (FCAS); and
- provide back-up power provisions while reducing emissions compared to using a fossil fuel supply such as diesel.

In particular, energy storage provides an opportunity to improve resilience and provide back-up power to towns and properties to the south of the region which are more vulnerable to power losses due to transmission and distribution infrastructure (poles and wires) disruptions. These regions may be able to take advantage of the Australian Government Regional and Remote Communities Reliability Fund Microgrids which is being run over 5 years through to 2023/24.

There are a range of energy storage opportunities available to the region which will provide solutions for increasing renewable energy integration and improving grid stability and resilience. This includes pumped hydro, battery storage, thermal storage, hydrogen gas and biogenic gas as per the below sections. The recent 'wholesale demand response' rule change may also be an opportunity for energy storage where organisations can maximise their demand reduction during demand response periods, while still maintaining operations. This should be considered further as part of a regional response to demand management.

Additional energy storage technologies such as flywheels and compressed air are also available however are typically site specific and require further investigations. This can also be undertaken as part of collaborative investigations outlined in Section 12.

7.1 Pumped Hydro

As part of the NSW Pumped Hydro Roadmap, priority sites have been identified in the region including the upgrade of the Shoalhaven Hydro Pump Storage power plant located in Kangaroo Valley and additional opportunities in the region including utilising historical mines.

Figure 29: Shoalhaven Pumped Hydro

These sites have been mapped in further detail as part of an Australian Renewable Energy Agency (ARENA) funded study by the Australian National University (ANU) which is available on the Australian Renewable Energy Mapping Infrastructure (AREMI – Refer Figure 31 for an example). The ANU and ARUP were also engaged to undertake further study of pumped hydro sites to inform WaterNSW' Expression of Interest (EOI) run at the end of 2018 to attract private investment in pumped hydro at WaterNSW sites.

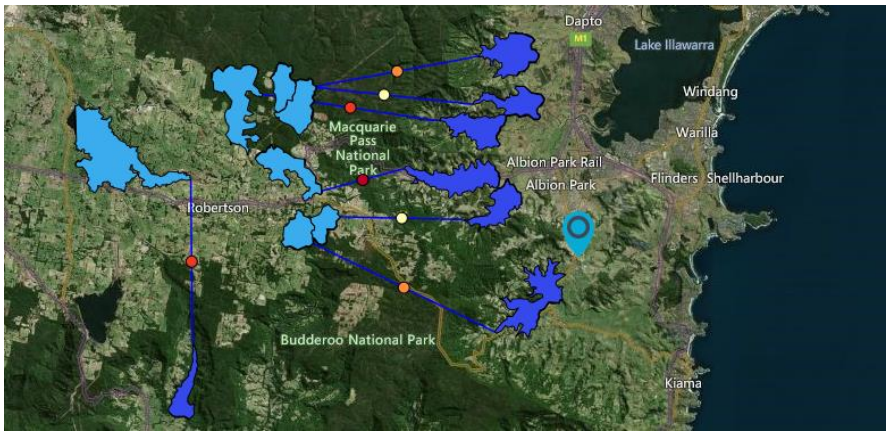


Figure 30: AREMI Map Example for the Illawarra Shoalhaven Region

A Request for Proposal (RFP) was recently released by WaterNSW based on the EOI however identified Burrendong Dam and Windamere Dam as priority sites for renewable energy investment to support potential energy shortfalls in the NSW electricity network. It is recommended that pumped hydro continues to be supported in the region to facilitate increased renewable energy and take advantage of the increase in large scale renewables in adjacent regions. This will also reduce reliance on fossil fuel power plants while maintaining reliability.

7.2 Battery Energy Storage System (BESS)

Battery Energy Storage Systems (BESS) such as lithium-ion, zinc-bromine flow batteries and advanced lead acid batteries are increasingly being utilised at a residential through to utility scale to support the integration of renewable energy and provide services such as peak demand management, frequency control and voltage control. Battery prices have reduced significantly over the past few years and are projected to continue to decrease as the volume of batteries produced increases to meet demand (refer Figure 32) and as the technologies continue to mature (refer figure 33).

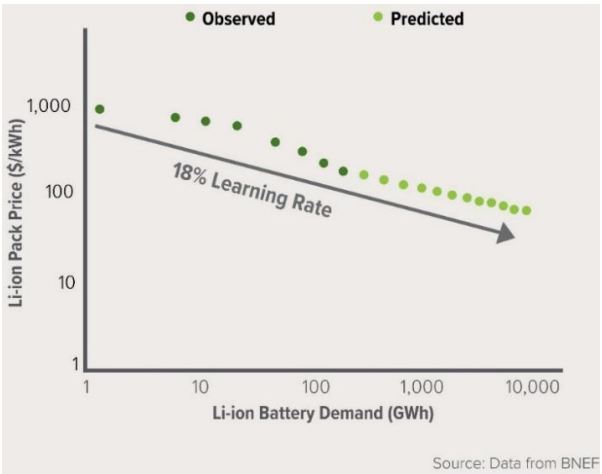


Figure 31: Price, Demand and Learning Curve

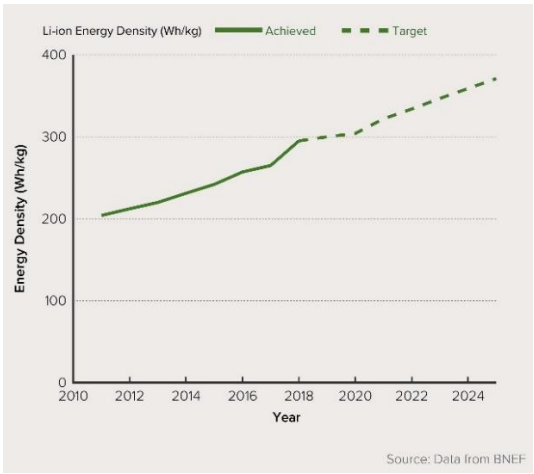


Figure 32: Battery Density

Recent studies of grid scale batteries such as the 100MW/129MWh Neoen Hornsdale Power Reserve battery in South Australia and smaller commercial scale batteries such as the University of Queensland's 1.1MW/2.15MWh battery storage project, along with the Endeavour Energy battery installed at Dapto, have demonstrated that grid connected battery storage is providing a tangible benefit to managing grid stability and providing a revenue source. This has been further demonstrated with the soon to be completed upgrade of the Hornsdale battery which will increase the battery size to 150MW/193.5MWh and is being used to provide inertia capabilities. Inertia is typically provided by large gas and coal power plant which will need to considered as these power plants reach the end of their operating life.

Grid scale battery storage viability is expected to continually improve as prices decrease and with the introduction of new electricity market rules such as 5min trading intervals which will start in July 2021, and the wholesale demand response which will start in October 2021.

In addition, Virtual Power Plant (VPP) programs across Australia are demonstrating how a coordinated approach to integrating renewables and energy storage can be used to provide flexibility and grid stability. Refer to section 8 for further information on VPPs.

Supporting additional battery storage across the region is recommended to provide both increased resilience and to advantage of increased renewable energy.

7.3 Thermal Storage

In addition to pumped hydro and battery storage, thermal storage also presents an opportunity for the region due the large industrial processes which require significant amounts of thermal energy. Thermal storage uses materials (e.g. building mass, water, phase change materials) to store excess thermal energy for later utilisation e.g. cooling and storing water at night during off-peak periods to supply cooling to systems in peak periods.

Thermal storage can be utilised at a site or precinct level and can provide significant opportunities to reduce peak demand by capturing excess energy in thermal storage mediums and then using the energy during peak events when electricity prices are typically at their highest. Due to the potential electricity network constraints identified by AEMO and the NSW Electricity Strategy, implementing peak demand management systems will benefit grid stability while also reducing network charges which are typically a significant component to energy costs for industry.

Examples of thermal storage being used at a campus level include the University of the Sunshine Coast's chilled water storage system (refer figure 33) and at a precinct level thermal storage has been utilised at industrial developments globally (refer to Section 10 for example precincts).

Figure 33: Chilled Water Storage Tank - University of the Sunshine Coast

It is recommended a feasibility assessment into shared thermal storage opportunities is undertaken for industrial areas across the LGAs to identify areas that are viable for industrial symbiosis integration. This could form part of a large industrial symbiosis analysis for areas with large industrial developments.

7.4 Hydrogen

In line with Australia's National Hydrogen Strategy, hydrogen production, utilisation and export has been identified as a high priority to maximise Australia's energy resources and transition to a low carbon economy. In addition, the NSW Government has set a target to blend up to 10% hydrogen into the existing natural gas network by 2030.

Hydrogen is a fuel that has zero carbon emissions when consumed, and if created using renewable energy can be a zero-emission energy resource i.e. "green" hydrogen. There are multiple definitions of hydrogen production as follows:

- **Green Hydrogen:** Produced from 100% renewable energy using electrolysis with zero emissions during production and consumption.
- **Blue Hydrogen:** Produced from fossil fuel energy supplies (e.g. coal and gas) coupled with carbon capture and storage (CCS) to reduce emissions. It be noted that CCS technologies are still in early stages of commercial deployment and typically require government policy and subsidies to be viable. A recent report by the International Energy Agency (IEA – June 2020) has stated that CCS deployment is not on track to achieve the required carbon emission reductions typically identified in emission reduction pathways. As a result, care should be taken when increasing energy demand from fossil fuels to power hydrogen plants due to the current status of CCS technologies.
- **Grey Hydrogen:** Typically produced from natural gas using a steam methane reforming process.
- **Brown Hydrogen:** Typically produced from the gasification of coal.

Hydrogen can be stored and used when required and can be transported in liquid form in a similar manner to liquid petroleum gas (LPG), petrol, and diesel fuels, and so is a dispatchable source of base load zero carbon energy. Through the process of electrolysis, hydrogen can be created using water as the feedstock, and zero or low carbon energy such as solar PV or natural gas as the catalyst.

The development of a hydrogen-based economy, the construction of hydrogen generation systems, and the development of a hydrogen export industry is under way in Australia, with South Australia releasing the first hydrogen roadmap in 2017 and Western Australia releasing theirs in 2019. In addition, hydrogen electrolyser demonstration plants are being implemented across the country with projects underway as per the below (refer to table 6). It should be noted that the demonstration plants are typically coupled with a renewable energy source to generate "green" hydrogen and ammonia. Where a fossil fuel energy source is used, they are heavily reliant on carbon capture and storage (CCS) technologies to reduce emissions and generate "blue" hydrogen. In these cases, they are unable to be marketed as a zero-emissions fuel supply unless additional renewable energy agreements are entered into which should be considered for both domestic and international markets.

Table 6: Australian Hydrogen Projects

Location	Organisation	Size	Output	Power Source	Grant Funding
Western Sydney NSW	Jemena	0.5MW	Hydrogen	Solar and Wind	ARENA
Tonsley SA	Australia Gas Networks	1.25MW	Hydrogen	Solar	SA Government

Location	Organisation	Size	Output	Power Source	Grant Funding
Port Lincoln SA	The Hydrogen Utility	30MW	Hydrogen + Ammonia	Solar and Wind	SA Government
Crystal Brook SA	Neoen	50 MW	Hydrogen	Solar, Wind, Battery Storage	SA Government
Latrobe Valley VIC	Hydrogen Energy Supply Chain	Unknown – Pilot project	Hydrogen	Brown Coal with carbon capture and storage/utilisation	Victorian Government
Perth WA	Hazer Group Limited		Hydrogen and Graphite	Biogas from wastewater	ARENA

An alternative to physically connected to renewable power is to enter into a renewable energy supply agreement such as a power purchase agreement (PPA) as outlined in section 6.4.

NSW has been key to developing the National Hydrogen Strategy and the NSW Chief Scientist and relevant NSW Government departments have been developing hydrogen hubs to support the strategy and maximise hydrogen opportunities. Port Kembla has been identified in the National Hydrogen Strategy as a potential hydrogen hub and was selected based on a Hydrogen Hubs Study commissioned by the Council of Australian Governments (COAG) Energy Council.

The following hydrogen opportunities are currently being pursued in the region which should be supported by the regional plan:

- Hydrogen production at Port Kembla
- Prefeasibility studies into replacing fossil fuel supplies with hydrogen in steelworks (University of Wollongong and BlueScope Steel)
- Supplying renewable hydrogen to the Tallawarra power plant with 10% hydrogen blend for the current plant possible and 15% blend when the expansion is completed.
- Supplying hydrogen to heavy transport including hydrogen powered trains and buses.
- Supplying hydrogen to new housing developments.
- Supplying a dedicated hydrogen pipeline to Sydney.
- Export of green hydrogen to international markets.

It should be noted that there are renewable hydrogen projects being proposed in Australia which are targeting 1-5GW electrolysers which demonstrates a significant shift from demonstration projects to utility scale generation for both domestic use and international exports.

The energy source for the hydrogen electrolyser plant, lifecycle emissions and ability to be marketed as “green” hydrogen will be a key component to developing a hydrogen supply chain in the region. It is recommended that the hydrogen supply chain including both renewable and fossil fuel energy supplies, distribution and transportation, storage and liquification, industrial uses and export potential continues to be investigated and supported.

Smaller scale hydrogen plants may also be appropriate when coupled with industrial and agricultural processes that use hydrogen or can substitute existing processes with hydrogen. Opportunities for smaller scale hydrogen electrolysers coupled with agribusinesses in the Shoalhaven region should be considered in larger agricultural areas. This could include engagement with existing organisations such as the Manildra Shoalhaven Starches facility which have already diversified their production facilities and may be a catalyst organisation for the region.

7.5 Biogenic Gas

Biogenic gas is generated from the decomposition of organic matter such as sewage and is already being utilised at the Wollongong wastewater treatment plant with biodigesters used to create biogas which is in turn used to generate power for the plant. Sydney Water has identified biogas as a significant opportunity in their Energy Master Plan to reduce emissions and costs.

A feasibility study in the Nowra region by Innovative Energy has recently been successful in gaining a $3 million grant to trial a waste to energy (biogas) plant from dairy manure. The proposal will interconnect 18 dairy farms through a shared manure waste pipeline which will:

- Supply an anerobic bio-digester to generate electricity.
- Provide a non-potable water and residual solids pipeline back to the farms to be used as part of processes and as a fertiliser.
- Supply electricity to the farms as part of a Virtual Power Plant (VPP) model. The farmers will be supplied electricity at no cost based on the amount of manure generated and supplied to the plant.
- Generate excess electricity which will be sold back into the grid and could form part of the VPP outlined in Section 8.

Waste to energy plants using agricultural inputs should continue to be explored in the region due to the large amounts of agricultural emissions.

Biogenic gas can also be injected into gas networks to provide a low emission fuel source which takes advantage of existing waste outputs in the wastewater treatment system. An opportunity to expand biogenic gas generation is outlined in the collaborative opportunities section of this Plan.

7.6 Key Energy Storage Initiatives

The following key energy storage initiatives have been identified for consideration:

Table 7: Energy Storage Initiatives

LGA	Centre	Residential Battery Storage	Large Scale Battery Storage	Thermal Storage	Pumped Hydro	Hydrogen & Biogenic Gas
Wollongong	Corrimal					
	Wollongong		Industrial	Industrial		Hydrogen at Port Kembla + Biogas at Wollongong Wastewater Plant
	West Lake Illawarra		Industrial			
	Dapto		Car import storage areas			

Shellharbour	Shellharbour					
Kiama	Kiama					
Shoalhaven	Nowra-Bomaderry		Industrial + Utility/grid scale storage		Shoalhaven Pumped Hydro Upgrade	Small scale hydrogen plants with agri businesses + Waste to energy plant proposed for dairy farms
	Ulladulla		Industrial + Utility/grid scale storage			

7.7 Energy Storage Implementation Guide

It is recommended energy storage is implemented with a staged approach to facilitate increased renewable energy in the region and as energy storage technology continues to mature and decrease in prices. The following implementation guide has been developed with potential timeframes for implementing energy storage projects (refer Figure 34).

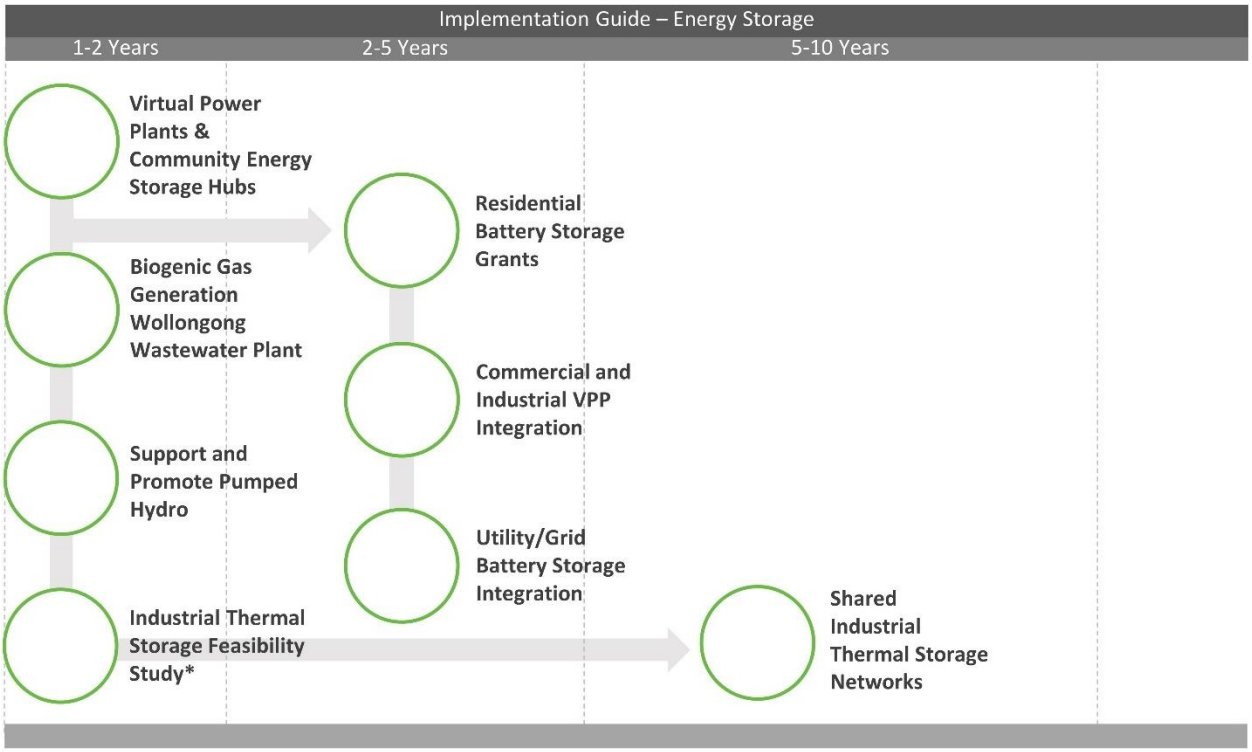


Figure 34: Energy Storage Implementation Guide

Hydrogen systems and opportunities have already been outlined and are being actively implemented by NSW Government and therefore have not been included in the above implementation guide. However, the hydrogen supply chain should be actively pursed and supported by the region and LGAs with additional opportunities to create demand for green hydrogen by committing to purchasing hydrogen vehicles and updating procurement processes to support the hydrogen industry.

It is recommended that a hydrogen focus group is maintained to ensure all opportunities are shared with the local councils and that effective planning for a hydrogen transition can be undertaken in collaboration with government, education institutions and private industry.

7.8 Climate Change Impact

As per Section 5 Energy, there are a number of climate change impacts that have the potential to disrupt energy supplies to the region. As the impacts of climate change continue to be experienced, energy storage can play a vital role in providing grid stability services and providing back-up power to critical assets in the community.

As a result, increasing energy storage capacity in the region is critical to mitigating the impacts of climate change for the region's energy system and improving reliability and is a key focus in this Plan.

A Virtual Power Plant (VPP) is a distributed energy management system which aggregates standalone assets (e.g. commercial buildings and industrial facilities) and distributed energy systems (e.g. ground and rooftop solar PV, battery storage and bio-energy), and connects these systems in a virtual environment (refer Figure 35). The aggregated assets, energy demand, renewable energy systems and buying power can then be utilised to access existing licenced energy markets to buy, sell and share energy utilising these virtually connected assets. These assets (businesses, poles and wires, powerplants, etc.) can be physically disconnected, but operated in a virtual environment.

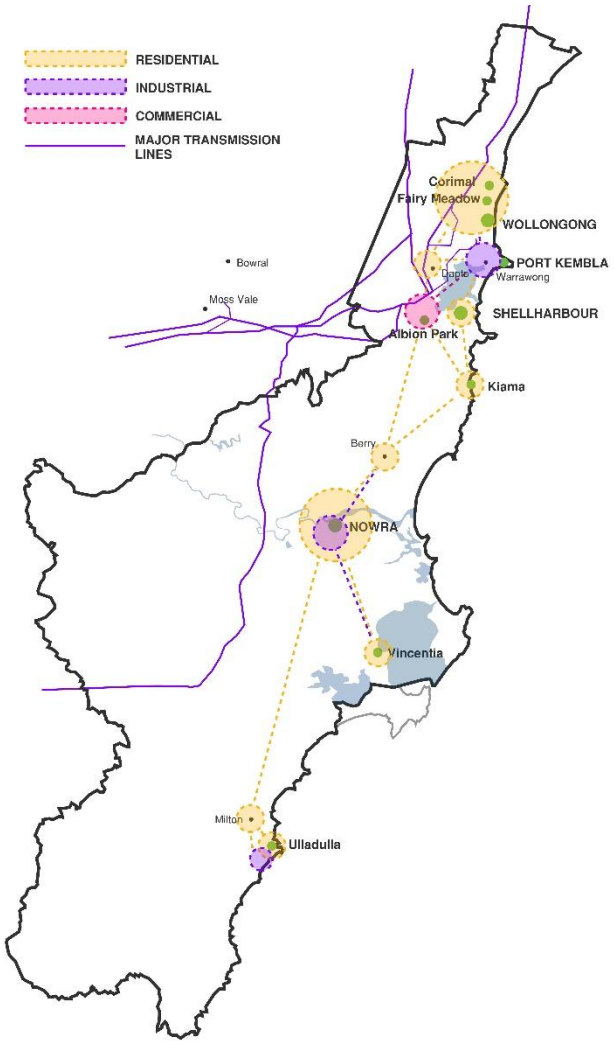


Figure 35: Virtual Power Plant Example

The strength of a VPP is that it can aggregate a range of customers with different load profiles and renewable energy assets to provide a flexible system that maximises the use of renewable energy. For example, commercial customers typically have higher electricity consumption during working hours, whereas residential customers typically use their electricity during the early morning and evenings. The ability to virtually share renewable energy generation, energy storage and exports can enable a more coordinated approach to distributed renewable energy and provides greater visibility for network operators.

Examples of VPPs in Australia include the South Australia VPP and AGL VPP which are participating in AEMO's VPP Demonstrations project. There are 5 VPPs shortlisted for capital funding as part of the NSW Emerging Energy Program with a VPP by Solar Analytics (solar monitoring company) selected for pre-investment studies.

Examples of VPPs being implemented at a commercial and industrial scale include the Southern California Edison's (SCE) VPP across greater Los Angeles and Statkraft's VPP in Germany which has over 1,300 generation assets in the network. These VPPs are providing a range of grid stability services, improving reliability for commercial customers and providing an additional revenue stream to customers.

VPPs should also be considered in the larger context of participating in alternative markets such as ARENA and AEMO's Demand Response Trials, trading on the wholesale electricity market and providing Frequency Control Ancillary Services (FCAS) which can provide a higher return on investment which also improving grid stability.

It is recommended that VPPs proposed for the region under the Emerging Energy Program are investigated further and opportunities to expand the VPPs in to commercial and industrial opportunities are considered.

8.1 VPP Implementation Guide

The VPP implementation guide has been included with the renewable energy (Section 6.6) and energy storage (Section 7.7) implementation guides as these require a fully integrated approach.

8.2 Climate Change Impact

As per Section 5 Energy, there are a number of climate change impacts that have the potential to impact energy supplies to the region. As the impacts of climate change continue to be experienced, VPPs can play a vital role in providing grid stability services, supporting the integration of back-up power to critical assets in the community and providing increased visibility of renewables and energy storage in the region. This will help both network operators and AEMO in managing the electricity grid as renewable energy continues to increase in the NEM.

As a result, supporting VPPS in the region is critical to mitigating the impacts of climate change for the region's energy system and improving reliability and is a key focus in this Plan.

The region has road and rail access to the majority of the major centres however improving access and connectivity has been identified as a key priority for the region to support a greater connection to Western Sydney and improve goods distribution and logistics. This includes an extension to the M1 motorway, a new 4 lane bridge over the Shoalhaven River at Nowra, improved train and bus services and newer more efficient trains.

With transport being the second largest source of emissions for the region, it is recommended that a transition to active and sustainable forms of transport is a priority with coordination required across the region to deploy supporting infrastructure. In particular, public transport options become increasingly challenging further south in the region where there is no rail access and roads through the region are limited. This is increasing dependence on private vehicles which in turn increases emissions.

The Future Transport strategy for the Illawarra Shoalhaven (currently under development) and Regional NSW Services and Infrastructure Plan has identified as number of priorities to improve transport systems across the region (refer to Figure 36) which are expected to both improve services and reduce emissions by implementing sustainable and active forms of transport.

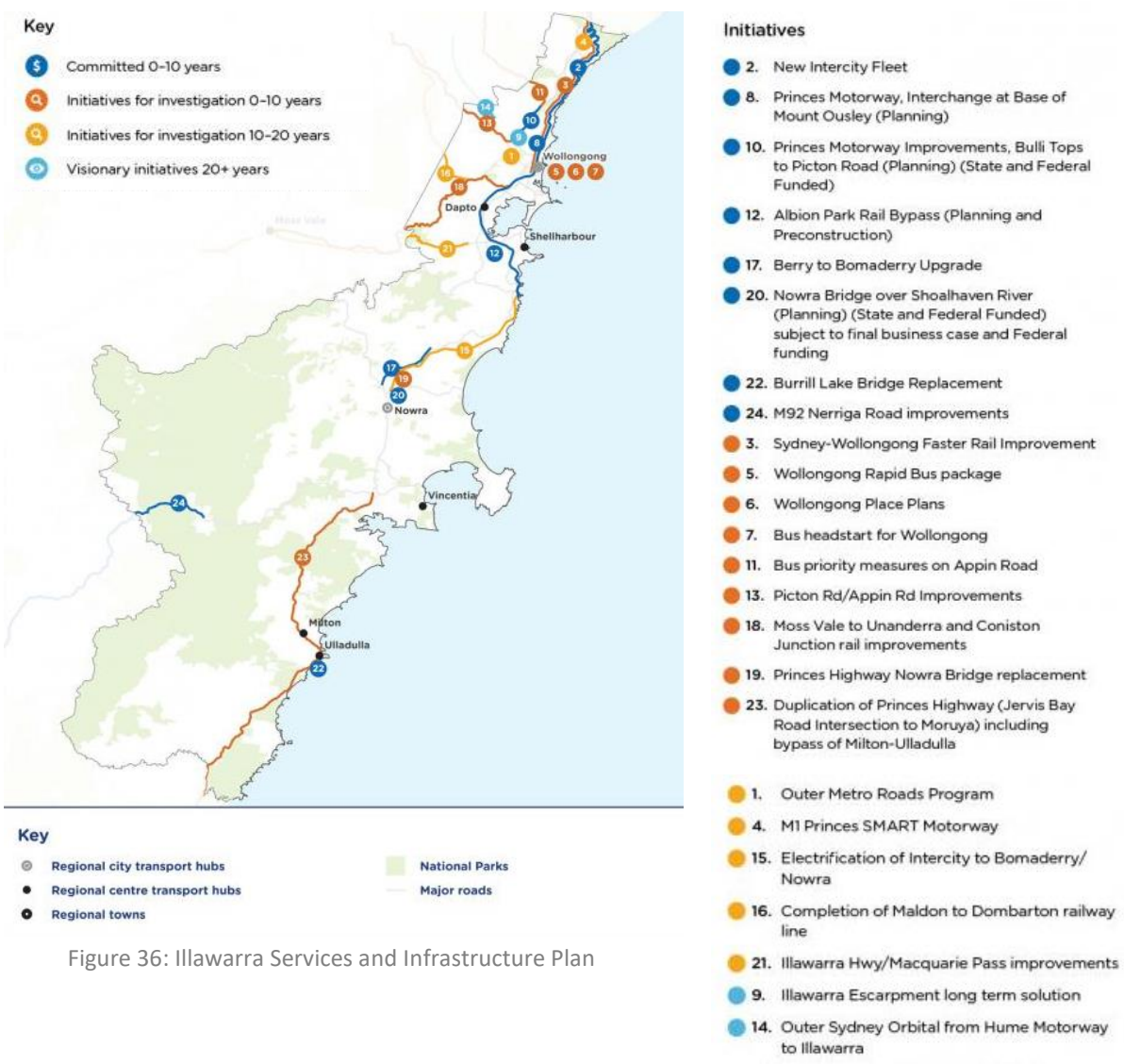


Figure 36: Illawarra Services and Infrastructure Plan

9.1 Rail

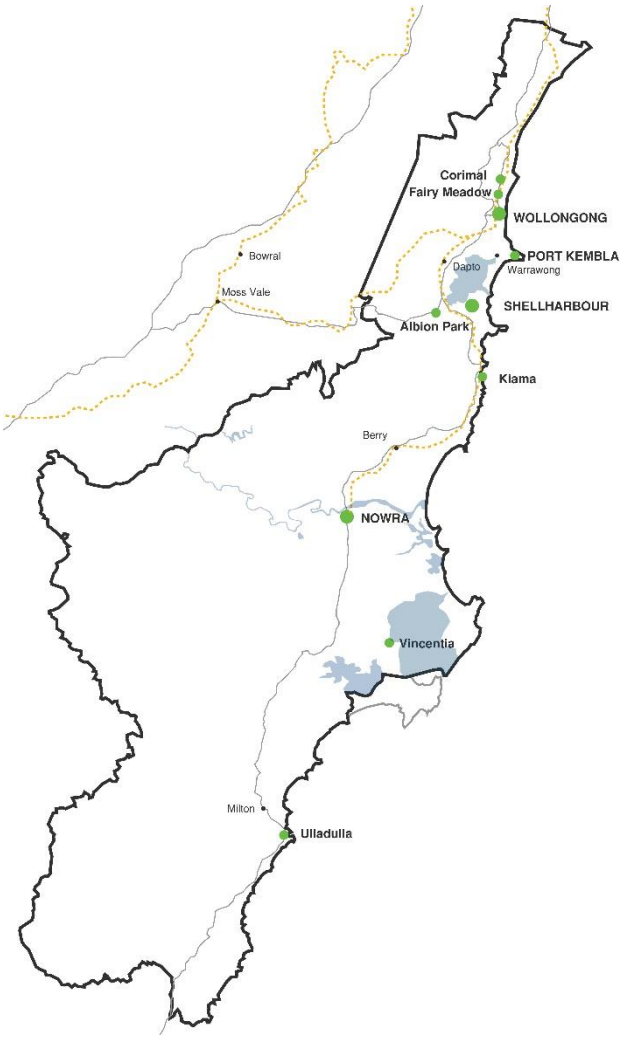


Figure 37: Road and Rail Access

The current rail network extends down to Nowra-Bomaderry and is electrified to Kiama with diesel trains utilised on the main South Coast Line which extends down to Nowra (Bomaderry Station). The rail network is used by both passenger and freight trains with industry utilising the freight network to export goods through Port Kembla and Port Botany.

There are currently no immediate plans to electrify the rail to Nowra citing excessive costs, a focus on increasing services and investing in new trains (Intercity Fleet Train). Small reductions in emissions are expected as newer more efficient diesel trains are introduced. However, electrifying the line in the next 10-20 years has been identified for potential investigation as part of the Future Transport strategy.

The impact of freight trains on congestion for both the road and rail in the region has been cited as a concern within the region and proposals have continually been developed to extend the rail network, implement new lines to adjacent regions and improving public transport options. As a result, alternative options to reduce freight on the rail network, by implementing new modes of transport could be an opportunity to reduce emissions.

Alternative options for more efficient and sustainable transport options should be investigated with a focus on transitioning trains to low or zero emissions fuels, increasing public transport, providing improved active transport solutions (bicycles, pedestrian access) and implementing Mobility-as-a-Service (MaaS) solutions. A particular focus should also be placed on public transport to the south which is heavily reliant on private vehicles and does not have direct access to the rail network. With residential growth and population projections for the region, the public transport network will continue to experience capacity challenges which could be facilitated by other modes of transport.

Hydrogen powered passenger trains are currently under investigation (refer to Section 7.4) as part of Port Kembla hydrogen feasibility studies.

9.2 Passenger Vehicles

Passenger vehicles are the predominant form of travel in the region which would be a significant source of emissions and air pollution. With increased renewable energy opportunities identified and a hydrogen supply chain in development, there are significant opportunities to facilitate a transition to sustainable transport and low to zero emission transport options for passenger vehicles.

Electric vehicles have been commercially available in Australia since 2010 with an exponential growth occurring in vehicle registrations since 2014. The Electric Vehicle Council has recently updated their

figures and have stated that over 6,700 EVs were sold in 2019 which was an increase of over 200% compared to approximately 2,200 sold in 2018. The following figure (Figure 38) shows the growth of EV sales from 2011 to 2018 (note that this does not take into account the significant growth in 2019 sales).

Figure 38: Electric Vehicle Sales. Source: Electric Vehicle Council

Projections from the Australian Energy Market Operator (AEMO) are that with moderate intervention from across government, EV sales will increase from approximately 2,200 vehicles in 2018, to 70,000 by 2023 and will make up the majority of vehicle sales by 2050 (refer Figure 39). Moderate intervention includes targets being set by state governments as part of net-zero strategies, transitioning state and local government fleets to EV's and the rollout of charging infrastructure. This also assumes a relatively slow uptake of hydrogen vehicles which may have changed since the National Hydrogen Strategy was released.

Figure 40 illustrates the increased uptake of EV sales in various scenarios of Government intervention.

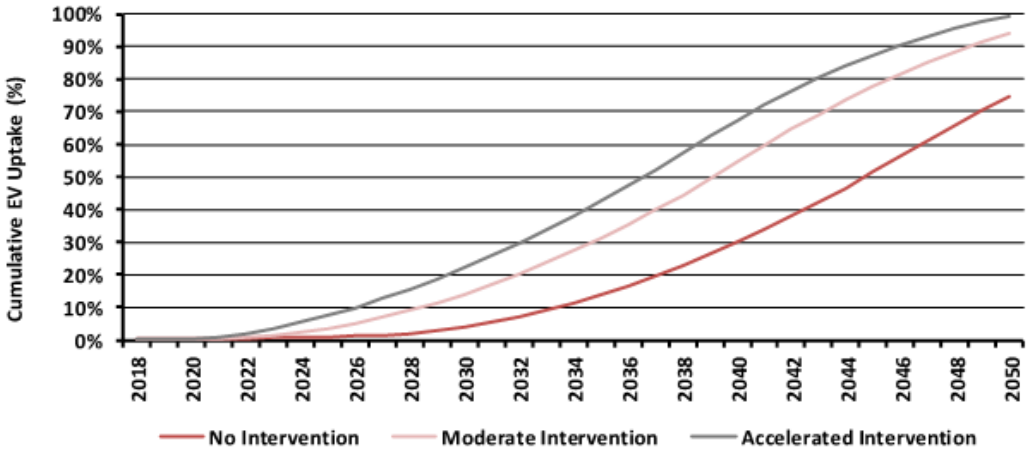


Figure 39: AEMO EV Projections

However, EV sales in NSW are comparatively low per 10,000 vehicles sold (refer Figure 40) and it is recommended the LGAs implement a coordinated approach to facilitating EV sales and travel to the region. The NSW Net Zero Plan has incorporated an Electric Vehicle Infrastructure and Model Availability Program to accelerate EV uptake which is an opportunity for the region if a coordinated approach to EVs and hydrogen cell vehicles is taken.

Figure 40: EV Sales per State

The provision of public charging infrastructure by government (Federal/State/Local) is one of the top three areas that consumers believe will increase the uptake of electric vehicles, along with subsidies for EV's and installing home charging systems. As a result, it is recommended that the LGAs develop a coordinated electric vehicle charging infrastructure strategy to facilitate the installation of additional charging points to both support the community and travellers from Sydney that will increasingly transition to electric vehicles. This can incorporate both council infrastructure to support fleet transitions and private partnerships where EV charging network operators are targeted by providing incentives or facilitating land access. The strategy should also focus on the retail and accommodation sectors and utilise EV charging facilities to attract EV owners to region.

The coordinated strategy should plan for and take advantage of the Electric Vehicle Infrastructure and Model Availability Program announced in the Net Zero Plan. As part of the strategy, the local councils should also investigate mandating a transition to low and zero emission vehicles as part of fleet procurement policies, with support infrastructure provided as part of asset management and capital works programs.

In addition, hydrogen cell vehicles are becoming increasingly available and with the hydrogen supply chain currently in development, and hydrogen vehicle production announced for the region (refer Figure 41), hydrogen vehicles may be a key transport initiative to reduce emissions.

Figure 41: H2X Australia - Hydrogen SUV to be manufactured at Port Kembla

As part of the transition to EVs and hydrogen vehicles, improving both physical and digital infrastructure to support autonomous vehicles will also play a key role in transitioning to lower emission transport options and MaaS models (refer Section 9.7).

9.3 Heavy Vehicles

The region is heavily dependent on heavy vehicles for goods distribution and public transport to the south of the region. In line with passenger EV's, current uptake of medium and heavy electric vehicles (trucks and buses) is relatively low, however is expected to grow significantly in the coming years. Electric truck and bus sales are expected to grow between 9% to 17% per annum through to 2030 across OECD countries.

Companies such as Volvo, Volkswagen, Izuzu (Mitsubishi), Iveco and Tesla are all developing heavy EV's, however one of the key challenges for medium and heavy EV's is the need for significant charging infrastructure required to charge the vehicles efficiently. In addition, distances travelled for regional routes typically exceed currently available EV ranges without charging infrastructure being available. With hydrogen production and vehicle manufacturing already proposed for the region which can provide increased range for heavy vehicles, there is a significant opportunity for hydrogen refuelling stations to be provided to support heavy vehicles both within and servicing the region. This can be further supported by EV fast charging to support both passenger vehicles and medium EVs which can utilise DC charging infrastructure.

It is recommended hydrogen and electric powered trucks and buses are investigated as part of fleet replacement programs and public transport fleet upgrades to take advantage of low and zero emission heavy vehicles. Supporting infrastructure for refuelling will need to be planned and coordinated across the region (as per Section 9.2) to ensure that there is sufficient infrastructure in place to support the transition, while also ensuring that infrastructure is not duplicated in adjacent LGAs.

In particular, the local councils should consider replacing garbage trucks with electric equivalents and buses with electric or hydrogen options to reduce emissions and improve air quality. Trials of electric and hydrogen buses in the region are already in development and should continue to be supported. As these options continue to mature, procurement policies should be updated to support a transition to low and zero emission heavy vehicles as existing vehicles reach end of life.

Trials of electric rubbish trucks are also underway across Australia including Sutherland Shire Council in NSW, East Waste in SA and Cleanaway in VIC. In addition, major industry and commercial companies are also transitioning to electric vehicles for distribution trucks including Amazon, IKEA and UPS. Key learnings from these organisations would be available to the local councils.

9.4 Agricultural Vehicles

With agriculture forming a comparatively large percentage of the region's emissions, emission reduction measures for agriculture should be a focus. As a result, transitioning agricultural vehicles (tractors, quad bikes, dirt bikes, etc.) to lower or zero emission options (refer Figure 42 and Figure 43) will provide an environmental benefit while also improving resilience by reducing the use of imported fossil fuel supplies.

Figure 42: Electric Quad Bike

Figure 43: H2X Hydrogen Tractor

With the implementation of increased renewables and energy storage in the region, along with opportunities for a hydrogen supply chain, options include electric farm vehicles and hydrogen heavy vehicles which can be fuelled from local supplies instead of imported fossil fuels. It is recommended information on lower emission options is provided to agricultural organisations to support uptake. Grants and incentives to assist organisations to transition, while providing initial demand for locally produced vehicles, may be an option to kick start low emission agricultural vehicle uptake in the region.

9.5 Active and Sustainable Transport

The Illawarra Regional Transport Plan, Future Transport strategy and local council strategies and plans have identified a large number of initiatives including improved pedestrian, bicycle, public transport and sustainable transport opportunities that are in various stages of delivery. It is recommended that these strategies continue to be developed and there is minimal benefit in repeating these actions in this Plan.

However, it is recommended that when analysing the benefits of active and sustainable transport options the full health and economic benefits should be factored in including:

- **Health benefits from walking and riding** which (typically) outweigh the increased risk of injury and death from road accidents.
- **Improved air quality** due to reduced personal vehicle use.
- **Reduced capital and operating costs** for vehicle maintenance.
- **Reduced emissions** associated with the transport sector. Note that for the local councils and commercial operators, reducing transport emissions can have a direct benefit when working towards carbon neutral certification and reduce the costs of carbon offsets.

It is recommended that the local councils also promote the use of active and sustainable transport options for their own operations and support options such as e-bikes, ride share schemes and public transport when staff are commuting for official duties.

9.6 Mobility as a Service

Mobility as a Service (MaaS) aims to shift travel from conventional options (car ownership) to a service experience where car ownership is no longer required for daily travel needs by combining multiple transport modes into a seamless user experience. MaaS options include car, bicycle, e-bike and e-scooter sharing networks and shared taxi services and when integrated with public transport networks, have the potential to reduce costs and emissions.

Figure 44: Uber Air

These opportunities should be investigated in the region, with a focus placed on low and zero emissions vehicles such as EVs, electric buses and shuttle bus services and facilitating active transport options such as bike and e-bike share schemes.

Additional opportunities in the future include autonomous vehicles and helicopter air services such as those proposed by Uber for Melbourne (refer Figure 44) which may assist in reducing congestion in areas with limited road access. There are also multiple companies working on autonomous drone technologies which could be used for passenger services. Although these types of services are many years away from mass commercialisation, future transport plans for the region should consider these changes as part of plans and strategies.

9.7 Digital and Autonomous Systems

In addition to physical infrastructure works (roads, rail, bike lanes, etc.), opportunities are also available to utilise digital and autonomous systems to reduce dependence on personal and business travel, while improving the efficiency of the transport system. This includes:

- **Remote Working and Teleworking**: Supporting teleworking (working from home), flexible working conditions (working from home and the office) and providing flexible work spaces (e.g. co-working spaces) to reduce transport use. Supporting the uptake of teleworking can provide a range of benefits for the region including reduced travel congestion, emissions and costs, improving work and life balance, improving productivity and maintaining a stronger connection within local communities by removing daily commutes outside of the region.
- **Real time data**: Supporting real time traffic and public transport data can assist in mapping and planning for congestion and support the uptake of MaaS.
- **On-demand Public Transport:** Supporting flexible public transport systems such as on-demand public transport can assist in improving public transport access and effectiveness and may be particularly relevant in the southern parts of the region where public transport is limited.
- **Ride Sharing**: Supporting ride sharing services such as Uber and OLA can reduce private car use, diversify the transport sector and reduce costs associated with purchasing and maintaining private vehicles. It should be noted that taxi services also provide some of these benefits and can have a larger presence in regional areas with potential job impacts considered.
- **Autonomous Vehicles:** Although autonomous vehicles are still a number of years away, supporting the industry through trials, providing research grants and supporting industry collaboration can place the region in a strong position to implement autonomous vehicles. Autonomous vehicles have a number of potential benefits including reduced car ownership, improved efficiency and safety and reduced congestion.

It is recommended digital and autonomous support mechanisms are investigated in the region including improved digital connectivity and supporting and collaborating with new industries to trial and research future transport opportunities.

9.8 Transport Implementation Guide

It is recommended low emission transport options are implemented with a staged approach to take advantage of increased renewable energy in the region and as the hydrogen supply chain is implemented. The following implementation guide has been developed with potential timeframes for implementing low emission transport options (refer Figure 46).

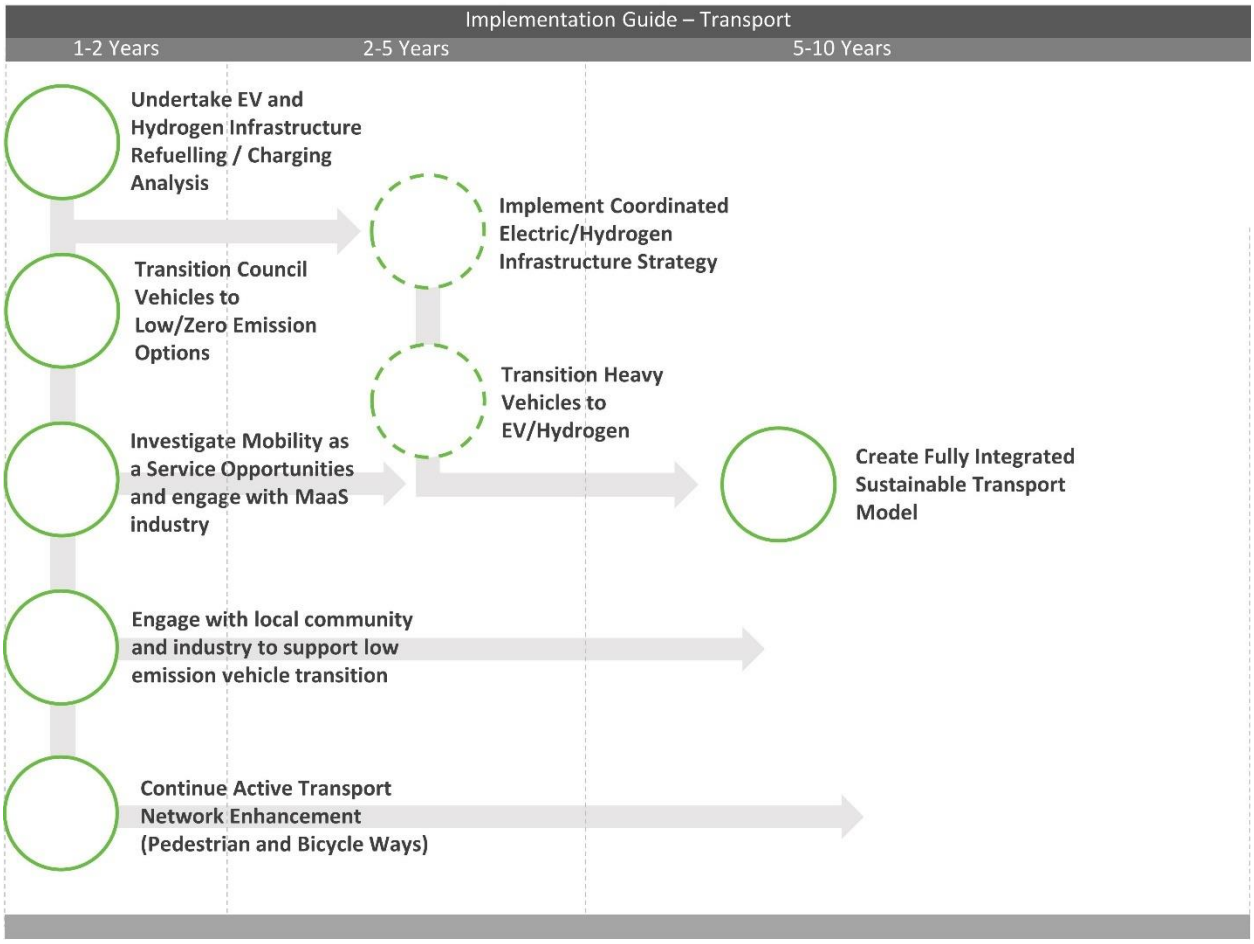


Figure 45: Transport Implementation Guide

9.9 Climate Change Impact

A number of climate change risks have the potential to impact transport networks in the region as per Table 8 below.

Table 8: Transport Climate Change Impacts

Climate Change Risks		Impact	Risk Rating
	Increased temperatures with prolonged and more frequent heat waves	Increased temperatures and prolonged heat waves can result in asphalt surfaces becoming unstable and train tracks buckling due to extreme temperatures.	**M**

	**Harsher fire-weather**	More frequent and intense bushfires may disrupt transport routes through road closures.	**H**
	**Increased rainfall intensity**	Road and rail access impacted by floodwater with associated increased soil erosion.	**H**
	**Rainfall variability with increased rainfall intensity and evaporation**	Soil expansion and erosion, resulting in cracks and damage to road surfaces causing road closures. May also impact the ability for fire crews to access regional areas and national parks due to large cracks forming.	**M**
	**All of the above**	The combination of climate change risks in the region has the potential of reducing the life of transport infrastructure with additional capital required to maintain, upgrade and replace infrastructure due to increased climate change design requirements.	**H**

The National Waste Policy and Action Plan and NSW Circular Economy Policy, along with the development of a 20-year waste strategy for NSW by the EPA, has placed a strong focus on increasing the capacity of Australia and NSW to process its own waste within a circular economy model and reduce waste to landfill with associated carbon emission reductions. This has been further driven by China's National Sword policy which although a major disruption the waste and resource management industry in Australia, has created a significant opportunity to implement improved waste management practices and maximise the use of resources.

Australia's waste generation per capita is one of the highest in the world at over 2.7 tonnes generated per year (total waste generated) and 2.2t per capita for core waste which is comprised of municipal solid waste (MSW), commercial and industrial (C&I) and construction and demolition (C&D) waste. Although recycling diversion rates are relatively good, contamination of waste streams, a lack of understanding of waste streams and services and an over consumption of resources are a significant challenge for government, industry and communities to overcome if waste and resource management is to be improved.

Improving waste and resource management has been highlighted as a priority for the region with each LGA developing strategies and action plans to reduce waste to landfill and improve waste management. In addition, the ISJO commissioned a Regional Waste Avoidance and Resource Recovery Strategy 2017-21 (RWARRS) on behalf of all of the councils which aims to provide a coordinated approach to reducing waste to landfill and improving waste management across the region.

The LGA documents and RWARRS have adopted a hierarchy of waste management (refer figure 46) in line with international standards and the National Waste Policy, with the aim to reduce waste to landfill. Significant opportunities to improve waste and resource management in the region have been identified and there is minimal value in duplicating these resources.

Figure 46: Waste Hierarchy

However, since these strategies were developed, significant events have impacted the region and new priorities have been identified for Australia and NSW which require a new lens to be applied. This includes China's National Sword Policy, a focus being placed on circular economy opportunities and the 2019/20 bushfires which had a significant impact on the region and in particular the Shoalhaven LGA.

As a result, this Plan has focussed on identifying additional improvement opportunities including:

- **A circular economy approach to resources and waste**
- **Disaster waste and demolition material within a CE approach**
- **Maximising existing assets and resources to increase landfill diversion rates**

10.1 Circular Economy and Resource Optimisation

A circular economy model redesigns current linear systems (take-make-waste) to a closed loop or circular systems which maximises resource efficiencies, reduces waste and improves natural systems. Creating a circular economy within the region will provides benefits from an environmental, economic and social perspective, with increased efficiencies providing greater return on investment for industry and reduced resource consumption decreasing environmental impact. The below diagram (figure 47) provides a high-level summary of integrating a circular economy model which has been used to inform the collaborative opportunities identified in this Plan.

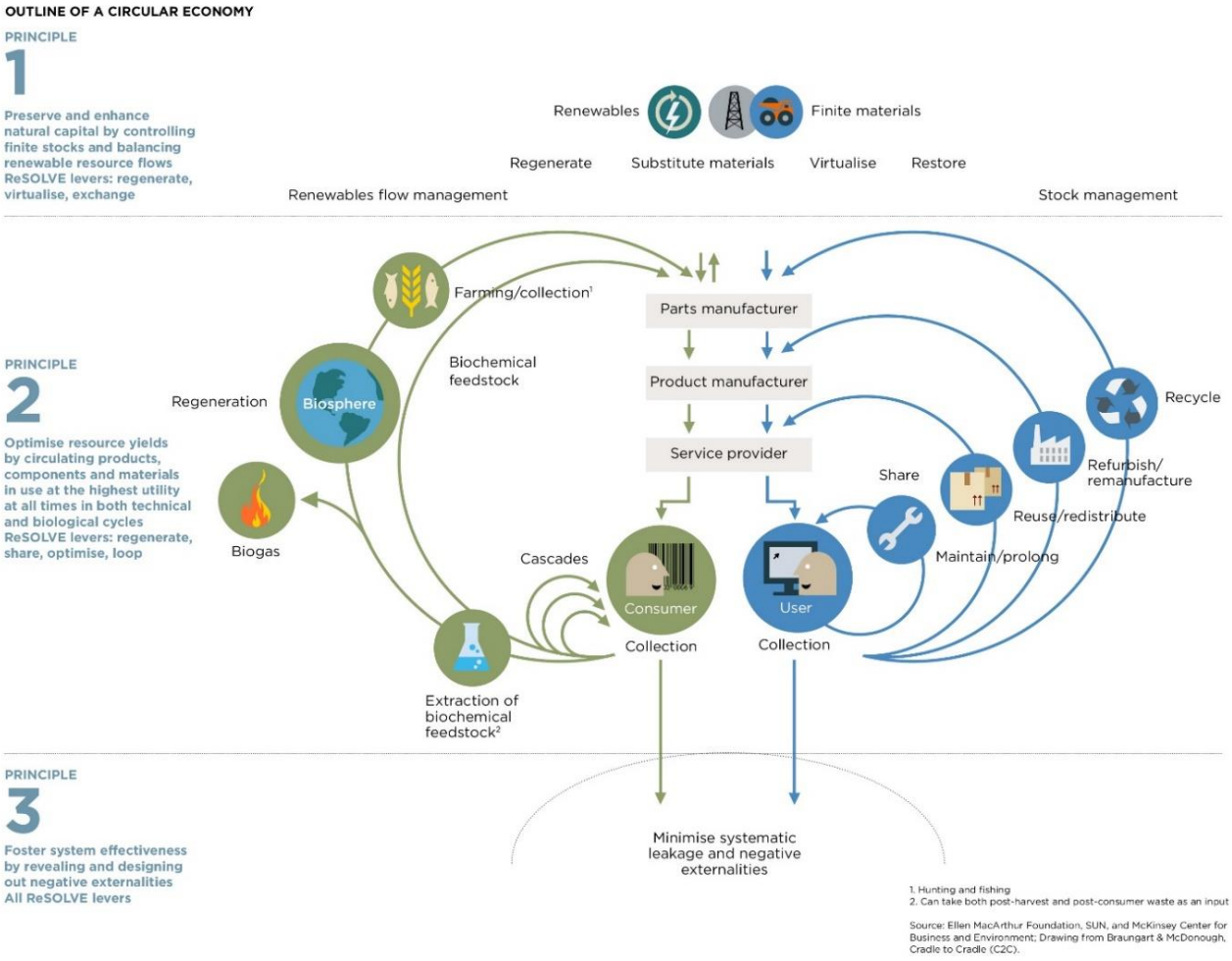


Figure 47: Circular Economy Outline - Ellen MacArthur Foundation

There are three core “I”s to ensure a circular economy which include:

1. Investment in infrastructure and new markets.
2. Improvement of recyclable material quality and recycling contracts.
3. Innovation in positive purchasing of recycled content products by government.

With the high proportion of industrial processes in the region, integrating circular economy principles into industrial processes is expected to be one of the largest resource optimisation and emission reduction opportunities in the region. Circular economy in an industrial precinct is typically referred to as industrial symbiosis and has been implemented globally to improve resource efficiencies, reduce operating costs and improve environmental management in what is usually considered a “dirty” sector. Industrial symbiosis has also formed the basis of the United Nations Industrial Development Organization (UNIDO) Eco-Industrial Park (EIP) Framework which aims to reduce the environmental impact of industrial precincts.

One of the original industrial precincts to implement industrial symbiosis into operations is the Kalundborg Eco-Industrial Park in Denmark. The first symbiotic process was introduced in 1961 with excess steam from the local powerplant being shared with industrial companies, a large number of symbiotic industrial processes have been implemented (refer Figure 49). A $60 million investment in EIP infrastructure generated $120 million in cost savings over five years.

Below is an example of the symbioses implemented by organisations in the precinct (refer figure 48).

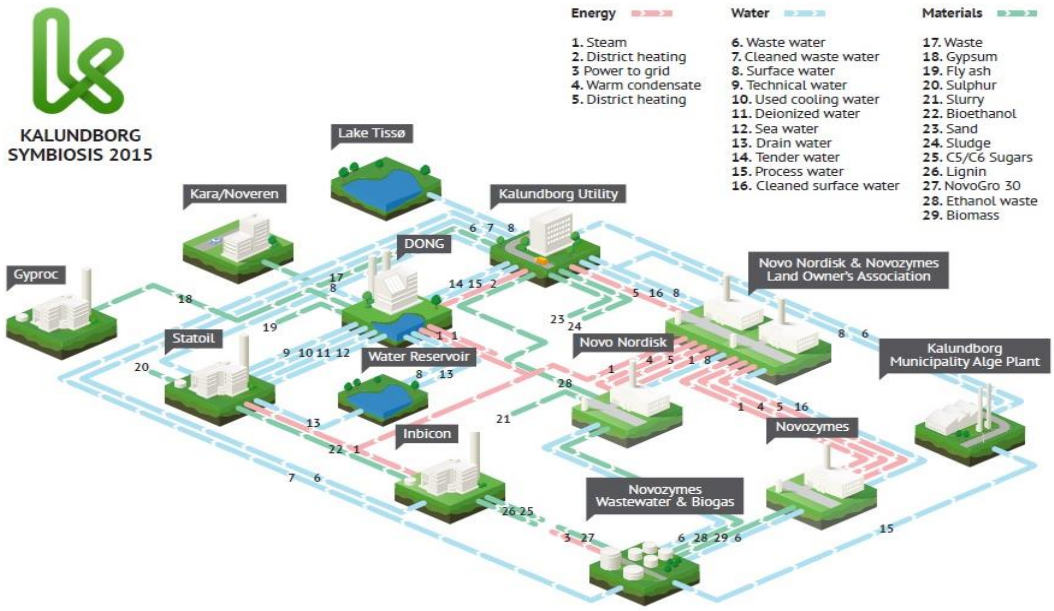


Figure 48: Industrial Symbiosis Example

Examples of industrial precincts which have successfully implemented environmental improvement programs based on an industrial symbiosis model and the UNIDO EIP Framework include:

Table 9: Industrial Symbiosis Precinct Examples

Industrial Precinct	Location	Summary
Kalundborg Eco-Industrial Park	Denmark	Heavy industrial area in which industrial symbiotic processes developed organically for economic and environmental gains. http://www.symbiosis.dk/en/

Kwinana Industrial Area	Western Australia	Established large heavy industrial area in Australia, focused on reducing environmental harm with improved economic returns through waste minimisation. www.kic.org.au/industry/kwinana-industrial-area.html
PIPA, Parc Industriel de Plaine de L'Ain	Lyon France	European industrial park which places strong focus on environmental sustainability for work and living. https://www.plainedelain.fr/en/
East London Industrial Development Zone	Eastern Cape Province, South Africa	Greenfield industrial site with strong environmental focus and is a UNIDO EIP pilot project. https://www.elidz.co.za/
Western Cape Province	South Africa	New SEZ established to create a base for renewable industries as part of a greening strategy. https://www.green-cape.co.za/content/sector/atlantis-sez
Ulsan-Mipo and Onsan Industrial Parks	South Korea	Established heavy industrial area, transformed to EIP under a national government scheme to achieve industrial sustainability and environmental outcomes. www.ulsan.investkorea.org

There is an opportunity to take the existing industry in the region and create a collaborative venture that aims to implemented industrial symbiosis opportunities between industry across the region.

This has been further explored in Section 12 which outlines some of the potential opportunities.

10.2 Disaster Waste and Materials

As disasters, such as bushfires, become more frequent and intense as a result of climate change, waste from assets (natural and built environments), facilities and infrastructure damaged or destroyed during a disaster is likely to increase. This will create both challenges for waste management while providing opportunities for improved waste capture and processing.

Potential waste outputs and contaminants from disasters include:

- Bushfire ash and debris entering water systems with potential impacts on potable water quality and water treatment systems.
- Demolition waste from fire and flood damaged facilities and assets.
- Organic materials created from land and vegetation clearing following a natural disaster.

It is recommended that waste outputs from natural disasters are assessed and potential circular economy opportunities identified to reduce waste to landfill.

10.3 Closing the loop

One of the key components to successfully implementing a circular economy is to ensure that the outputs generated in the system have sufficient demand to maintain production. For example, in the event that a recycled product is created in the region, the product will need to meet a particular demand which ideally is from within the same region. This can be facilitated by local councils, organisations and government specifying a minimum local and recycled content requirement in procurement policies.

In addition, circular economy opportunities can be facilitated by underwriting initial demand through major infrastructure projects to assist in making a new process viable. For example, a local asphalt compact may be considering incorporating recycled content from the region in their road base supply, however need sufficient demand of the product to justify the setup costs. In this example, the NSW Government or local council could include an innovation section in tenders for road upgrades that has a preference for local supplies that incorporate recycled content.

It is recommended local government procurement policies and guidelines are updated to integrated high priority recycled and local content opportunities that will assist in creating initial demand for local content and recycled material to facilitate a circular economy model.

10.4 Key Circular Economy Initiatives

The circular economy initiatives identified in this plan require a coordinated approach across all councils and will require initial feasibility studies and investigations to occur before being implemented at specific LGAs, precincts or sites. It is recommended the following circular economy initiatives are implemented which will then assist in identifying timeframes for implementation:

- Undertake an industrial symbiosis feasibility study across the region, focussing on the largest industries and processes, to identify resource optimisation and sharing opportunities. Refer to Section 12 Collaborative Opportunities for further information.
- Undertake an analysis of waste outputs from the recent bushfires and develop a plan to improve waste management practices as a result of future natural disasters.
- Create a regional sustainable procurement policy and update all LGA policies and procedures to maximise the use of local and recycled content, transition to low and zero emission transport, support the hydrogen supply chain and support the transition to a low emissions economy.

These initiatives are expected to have an environmental, social and economic benefit to the region by reducing the generation and disposal of waste to landfill, improving resource efficiencies and improving competitiveness by reducing operating costs for industry. In addition, implementing a circular economy model will assist in protecting the natural environment which is vital to the region. This will in turn support tourism in the region while maintaining a strong connection to nature for the community.

10.5 Climate Change Impact

A number of climate change risks have the potential to impact waste systems in the region as per Table 10 below.

Table 10: Waste Climate Change Impacts

Climate Change Risks		Impact	Risk Rating
	**Increased temperatures with prolonged and more frequent heat waves**	Some studies have shown that increased temperatures and drier conditions may increase the rate of methane emissions from landfill.	**L**
	**Harsher fire-weather**	Increased demolition and material waste from more frequent and intense bushfires. May also pose a risk to waste infrastructure including processing facilities.	**M**
	**Increased rainfall intensity**	Increased rainfall intensity may increase the likelihood of contaminated water from landfill sites entering waterways and ground water.	**M**

11 Water

The region is supplied water from dams and reservoirs managed by WaterNSW (refer figure 49) and water quality is managed with restrictions on accessing the areas around the water supply. However, water quality is declining due to over consumption and pollution which impacts both the environment, the sustainability of the water supply and may impact tourism opportunities.

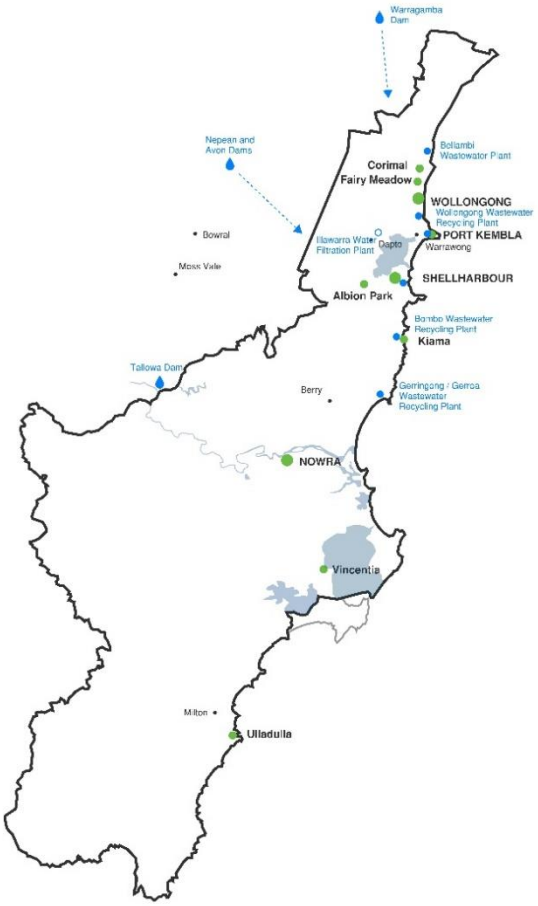


Figure 49: Water Assets

The Shoalhaven catchment covers over 5,640 square kilometres and also supplies over one third of Sydney's water. Controls are in place to ensure water supply is maintained and is only supplied to Sydney when dam levels are within set thresholds. However, the water system is under pressure due to a changing climate and population and residential growth in the region with capacity exceeded during seasonal peaks in demand due to tourism. This highlights a significant risk that will need to be addressed to ensure the region can grow while reducing environmental impacts.

During the recent period of drought and following dam levels across NSW falling below 60%, including those in the Shoalhaven region, the Sydney water supply has been supplemented by water from the Sydney Desalination plant since March 2019. Desalinated water has been implemented to future proof the NSW water supply, reduce environmental impacts associated with the over consumption of surface and ground water and increase resilience to periods of drought. However, desalinated water production is energy intensive with additional treatment compared to mains water and reducing dependence on the desalination plant is recommended.

Increasing the diversity, resilience and sustainability of the water supply in the region and improving water efficiency is a key focus in this Plan which will provide a benefit across the region and greater NSW.

11.1 Mains Water

There are a number of water filtration plants across the region operated by both Sydney Water and local councils which provide potable (mains) water supplies to the region. Increased mains water demand is expected due to population growth and residential developments which will place addition pressure on the water supply network.

Large users of mains water, such as for industrial processes and the irrigation of large open public space should be a focus with significant water efficiency gains typically available. This could include engagement with local councils and schools that irrigate large open spaces and large industrial organisations that have a high-water demand.

Although mains water is provided to the majority of residential properties in the major and minor centres, approximately 40% of industrial properties do not have a mains water connection. This is a significant constraint to attracting industrial developments and investment however would be resulting in reduced demand on the mains water supply. Increasing the supply of mains water to industrial properties should consider minimum efficiency requirements and alternative water supplies.

11.2 Stormwater and Flood Management

Stormwater and flood management is a local government responsibility however has been identified as a key risk across in the region with 33 floods classified as serious to extreme which impacts community safety and infrastructure. This is a significant risk to the region with climate change expected to further increase the risk due to increased rainfall intensity.

As a result, a coordinated approach to stormwater management across the region is recommended with organisations such as the ISJO playing a key potential role is facilitating collaborative action in the region. The ISJO is already managing the following water management programs which aims to improve stormwater management in the region:

- **Enabling Water Sensitive Communities:** Aims to increase the uptake of Water Sensitive Urban Design principles in urban areas to reduce environmental impacts including stormwater pollution and reducing pressure on catchments, streams and coastal lagoons.
- **Illawarra-Shoalhaven Smart Water Management Project**: Currently underway to provide improved stormwater monitoring and management for the region which will also be of benefit to surrounding regions. The project is a collaboration between local government tertiary and secondary education institutes and industry and is a strong example of collaboration in the region. It is recommended that the Smart Water Management Project continues to be supported and developed to provide real-world data that can inform decision making and planning processes.

Additional opportunities to improve stormwater management include expanding the above programs to incorporate stormwater capture and reuse opportunities such as onsite stormwater harvesting and Aquifer Storage and Recovery (ASR) or Managed Aquifer Recovery (MAR) schemes. Refer to Section 11.7 regarding an integrated water cycle model.

11.3 Wastewater

Wastewater (sewer) networks are provided across the region and where not available, onsite wastewater capture (septic tanks) and tradewaste units are utilised. To reduce potential environmental impacts, sewer networks are preferred over onsite wastewater capture as they are less likely to fail and have increased governance programs in place. Improving wastewater management systems is also expected to reduce environmental impacts on marine environments which are a key eco-tourism draw for the region and should be protected.

It has been identified that although sewer to residential properties is provided to the majority of major residential developments, approximately 67% of industrial properties are not provided with a mains sewer network connection and approximately 40% are not provided with a mains water connection. This is a significant constraint to attracting businesses and investment to the region and would be increasing risks associated with wastewater capture, storage and treatment.

It is recommended that wastewater networks are extended to industrial areas with opportunities available for a dedicated pre-treatment tradewaste water plant for industrial customers and sewer network extensions. This will facilitate improved environmental performance, create opportunities for shared utility networks and may increase the market value or investment attractiveness of industrial land.

In addition, extending the sewer network to new developments and industrial areas will increase the volume of wastewater being treated and potentially increase the availability of recycled water over time. It is recommended Sydney Water and the local councils investigate a coordinated approach to planning wastewater treatment plant upgrades and sewer extensions across the region, with learnings that could be gained for both parties.

11.4 Recycled Water

Recycled water (non-potable water) is currently provided from wastewater treatment plants across the region and is also an output from coal mine wastewater treatment processes. The recycled water is provided for both industrial and irrigation purposes which would be reducing dependence on mains water and catchments across the region.

It is recommended that the capacity to supply recycled water from wastewater treatment plants and viability of extending the recycled water supply is undertaken in collaboration with Sydney Water with potential options including:

- Incorporating non-potable water supplies into new residential developments.
- Extending recycled water to industrial areas for water intensive processes.
- Extending recycled water to additional irrigated areas to ensure turf can be maintained during periods of drought, reducing heat island effect and providing areas of respite.
- Supporting the incorporation of recycled water into the proposed hydrogen electrolyser at the Port of Port Kembla.
- Investigating alternative non-potable water supplies such as ASR/MAR schemes to improve resilience.

11.5 Rainwater

Alternative water supplies such as rainwater are currently captured in the NCC and BASIX as a method to reduce mains water consumption. It is recommended rainwater harvesting continues to be incorporated however is considered in the larger perspective of an integrated water cycle, with some developments being more suitable for onsite collection and use, and others providing a greater benefit to alternative water systems such as ASR/MAR.

Another opportunity for rainwater is to incorporate rainwater harvesting systems into larger industrial developments where non-potable water can be used in systems and processes which currently use mains water. It is recommended that rainwater harvesting and re-use is incorporated into the industrial symbiosis feasibility study outlined in Section 10.

11.6 Water Sensitive Urban Design

As per the above, WSUD initiatives are already being implemented across the region and are a key example of improving the sustainability of water management systems. It is recommended WSUD continues to be a priority and is incorporated into the integrated water supply model outline below in Section 11.7.

In addition, WSUD initiatives can strengthen a connection to country with opportunities to engage with and include local Aboriginal knowledge and expertise into WSUD planning. The Government Architect NSW (GANSW) office recently published a discussion paper on Design with Country which should be referenced as part of urban planning for new developments and incorporated into WSUD initiatives (refer Figure 50 for an example of urban design planning from the discussion paper). WSUD initiatives are also expected to improve community facilities while reducing urban heat load which will have direct benefits for the community.

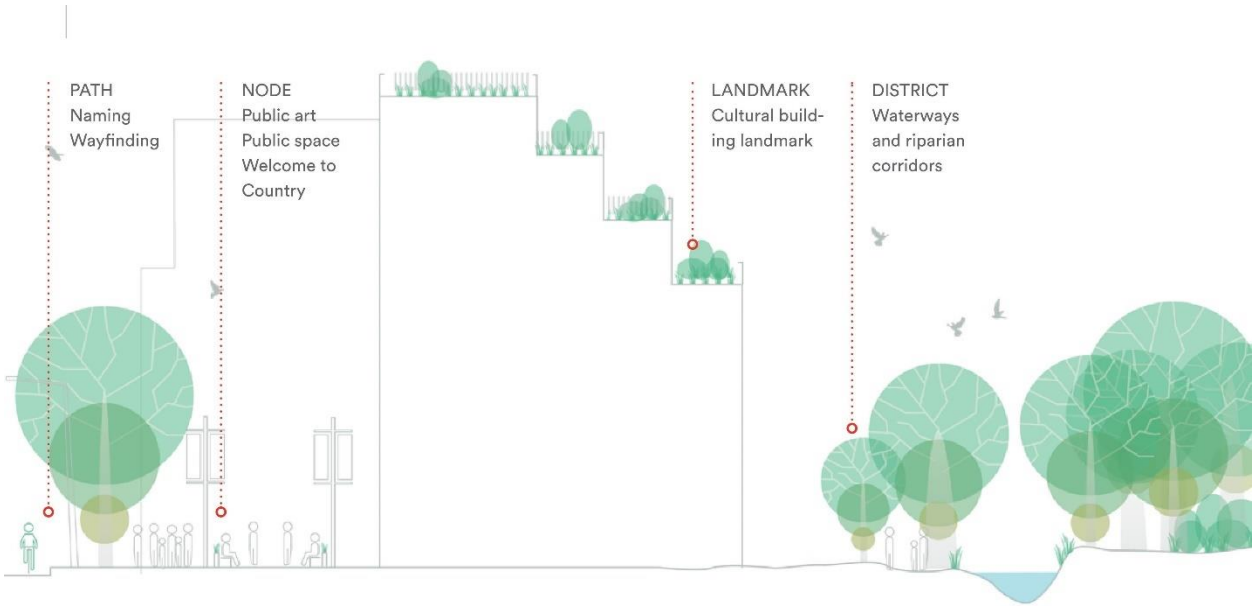


Figure 50: Designing with Country Example

11.7 Integrated Water Cycle

As a result of existing and projected residential growth in the region and existing industrial demand, water supply sustainability should be carefully considered to ensure environmental impacts are mitigated and water quality maintained. To support this, it is recommended an integrated water cycle supported by water sensitive urban design (WSUD) principles is implemented to minimise impact on the environment and adapt to a changing climate. This includes the following water supplies which will need to be integrated in combination to provide a balanced outcome which reduces environmental impact (refer Figure 51).

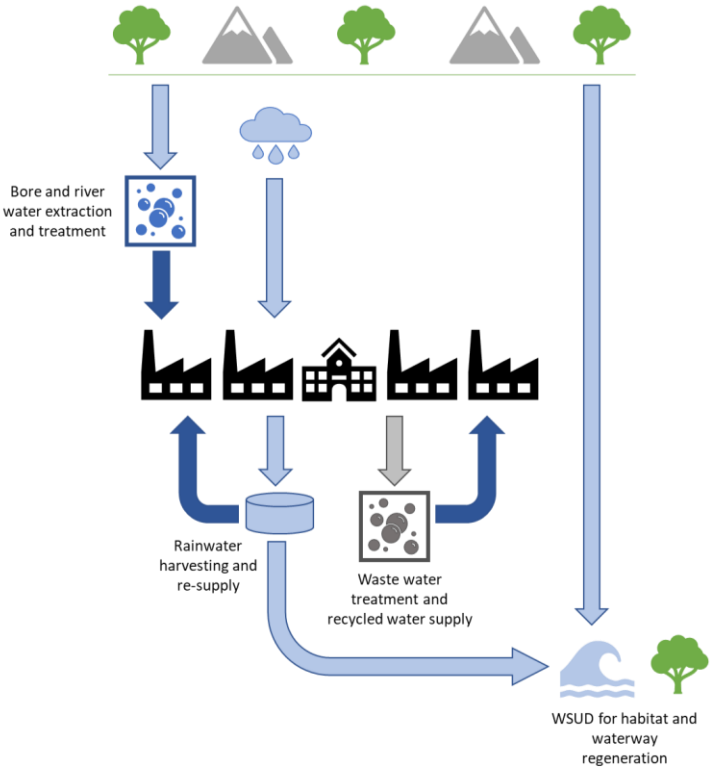


Figure 51: Integrated water cycle example

In particular, an integrated water cycle should be considered for major new residential developments and aligned with alternative water supplies that have the potential to provide hybrid water supplies that are more resilient to climate change. An example of this is creating an integrated non-potable water supply which takes advantage of and shares water from the following sources:

- Recycled water from wastewater treatment (sewer).
- Recycled water from industrial process wastewater treatment (industry and mines).
- Harvested and treated stormwater (through wetlands and filtration) from new residential developments and large hard stand spaces (car import storage areas).

The water captured and treated from these sources can also utilise Aquifer Storage and Recovery (ASR)/ Managed Aquifer Recovery (MAR) processes to store the water in the aquifer before drawing from the aquifer in peak water demand periods (summer). In addition, the ASR wetlands can provide valuable habitats for flora and fauna while also providing quality outdoor areas accessible by the community.

The Parkes Shire Council provides an example of an integrated water cycle strategy which captures and treats wastewater and stormwater for non-potable use and should be considered as part of larger water management strategies for the region.

ASR/MAR schemes have been successfully implemented across Australia and can be effectively coupled with recycled wastewater supplies to provide a reliable non-potable water supply. An example of this is the recycled water networks in the City of Salisbury and City of Playford which have interconnected their ASR networks with recycled water supplied from wastewater treatment plants. This has ensured that during periods of drought when stormwater capture and injection is low, the non-potable water supply can be supplemented by recycled water to maintain decreased mains water consumption.

11.8 Key Water Initiatives

The following key water initiatives have been identified for consideration:

Table 11: Key Water Initiatives

LGA	Centre	Water Efficiency	Recycled water	Rainwater harvesting	Aquifer Storage and Recovery	Water Sensitive Urban Design
Wollongong	Corrimal		New Residential Developments	New Residential Developments		
	Wollongong		Industrial + New Residential + Recycled water from mines	Industrial + Residential	Car import storage areas + West Dapto Employment Lands + New Residential	
	West Lake Illawarra		New Residential Developments	New Residential Developments		
	Dapto		West Dapto Employment Lands + New Residential	New Residential Developments	Car import storage areas + West Dapto Employment Lands + New Residential	

Shellharbour	Shellharbour			Industrial + Residential		
Kiama	Kiama		New Residential Developments	New Residential Developments		
Shoalhaven	Nowra-Bomaderry			Industrial + Residential		
	Ulladulla			Industrial + Residential		

11.9 Water Implementation Guide

It is recommended that existing water programs and assets are maximised and extended to increase resilience and support a fully integrated water cycle across the region. The following implementation guide has been developed with potential timeframes for implementing an integrated water cycle (refer Figure 52).

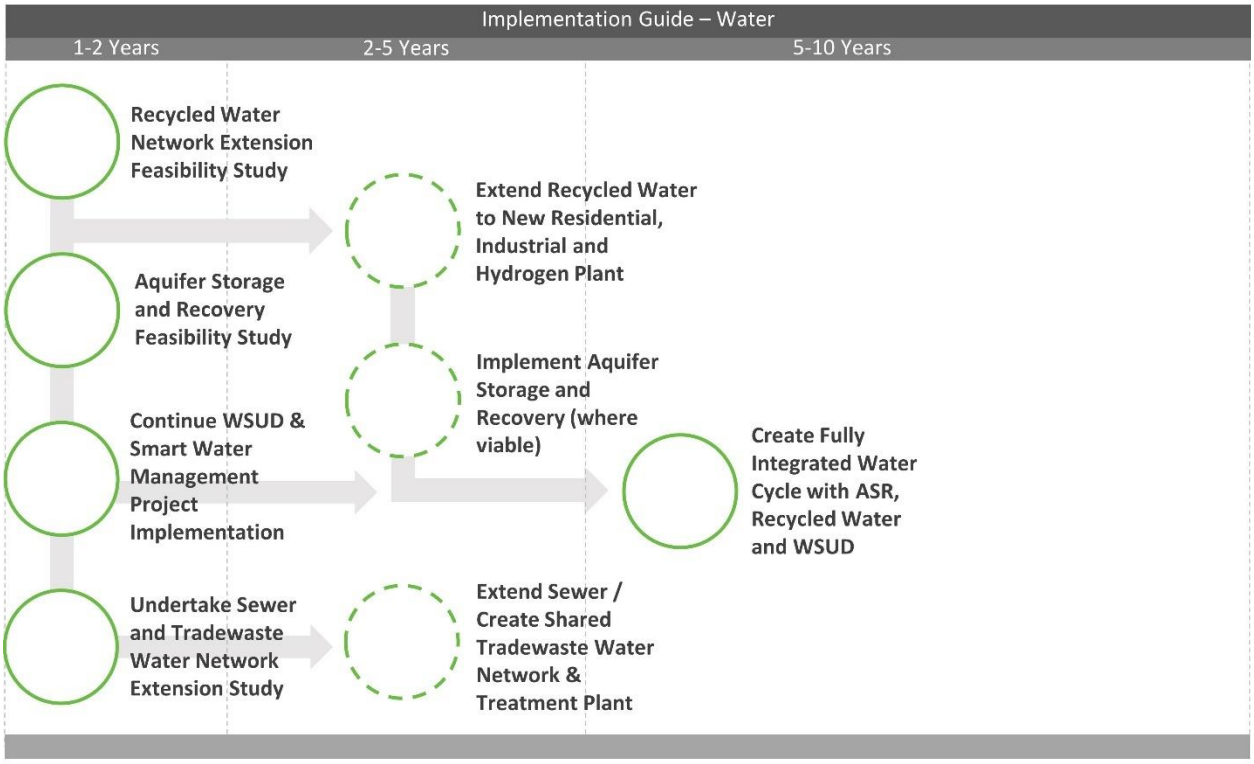


Figure 52: Water Implementation Guide

11.10 Climate Change Impact

A number of climate change risks have the potential to impact water supplies in the region as per Table 12 below.

Table 12: Climate change risks for water

Climate Change Risks		Impact	Risk Rating
	**Increased Temperature**	Increased water demand for processes and irrigation and likelihood of network capacity being exceeded with potential supply shortages/loss.	**H**
	**Harsher Fire-weather**	More frequent and intense bushfires are likely to disrupt utility supplies. In addition, ash, debris and hazardous materials washed into waterways are likely to impact water quality in catchments and increase water treatment requirements.	**H**
	**Longer periods of drought and increased evaporation**	Increased likelihood of the region's water supply capacity being exceeded during peak periods due to lower dam levels and drought conditions.	**M**
	**Increased rainfall intensity**	Increased likelihood of flooding and stormwater management system capacity being exceeded with increased likelihood of road closures due to landslides and access restrictions. Increased volume of contaminated water from bushfire affected areas likely to impact water quality impacting both the environment and potable water supply.	**M**
	**Sea level rise**	Sea level rise has been projected along the region's coast impacting assets and infrastructure including roads, property and assets.	**H**
	**All of the above**	The combination of climate change risks in the region has the potential of reducing the life of water assets and infrastructure with additional capital required to maintain, upgrade and replace infrastructure due to increased climate change design requirements.	**H**

12 Collaborative Opportunities

12.1 Introduction

The following key collaborative opportunities that have the potential to reduce emissions, operating costs and environmental impacts, improve competitiveness and transition the region to a new model of sustainable development have been identified for immediate investigation.

These opportunities are already in various stages of deployment and maturity, however embedding these options in the regional plan and reinforcing the key collaborative opportunities will provide significant environmental improvements, reduce emissions and reduce costs.

12.2 Industrial Symbiosis

Due to the large industrial presence in the region there are significant opportunities to create an industrial symbiosis model to maximise resource efficiencies and reduce costs, emissions and environmental impact. A desktop review of businesses in the vicinity of Port Kembla was undertaken with a number of industries identified that typically have resource sharing opportunities (refer Figure 53).

Figure 53: Example of major industry

From the analysis, the following immediate opportunities were identified and it is recommended that a circular economy or industrial symbiosis working group is created, and a feasibility study undertaken, to identified shared resource and material sharing opportunities.

The Sustainability Advantage program could be utilised to leverage existing organisations in the program, integrate new organisations and potentially fund a collaborative feasibility study into industrial symbiosis across the region. Opportunities may include resource and material inputs and outputs from physically co-located organisations and those connected by road, rail and ports to share resources within the region and maximise circular economy opportunities.

Refer to the below example of industrial symbiosis opportunities in the region (refer Figure 54).

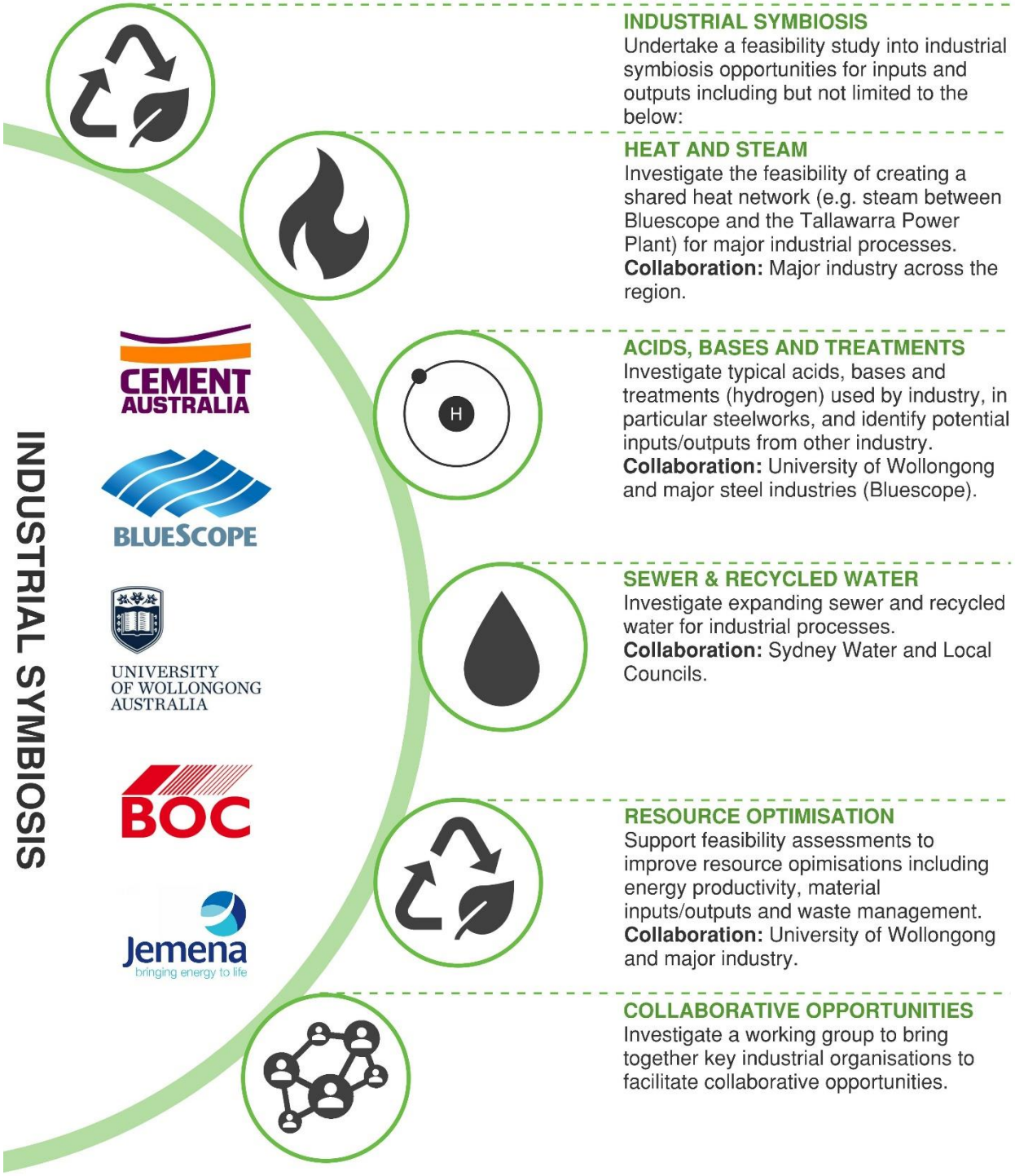


Figure 54: Industrial Symbiosis Example

12.3 Sydney Water

Sydney Water has been identified as a key organisation that could facilitate a number of initiatives across the region (refer to Figure 55 below).

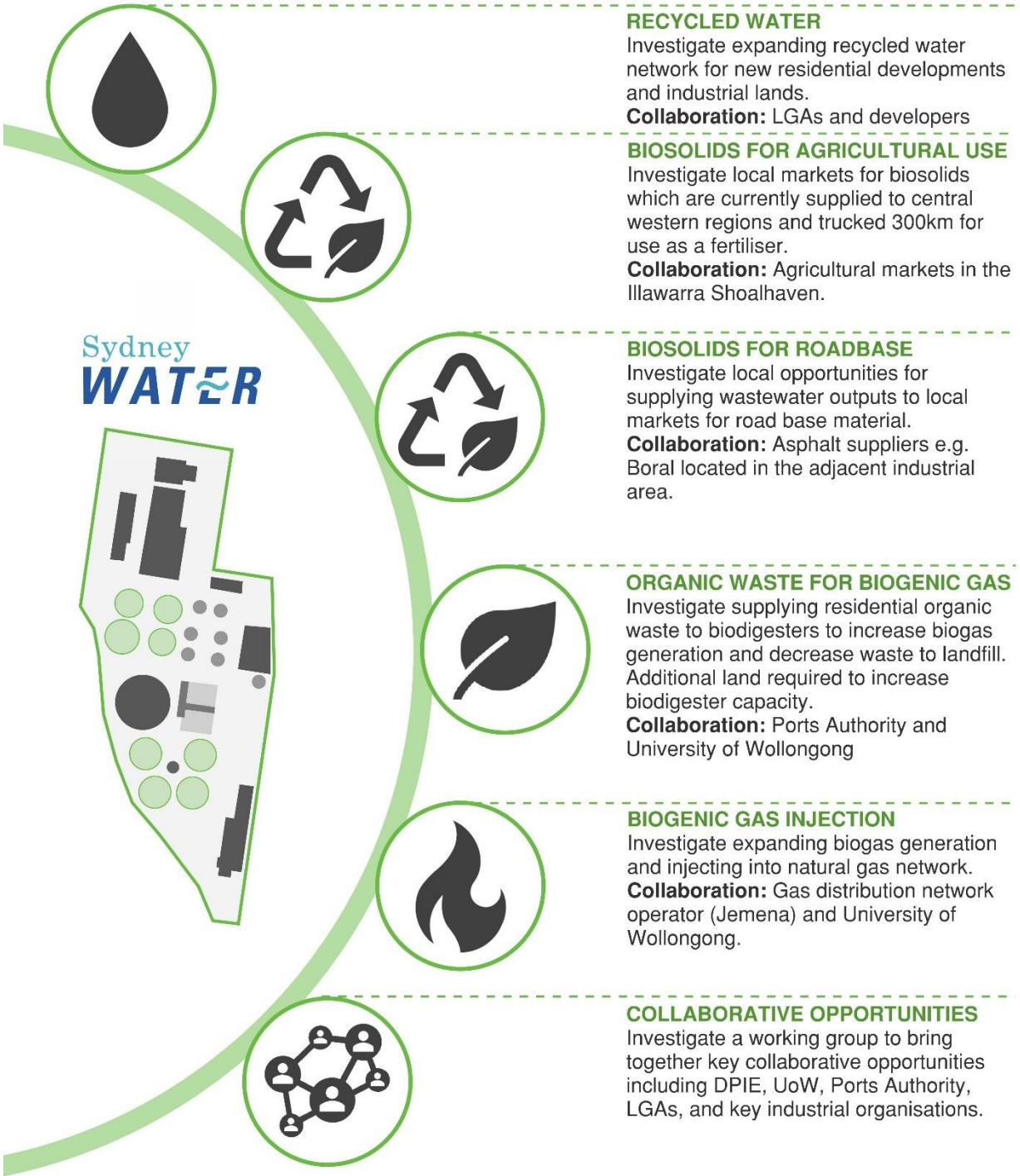


Figure 55: Sydney Water Opportunities

12.4 Collaborative Organisations

The following collaborative organisations are expected to facilitate many of the opportunities identified in this Plan however a detailed stakeholder engagement program will be required to capture all of the key stakeholders (refer to figure 56).

Collaborative Organisations

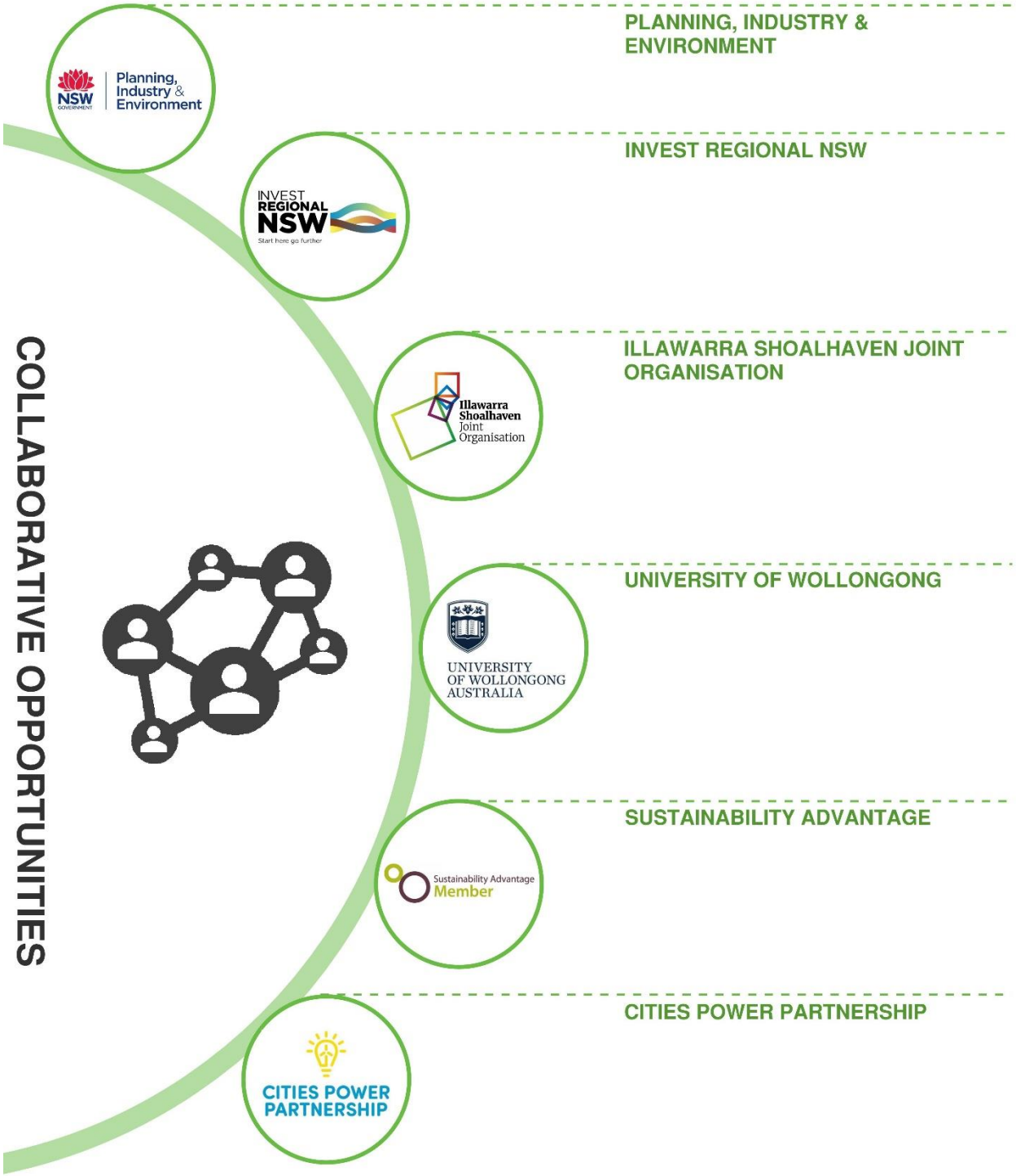
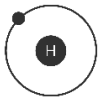


Figure 56: Collaborative Organisations

13.1 Collaborative Local Government Area Initiatives

The following key initiatives have been identified that will require collaborative projects to be implemented across the LGAs. The majority of the sustainability initiatives identified in this Plan apply to the region, however where a specific action is applicable at a local council level, this is outlined in the individual council sections.

Topic	Initiatives	Summary	Potential Action/s	Collaboration
	**Hydrogen Supply Chain Analysis**	An investigation into the complete hydrogen supply chain should be undertaken including both renewable and fossil fuel energy supplies, distribution and transportation, storage and liquification, industrial and agricultural uses (Green Ammonia), heavy and agricultural vehicle refuelling, grid stability services and export potential to maximise hydrogen potential.	A collaborative review and feasibility study of the hydrogen supply chain could be undertaken to maximise the use of hydrogen in the region and create underwriting demand.	**DPIE, Local Councils, University of Wollongong, ISJO and key industry.**
	**Emissions Inventory**	To ensure carbon emissions can be accurately tracked, it is recommended that the local councils implement a consistent and agree emissions boundary and create a holistic emissions inventory which can be used to track emission reduction initiatives.	Investigate the procurement of a regional emissions inventory to allow effective monitoring and to track emissions reduction initiatives.	**Local Councils and ISJO**
	**Renewable Energy Agreements**	Renewable energy supply agreements (e.g. power purchase agreements) can provide a significant emissions reduction opportunity while supporting the uptake of renewables both within and outside of the region.	Investigate a renewable energy EOI which aggregates the energy demand of the local councils, major industry and commercial operators to negotiate a competitive renewable energy supply contract. The EOI should incorporate large industrial estates which have significant roof areas.	**DPIE, Local Councils and major industry.**

Topic	Initiatives	Summary	Potential Action/s	Collaboration
	**Energy Efficiency and Productivity**	Energy efficiency and productivity is expected to be a significant opportunity due to the relatively large amounts of industrial processes, along with significant residential developments and growth in the region. In line with the feasibility study into industrial symbiosis, energy efficiency should be integrated to improve existing operations which will reduce consumption, costs and emissions while supporting the grid and renewable energy integration.	Integrate energy efficiency and productivity into industrial symbiosis feasibility studies due to the extensive industrial developments already operating. Investigate local councils participating in the Building Upgrade Finance program to support energy efficiency upgrades for leased facilities. Investigate opportunities to improve residential, commercial and industrial energy efficiency through existing grant programs and to take advantage of new electricity market rules. Investigate improving energy efficiency requirements as part of development and building approvals (beyond NCC/BASIX) and consider creating a sustainable housing demonstration hub to showcase energy efficiency design. Collaborate with the local construction industry to investigate energy efficiency and building sealing improvements into new housing developments.	**DPIE, Sustainability Advantage, University of Wollongong and Local Councils**
	**Demand Management**	Reducing peak electricity demand will assist in improving grid stability, extending timeframes for network upgrades and reducing operating costs.	Investigate peak demand management opportunities for major industry and commercial operators to take advantage of new electricity market rules and improve grid stability. This includes upgrading equipment, demand shifting/management, incorporating energy storage and utilising hydrogen electrolysers for grid stability and peak demand management services.	**DPIE and Locals Councils**

Topic	Initiatives	Summary	Potential Action/s	Collaboration
	**Solar PV Systems**	Solar PV rooftop penetration is currently below the region and state average. Targeted promotion of solar PV and incentives by the council may provide an opportunity to increase rooftop solar PV for households, commercial and industrial properties.	Local councils to promote residential, commercial and industrial solar PV with information provided on website and information sessions. An opportunity may also be present to provide grants or incentives to businesses through a sustainability incentive scheme e.g. grants for solar PV and battery storage for businesses. This can also support a VPP model by increasing the uptake of renewables on various building types. Investigate medium to large scale solar PV systems on industrial estates and over large car import storage yards as part of a VPP model. Continue rollout of solar PV on council facilities.	**All Local Councils**
	**Virtual Power Plant Extension**	Explore the feasibility of extending the proposed VPPs to industrial and commercial customers to increase renewable energy and energy storage capacity adjacent the Port of Port Kembla. This will assist in the increasing renewable energy which could in turn by supplied to the hydrogen plant to create green hydrogen. Incorporate the VPP proposed as part of the Innovative Energy dairy manure waste to energy plant in the Nowra Region.	Collaborate with VPP operators participating in the NSW Emerging Energy Program to expand existing proposals to accommodate residential, commercial and industrial customers with the aim of maximising solar PV and battery storage while taking advantage of different load profiles. This will enable large scale solar to be installed on properties that may not have significant electrical loads, with the excess energy sold at a discounted rate to other VPP users. The VPP could form part of the EOI (refer Renewable Energy Agreements above).	**DPIE, NSW Emerging Energy Program, Local Councils, and VPP operators**

Topic	Initiatives	Summary	Potential Action/s	Collaboration
	**EV and Hydrogen Vehicles**	Electric and hydrogen fuelled vehicles have been identified for deployment in and around the region and coupled with an increase in renewable energy and hydrogen production, have the potential to reduce transport emissions significantly.	Continue to support the transition to EVs and hydrogen vehicles by updating procurement policies to preference low and zero emission vehicles and provide information to the public on the benefits. In addition, continue to investigate opportunities such as replacing council operated services such as shuttle buses and rubbish trucks with EV/hydrogen equivalents.	**DPIE and Local Councils**
	**EV and Hydrogen Refuelling Stations**	Development of an electric and hydrogen fuelling network strategy to facilitate the transition to low and zero emission transport, increase resilience and support the hydrogen supply chain.	Create a focus group to map potential sites for EV charging and hydrogen refuelling stations that will create a coordinated network to support various vehicle types e.g. EV charging for passenger vehicles and smaller shuttle buses and hydrogen refuelling for heavy vehicles. Develop an EV and hydrogen refuelling strategy to take advantage of the proposed hydrogen electrolyser and to support a transition to zero emission vehicles. Target retail and accommodation as an opportunity to attract EV owners to the region. Engage with EV charging network operators to explore collaborative ventures to reduce capital costs.	**DPIE and Local Councils**

Topic	Initiatives	Summary	Potential Action/s	Collaboration
	**Industrial Symbiosis**	Undertake an industrial symbiosis feasibility study which analyses the inputs and outputs from large industrial and agricultural organisations and identifies opportunities for resource and material sharing. Opportunities may include resource and material inputs and outputs from physically co-located organisations and those connected by road, rail and ports to share resources within the region and maximise circular economy opportunities. Refer to each LGA below for potential opportunities for organisations already working in innovative ways that could support this model.	Investigate collaborative opportunities with DPIE Sustainability Advantage program to leverage existing organisations in the program, integrate new organisations and potentially fund a collaborative feasibility study into industrial symbiosis across the region.	**DPIE, Sustainability Advantage and Local Councils**
	**Fully Integrated Water Cycle**	Investigate a fully integrated water cycle model which takes advantage of existing water resources in the region while diversifying into alternative supplies such as ASR/MAR, onsite stormwater harvesting, rainwater harvesting, WSUD and water efficiency.	Support industrial developments in maximising the use of rainwater and improving water efficiency through the Sustainability Advantage program. Work with Sydney Water, University of Wollongong and local councils to investigate expansion options of the recycled water network and implementation of Aquifer Storage and Recovery (ASR) in the region. The ISJO may take a lead role for coordinating due to the infrastructure being spread across the whole region. Continue ISJO led programs such as the Enabling Water Sensitive Communities and Smart Water Management Project to continue to improve stormwater management in the region.	**ISJO, Sydney Water, Local Councils, Sustainability Advantage, University of Wollongong**

Topic	Initiatives	Summary	Potential Action/s	Collaboration
	**Wollongong Wastewater and Water Recycling Plant**	Undertake a feasibility study to upgrade the Wollongong wastewater treatment plant biodigesters to accommodate organic waste from municipal solid waste (MSW). Additional land and biodigester capacity will be required if large scale upgrade is planned with opportunities to integrate an organics processing facility adjacent to the wastewater treatment plant which can process and sort the organic material before use in the biodigesters. Recycled water capacity/potential should also be considered as a supply to the proposed hydrogen electrolyser at the Port of Port Kembla.	Investigate capacity and maximise existing opportunities to increase biogas generation at the Wollongong wastewater plant which will assist in powering the recycled water plant and increase opportunities to inject biogas into the natural gas network. Investigate co-locating an organic waste processing facility adjacent the plant to sort and supply residential organic waste materials to the biodigesters. Investigate local markets to take advantage of the biosolids generated at the wastewater plant which are current supplied to agricultural regions >300km away. Incorporate the wastewater plant into the industrial symbiosis feasibility study.	**Sydney Water, Ports Authority and Local Councils**
	**Procurement Policies**	A regional approach to sustainable procurement should be implemented with a strong focus on local and recycled content to facilitate circular economy opportunities.	Create regional procurement policy positions and update all LGA policies and procedures to maximise the use of local and recycled content, transition to low and zero emission transport, support the hydrogen supply chain and support the transition to a low emissions economy.	**All Local Councils**
	**Sustainability Focus Group**	Create a dedicated sustainability working/focus group with key stakeholders for exploring circular, economy/industrial symbiosis, VPP, hydrogen supply chain planning and implementation of an integrated water cycle model to inform the regional plan.	Create a focus group and/or workshop sustainability plan with key stakeholders to integrate sustainability into the Regional Plan.	**DPIE, Local Councils, ISJO and Key Stakeholders identified throughout this Plan.**

13.2 Wollongong City Council

The Wollongong City Council LGA presents a number of significant opportunities due to the strong interconnectivity with Sydney and the wider region through excellent road, rail and port access. In addition, the strong industrial presence, coupled with the University of Wollongong and high levels of tertiary education, places Wollongong in an excellent position to take advantage of a low carbon economy transition.

The following key initiatives for the Wollongong City Council have been identified:

Topic	Sub-topic	Summary	Potential Action
	**Residential, Industrial and Commercial Solar PV**	Solar PV rooftop penetration is currently below the region and state average. Targeted promotion of solar PV and incentives by the council may provide an opportunity to increase rooftop solar PV for households, commercial and industrial properties. In particular, the Wollongong City Council area has large amounts of developed industrial land which could support significant amounts of rooftop solar PV.	Local council to promote residential, commercial and industrial solar PV with information provided on website and information sessions. An opportunity may also be present to provide grants or incentives to businesses through a sustainability incentive scheme e.g. grants for solar PV and battery storage for businesses. In addition, support mechanisms for upgrading leased buildings should be investigated to provide a model for building owners to upgrade their assets with benefits for both the owner and tenant. Investigate participating in the Building Upgrade Finance program as a potential mechanism.
	**Virtual Power Plant Extension**	Collaborate with VPP operators participating in the NSW Emerging Energy Program to expand existing proposals to accommodate residential, commercial and industrial customers with the aim of maximising solar PV and battery storage while taking advantage of different load profiles. This will enable large scale solar to be installed on properties that may not have significant electrical loads, with the excess energy sold at a discounted rate to other VPP users.	Focus on VPP opportunities adjacent to the Port of Port Kembla to increase renewable energy and energy storage capacity adjacent to the proposed hydrogen plant. This will assist in the increasing renewable energy which could in turn by supplied to the hydrogen plant to create green hydrogen.
	**Hydrogen Refuelling Stations**	The hydrogen supply chain provides a unique opportunity for the area as supply and demand can be closely integrated.	Investigate hydrogen refuelling opportunities for rail and public transport networks and Mobility-as-a-Service (MaaS) solutions e.g. shuttle buses to underwrite initial demand and transition to low and zero emission transport system.

13.3 Shellharbour City Council

Although Shellharbour City Council is only responsible for approximately 15% of the region's emissions, there is still a large opportunity to integrate sustainability into the LGA and support major industry in transitioning to a circular economy model.

The following key initiatives for the Shellharbour City Council have been identified:

Topic	Sub-topic	Summary	Potential Action
	**Residential and Commercial Solar PV**	Solar PV rooftop penetration is currently below the region and state average and BASIX ratings have also identified that solar PV as part of new residential developments is lower than average. Targeted promotion of solar PV and incentives by the council may provide an opportunity to increase rooftop solar PV for households and commercial properties.	Local council to promote residential and commercial solar PV with information provided on website and information sessions. An opportunity may also be present to provide grants or incentives to businesses through a sustainability incentive scheme e.g. grants for solar PV and battery storage for businesses. In addition, support mechanisms for upgrading leased buildings should be investigated to provide a model for building owners to upgrade their assets with benefits for both the owner and tenant. Investigate participating in the Building Upgrade Finance program as a potential mechanism.
	**Circular Economy & Resource Optimisation**	Circular economy opportunities already implemented include recycled content trials in asphalt, procuring recycled plastic boardwalks and organic waste collection and composting.	Continue expanding circular economy opportunities and exploring initiatives for resource optimisations in council operations. Continue to share key learnings with the region and organisations in the LGA.
	**Industrial Symbiosis**	Although industrial areas are not as extensive as Wollongong, industry and in particular the local steelworks, the Dunmore hard rock quarry and Albion Park Quarry should be considered for industrial symbiosis opportunities.	Support the collaborative feasibility study into industrial symbiosis across the region and ensure major industry is captured.
	**Sustainable Procurement**	The council has hosted sustainable procurement sessions previously and may be able to facilitate additional learning opportunities.	Continue to lead sustainable procurement investigations and provide upskilling opportunities.

13.4 Kiama Municipal Council

The Kiama Municipal Council area accounts for approximately 7% of the region's emissions however has a higher than average penetration of solar PV, has been implementing a range of waste and resource management programs and has a strong focus on protecting the environment, natural resources and preserving agricultural and production lands.

The following key initiatives for the Kiama Municipal Council have been identified:

Topic	Sub-topic	Summary	Potential Action
	**Residential and Commercial Solar PV**	Solar PV rooftop penetration is above average for the region and has reached the state average. Continued promotion of solar PV and incentives by the council may provide an opportunity to increase rooftop solar PV for households and commercial properties however high levels of solar PV may impact grid stability.	Monitor solar PV uptake and ensure grid stability is maintained as increased renewable energy is integrated into the electricity network across NSW.
	**Energy Storage**	The higher solar PV penetration in Kiama will support increased battery storage as prices reduce and to take advantage of alternative energy markets.	Utilise the higher percentage of solar PV in the area as a drawcard to attract VPP operators and increase the uptake of battery storage.
	**Waste Management**	The Kiama Municipal Council has been leading many of the waster initiatives in the region and should continue to lead the way with improving waste management across the region.	Continue FOGO and waste education initiatives and expand into circular economy and resource optimisation to reduce the source of waste generation.
	**Circular Economy & Resource Optimisation**	Kiama Municipal Council has a strong focus on preserving the environment and growing tourism/eco-tourism, a focus on circular economy principles and resource optimisation may provide an opportunity to continue to promote the area's environmental focus.	Undertake an assessment of the largest tourism services and operators, industry and commercial operators and identify opportunities for improved waste management through circular economy principles. This could also capture events and conferences with the aim of avoid waste sources and generation.

13.5 Shoalhaven City Council

The Shoalhaven City Council LGA is relatively unique due to its significant natural environments, large agricultural presence and its distance from the more developed LGAs which have a higher urban density. As a result, initiatives to embed sustainability into the LGA should focus on improving the resilience of smaller satellite areas and towns and improving energy and transport resilience by reducing dependence on imported energy supplies (electricity, gas, fuel, etc.). There is a significant opportunity to transition to alternative energy and transport systems

The following key initiatives for the Shoalhaven City Council have been identified:

Topic	Sub-topic	Summary	Potential Action
	**Residential and Commercial Solar PV**	Solar PV rooftop penetration is currently below the region and state average however has been increasing considerably over the last few years. Targeted promotion of solar PV and incentives by the council may provide an opportunity to increase rooftop solar PV for households and commercial properties.	Local council to promote residential and commercial solar PV with information provided on website and information sessions. An opportunity may also be present to provide grants or incentives to businesses through a sustainability incentive scheme e.g. grants for solar PV and battery storage for businesses. In addition, support mechanisms for upgrading leased buildings should be investigated to provide a model for building owners to upgrade their assets with benefits for both the owner and tenant. Investigate participating in the Building Upgrade Finance program as a potential mechanism.
	**Virtual Power Plant Extension**	Collaborate with VPP operators participating in the NSW Emerging Energy Program to expand existing proposals to accommodate residential, commercial and industrial customers with the aim of maximising solar PV and battery storage while taking advantage of different load profiles. This will enable large scale solar to be installed on properties that may not have significant electrical loads, with the excess energy sold at a discounted rate to other VPP users.	Focus on extending VPP opportunities with existing programs and in particular Innovative Energy's biogas power plant in Nowra which includes a VPP to provide free electricity back to the farms. This could be a catalyst to extending VPPs to addition sectors and increasing resilience in the region.

Topic	Sub-topic	Summary	Potential Action
	**Energy Storage – Battery Storage**	Battery storage prices are expected to continue to decrease and when coupled with solar PV systems can provide power for critical assets and community services and are not reliant on importing fossil fuels (e.g. diesel generators).	Investigate installing battery storage systems coupled with solar PV at key community sites to provide core community services during disasters and emergencies. Investigate battery storage grants and incentives for residential properties to increase the uptake of battery storage and improve community resilience.
	**Energy Storage - Microgrids**	The Regional and Remote Communities Reliability Fund – Microgrids may present an opportunity to implement community renewable energy hubs as part of a microgrid to improve resilience and ensure the region can continue to operate during network disruptions and disasters/emergencies.	Investigate potential projects that could apply for a grant as part of the Regional and Remote Communities Reliability Fund – Microgrids program.
	**EV and Hydrogen Refuelling Stations**	Development of an electric and hydrogen fuelling network strategy to facilitate the transition to low and zero emission transport, increase resilience and support the hydrogen supply chain.	A strong focus should be placed on supporting the transition to EVs which can then be powered by local renewable energy and energy storage supplies. This includes: • Installing EV charging adjacent to council operated facilities powered by renewables. • Supporting households with solar PV in transitioning to EVs and in installing household EV charging systems. • Transitioning council operated vehicles to EV equivalents.
	**Hydrogen Plants**	Smaller-scale hydrogen plants for agricultural and industrial processes may be applicable. These plants can be co-located at agricultural processing facilities and be utilised as a zero-emission gas.	Work with agricultural and industrial organisations to investigate green hydrogen supply opportunities. This could be incorporated into the Industrial Symbiosis feasibility study outlined in Section 13.1. Manildra Shoalhaven Starches facility could act as a catalyst for the area.

Topic	Sub-topic	Summary	Potential Action
	**Waste from Bushfire Events**	With the increased risk of bushfire in the region, opportunities to divert bushfire waste from landfill should be investigated.	Undertake an analysis of waste outputs from the recent bushfires and develop a plan to improve waste management practices as a result of future natural disasters.

The climate change summary tables incorporated in this Plan have been based on the risk assessment likelihood and consequence tables from AS 5334:2013 as per the below.

Table 13: Likelihood and Consequence Table

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	L	M	H	E	E
Likely	L	M	M	H	E
Moderate	L	L	M	H	E
Unlikely	L	L	M	M	H
Very Unlikely	L	L	L	M	M

Table 14: Climate Risk Assessment

Topic	Climate Change Risks		Impact	Likelihood	Consequence	Risk Rating
Energy		**Increased Temperature**	Increased energy demand and likelihood of network capacity being exceeded with potential brown/black-outs.	Likely	Moderate	**M**
		**Harsher Fire-weather**	More frequent and intense bushfires are likely to disrupt utility supplies.	Likely	Major	**H**

Topic	Climate Change Risks		Impact	Likelihood	Consequence	Risk Rating
		**Increased Rainfall Variability and Evaporation**	Reduced capacity of hydro power plants, resulting in potential reduced generation capacity in the region.	Moderate	Minor	**L**
		**Sea level rise**	Increased sea levels have the potential to impact utility supplies however major infrastructure has likely incorporated this risk in facility designs. Sea level rise is not expected to impact major facilities such as the Tallawarra Gas Power Plant.	Likely	Minor	**L**
		**All of the above**	The combination of climate change risks in the region has the potential of reducing the life of energy infrastructure with additional capital required to maintain, upgrade and replace infrastructure due to increased climate change design requirements.	Likely	Major	**H**
Renewable Energy		**Increased solar radiation**	Increased solar radiation for the region has been projected which will result in a minor increase in the productivity of solar PV systems.	N/A	N/A	N/A
		**Minor increase in mean wind speed**	Minor increases in mean wind projected for the southern region of the sub-clusters however minimal impact on wind resources for the Illawarra Shoalhaven.	Likely	Minor	**Low**
		**Increased rainfall variability, evaporation and longer periods of drought**	Reduced capacity of hydro power plants, resulting in potential reduced generation capacity in the region.	Moderate	Minor	**Low**

Topic	Climate Change Risks		Impact	Likelihood	Consequence	Risk Rating
		**Increased sea surface temperatures and more acidic oceans**	No impact on wave energy resources projected.	N/A	N/A	N/A
Transport		**Increased temperatures with prolonged and more frequent heat waves**	Increased temperatures and prolonged heat waves can result in asphalt surfaces becoming unstable and train tracks buckling due to extreme temperatures.	Likely	Moderate	**M**
		**Harsher fire-weather**	More frequent and intense bushfires may disrupt transport routes through road closures.	Likely	Major	**H**
		**Increased rainfall intensity**	Road and rail access impacted by floodwater with associated increased soil erosion.	Likely	Major	**H**
		**Rainfall variability with increased rainfall intensity and evaporation**	Soil expansion and erosion, resulting in cracks and damage to road surfaces causing road closures. May also impact the ability for fire crews to access regional areas and national parks due to large cracks forming.	Likely	Moderate	**M**
		**All of the above**	The combination of climate change risks in the region has the potential of reducing the life of transport infrastructure with additional capital required to maintain, upgrade and replace infrastructure due to increased climate change design requirements.	Likely	Major	**H**

Topic	Climate Change Risks		Impact	Likelihood	Consequence	Risk Rating
Circular Economy		**Increased temperatures with prolonged and more frequent heat waves**	Some studies have shown that increased temperatures and drier conditions may increase the rate of methane emissions from landfill.	Moderate	Minor	L
		**Harsher fire-weather**	Increased demolition and material waste from more frequent and intense bushfires. May also pose a risk to waste infrastructure including processing facilities.	Likely	Moderate	M
		**Increased rainfall intensity**	Increased rainfall intensity may increase the likelihood of contaminated water from landfill sites entering waterways and ground water.	Likely	Moderate	M
Water		**Increased Temperature**	Increased water demand for processes and irrigation and likelihood of network capacity being exceeded with potential supply shortages/loss.	Likely	Major	H
		**Harsher Fire-weather**	More frequent and intense bushfires are likely to disrupt utility supplies. In addition, ash, debris and hazardous materials washed into waterways are likely to impact water quality in catchments and increase water treatment requirements.	Likely	Major	H
		**Longer periods of drought and increased evaporation**	Increased likelihood of the region's water supply capacity being exceeded during peak periods due to lower dam levels and drought conditions.	Likely	Moderate	M

Topic	Climate Change Risks		Impact	Likelihood	Consequence	Risk Rating
		**Increased rainfall intensity**	Increased likelihood of flooding and stormwater management system capacity being exceeded with increased likelihood of road closures due to landslides and access restrictions. Increased volume of contaminated water from bushfire affected areas likely to impact water quality impacting both the environment and potable water supply.	Likely	Major	**H**
		**Sea level rise**	Sea level rise has been projected along the region's coast impacting assets and infrastructure including roads, property and assets.	Likely	Major	**H**
		**All of the above**	The combination of climate change risks in the region has the potential of reducing the life of water assets and infrastructure with additional capital required to maintain, upgrade and replace infrastructure due to increased climate change design requirements.	Likely	Major	**H**

Table 15: Consequence Descriptions

Consequence descriptor	Adaptive capacity (see Note 1)	Infrastructure, service	Social/cultural	Governance	Financial (see Note 2)	Environmental (see Note 3)	Economy (see Note 4)
Insignificant	No change to the adaptive capacity	No infrastructure damage, little change to service	No adverse human health effects	No changes to management required	Little financial loss or increase in operating expenses	No adverse effects on natural environment	No effects on the broader economy
Minor	Minor decrease to the adaptive capacity of the asset. Capacity easily restored	Localised infrastructure service disruption No permanent damage. Some minor restoration	Short-term disruption to employees, customers or neighbours Slight adverse	General concern raised by regulators requiring response action	Additional operational costs Financial loss small, <10%	Minimal effects on the natural environment	Minor effect on the broader economy due to disruption of service provided by the asset

Consequence descriptor	Adaptive capacity (see Note 1)	Infrastructure, service	Social/cultural	Governance	Financial (see Note 2)	Environmental (see Note 3)	Economy (see Note 4)
		work required Early renewal of infrastructure by 10–20% Need for new/modified ancillary equipment	human health effects or general amenity issues				
Moderate	Some change in adaptive capacity. Renewal or repair may need new design to improve adaptive capacity	Limited infrastructure damage and loss of service Damage recoverable by maintenance and minor repair Early renewal of infrastructure by 20–50%	Frequent disruptions to employees, customers or neighbours. Adverse human health effects	Investigation by regulators Changes to management actions required	Moderate financial loss 10–50%	Some damage to the environment, including local ecosystems. Some remedial action may be required	High impact on the local economy, with some effect on the wider economy
Major	Major loss in adaptive capacity. Renewal or repair would need new design to improve adaptive capacity	Extensive infrastructure damage requiring major repair Major loss of infrastructure service Early renewal of infrastructure by 50–90%	Permanent physical injuries and fatalities may occur Severe disruptions to employees, customers or neighbours	Notices issued by regulators for corrective actions Changes required in management. Senior management responsibility questionable	Major financial loss 50–90%	Significant effect on the environment and local ecosystems. Remedial action likely to be required	Serious effect on the local economy spreading to the wider economy

Consequence descriptor	Adaptive capacity (see Note 1)	Infrastructure, service	Social/cultural	Governance	Financial (see Note 2)	Environmental (see Note 3)	Economy (see Note 4)
Catastrophic	Capacity destroyed, redesign required when repairing or renewing asset	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service Loss of infrastructure support and translocation of service to other sites Early renewal of infrastructure by >90%	Severe adverse human health effects, leading to multiple events of total disability or fatalities Total disruptions to employees, customers or neighbours Emergency response at a major level	Major policy shifts Change to legislative requirements Full change of management control	Extreme financial loss >90%	Very significant loss to the environment. May include localised loss of species, habitats or ecosystems Extensive remedial action essential to prevent further degradation. Restoration likely to be required	Major effect on the local, regional and state economies

NOTES:

1 Adaptive capacity relates to the ability of the infrastructure element and/or organisation to adapt/change/cope with change in the climate change variable.

2 Financial loss will be relative to the infrastructure element being considered (i.e. a single building, coastal town, rail system). Dollar values need to include replacement cost for the infrastructure item and financial loss/costs relating to the loss of the service provided by the infrastructure item.

3 While the term 'environment' can include both man-made and natural systems, in this Standard 'environment' is limited to the natural environment outside the asset being considered.

4 Economy refers to the local economy (e.g. town or region), the state economy, or the economy of Australia as a whole. Significance of this measure will depend on the asset being considered.