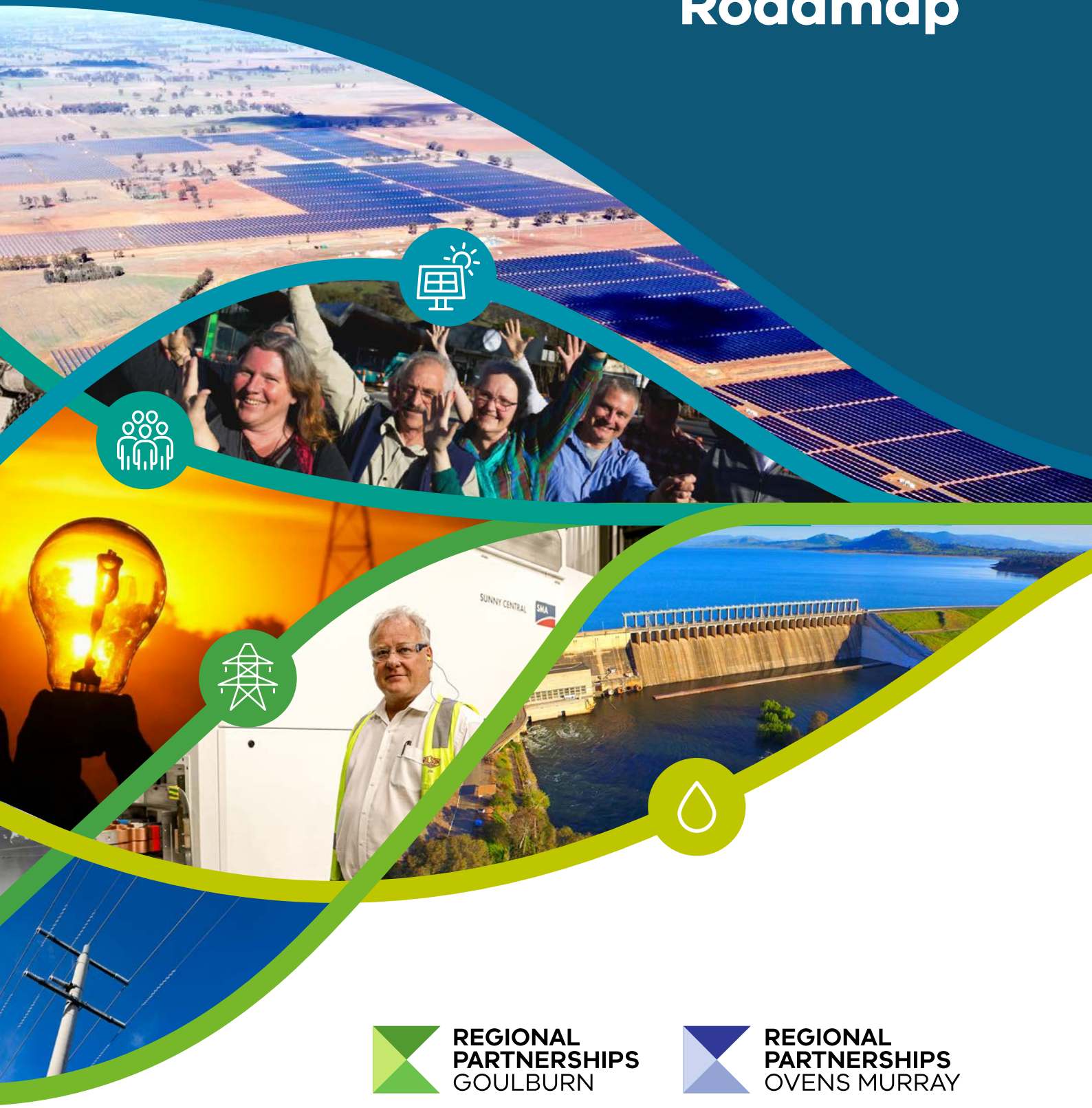
Hume Region
Renewable Energy Roadmap



REGIONAL PARTNERSHIPS GOULBURN

REGIONAL PARTNERSHIPS OVENS MURRAY

Hume - our voices, our vision for a renewable energy future

The voices of the Hume are loud, powerful and direct particularly on issues that matter like, education, local jobs, responding to climate change, fair and equitable access to cheap, clean energy, appropriate use of agricultural land, local investment and benefit sharing from renewable energy developments.

Over the past 12 months, community leaders and members have joined us to understand what a renewable energy future in Hume could look like, and how we can achieve it together. This Roadmap represents our community's voices, ideas and values.

Contents

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Foreword

The Hume Renewable Energy Roadmap project was established by the Goulburn and Ovens Murray Regional Partnerships to support and guide an exciting renewable energy future for our region.

Today, Hume's energy system is sophisticated, interconnected, and governed by national rules. Historically it was more localised, with community-owned power stations supplying individual communities. Hume also has a proud history of renewable hydroelectric generation, commencing in the 1920s with the 13.5MW Rubicon scheme and most recently with the 140MW Bogong power station in 2009.

During this Roadmap's development, we focused on two streams of work. A major emphasis has been to build the skills, capacity and understanding within our communities, industry and government to shape our renewable energy future. Over 30 capacity building and skills development activities were delivered, bringing thousands of voices to the conversation about renewable energy in our future.

We've also identified regional opportunities for renewable energy in Hume. These are:

1. **Willing, engaged communities,** a coalition of community energy groups delivering localised energy generation and distribution for community benefit.
2. **Distributed energy resources** and smart integration of these into our local grid. These technologies are already being embraced by the 13 community energy groups active in our region and supported by industry partners.
3. Hume also has significant **pumped hydro energy storage** development potential, so much so there is 13 times more storage potential than is required to support a 100 percent renewable grid, for all of Australia.
4. **Large scale solar** will have a place in Hume, and our quality solar resources and the main transmission lines running through our region are attracting investment interest. At the time of this report, there is more than 2,700MW of solar farm connection interest from investors.
5. **Bioenergy** resources are abundant in the region, with softwood plantation feed stocks in the North East and agricultural feed stocks in the Goulburn Valley. Our region annually produces over 1.5 million tonnes of organic/ biomass resources material suitable for bioenergy. There are already three biogas generators operating in Hume, supplying power to 1,700 homes.

This Roadmap tells the story of our region's energy history, how we are beginning to embrace renewable energy technology, and what a future sustainable renewable energy landscape could look like. It also draws on and celebrates the contributions of people from across Hume, highlighting what's important for our future renewable energy landscape.

It signposts the way to a renewable energy future for Hume, which builds on and complements the tremendous amount of work and initiatives already underway.

Chair David McKenzie
Goulburn Regional Partnership

Chair Irene Grant
Ovens Murray Regional Partnership

About this Roadmap

This Roadmap provides a region-specific strategy for Hume. It articulates our renewable energy past, present and potential future, and captures how our region's leadership, drive and ingenuity is creating jobs and economic benefits, and helping address broader climate challenges.

The Roadmap was identified as a priority project through the Goulburn and Ovens Murray Regional Partnerships. There are nine Regional Partnerships in Victoria and these were established in 2016 on the basis that local communities are best placed to understand and address the challenges and opportunities faced by their region.

In 2016 at both the Ovens Murray and Goulburn Regional Partnership Assemblies community and industry participants told us one of their priorities was to support action on climate change and renewable energy. From these priorities the idea of a regional renewable energy Roadmap was formed.

What are we trying to achieve with this Roadmap?

Hume's uptake of renewable energy is already providing significant economic, social and environmental benefits. These benefits are expected to increase as we see further commitment via locally led initiatives. Through the Roadmap process, we have listened to and consulted with the community, through events, meetings and workshops, and by reporting back through regular communication and updates.

Our community has strong ties to the region and it's important we find a balance in how we use Hume's abundant natural resources. Acknowledging and protecting what we value is important as we transition to a renewable energy future, including looking after high value agricultural land and protecting the abundant natural resources which make our region unique.

This Roadmap provides an insight to the energy landscape in our region. It includes our progress, our priorities and pathways. It tells our renewable energy story, where we've come from, where we're up to and what's next.

It's our story and it's about making the best use of our abundant, local natural resources, and harnessing the enthusiasm, drive and passion of the people who make up our communities.

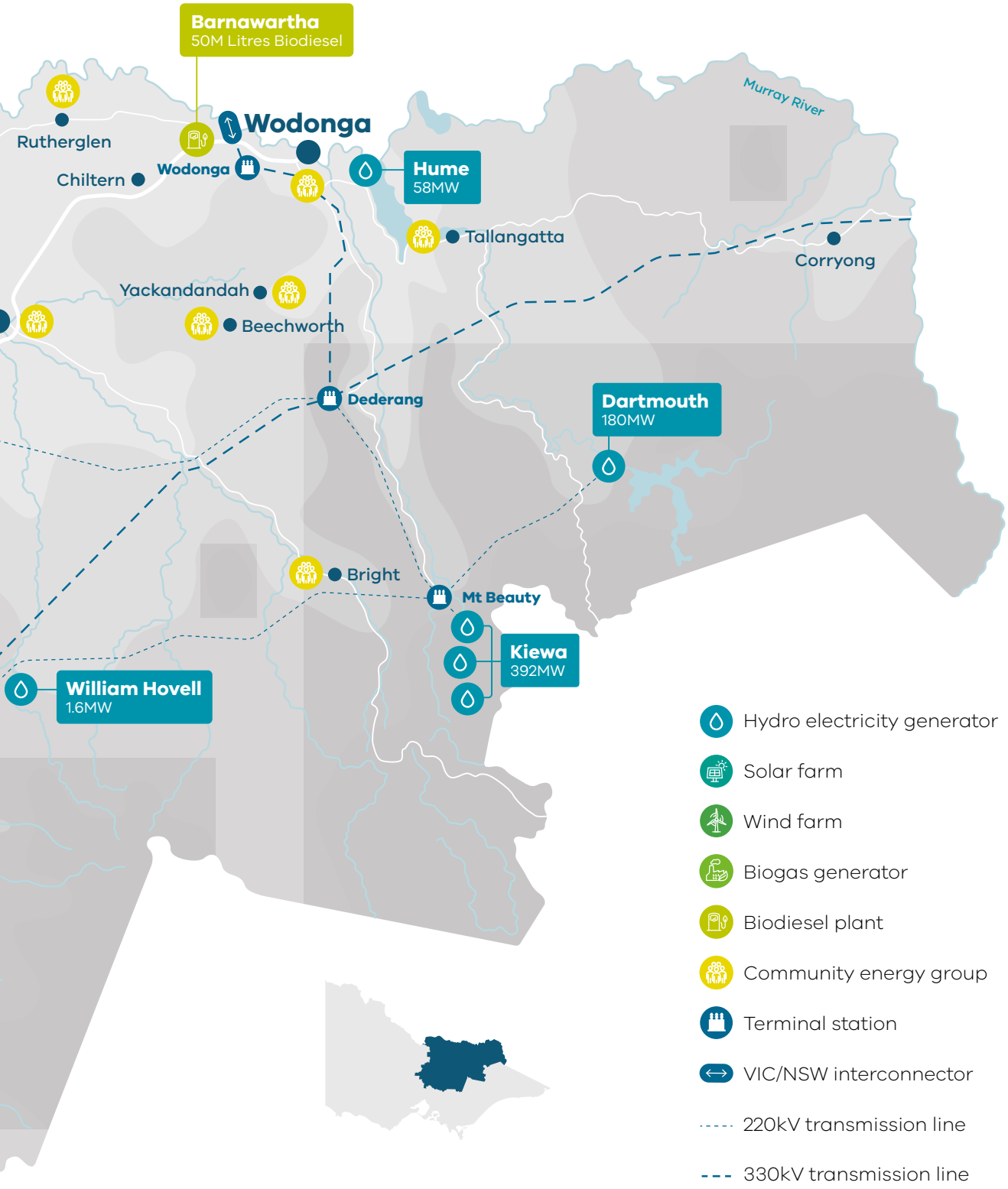
Most importantly, this Roadmap is a snapshot of the achievements, activities and future that our community wants to share.

Power of Solar by Liam Hindle, winner of Renewable energy youth photo competition ▶

Benalla renewable energy street art ▼

Our renewable energy landscape today

***Hume currently has over 1GW (1,000MW) of renewable electricity generation**. The annual output of this generation is around 1,700GWh.*



Hume's renewable energy **history**

The people of Hume are historically enthusiastic adopters of electric technology. Local communities met in halls across the region to discuss the introduction of electricity and electric lighting to their towns, with votes held, for example, in Rutherglen and Kilmore in 1906, Shepparton in 1911, Cobram in 1912, and Wagunyah in 1913.

As part of Cobram's 1912 vote, homeowners signed a written guarantee to install 400 electric lights in their premises, while, in Kilmore, the 1906 debate resulted in local people becoming shareholders in the Kilmore Electric Light Company.

With limited or no transmission infrastructure in Victoria, towns that wanted to use electricity needed to build their own distributed energy resources. This pioneering spirit in the early twentieth century was the start of the Hume region generating its own power. Rutherglen, for example, had a small plant operating by 1911, and Cobram had its own generation by 1914.

This was typical of early power supply in Victoria, with many small private electricity companies supporting local areas.

Pioneering renewable hydro generation

In 1921, the State Electricity Commission of Victoria (SECV) was formed to merge small generating operations and pursue the economies of larger-scale production and transmission of electricity across the state. This was to become vital as demand for connections kept growing, including in Victoria's regional towns and rural areas.

After six years of construction, the Rubicon Hydroelectric project began operations – the first state-owned hydro scheme to start generating in mainland Australia, and one of the first remotely controlled hydro operations in the world.

In its first 10 years of operation, the Rubicon scheme supplied on average some 17 percent of all electricity supplied to Victorian customers by the SECV.

By the late 1930s, the Victorian Government had also launched a second major hydro works program, the Kiewa Hydroelectric Scheme, to harness energy from water draining off the Bogong High Plains. Both these pioneering projects are still operating today.

The Snowy hydroelectric scheme, built in the 1950s and just over the border in New South Wales, is connected to Victoria by transmission lines which also service our hydroelectric generators.

▼ *Kiewa Hydro-electric Scheme tunnel construction c1938 (Public Records Office Victoria)*

◄ *Junction Dam spillway (State Library)*

▼ *Kiewa power station 3, Rubicon looking up and Kiewa transmission (State Library)*

Renewable energy in Hume **today**

▲ *Solar powered irrigation near Yarrawonga*

◀ *Transmission power lines running through orchards in Shepparton*

The Hume community's enthusiastic adoption of renewable energy projects means our region is one of the leading community energy hubs in Australia. Currently, across Hume, renewable energy generation equates to around 1,700GWh per year[1] .

Key drivers for local renewable energy, generation, innovation and take-up include a willingness to acknowledge and address the impacts of climate change and strive to achieve a cleaner energy future, reduce energy costs, ensure energy justice and keep the benefits of local energy investment within the community.

Today, there are many examples of community leaders, groups and organisations finding tangible ways to reduce their energy costs and support a renewable energy future.

Hume is attracting significant large-scale solar development interest, driven by our excellent solar resources and access to an extensive and stable transmission network, capable of distributing renewable energy from Hume to support the state energy supply.

However, the region's diversity means there are other developments and opportunities. These include Hume's first wind farm in the south of the region, hydro generation, pumped hydro energy storage opportunities, bioenergy plants, significant uptake of rooftop solar and numerous small-scale distributed renewable energy projects.

1. *Renewable energy generation is based on data from the Clean Energy Regulator and the Australian Energy Market Operator (AEMO).*

Community energy groups in Hume

Hume has the highest number of community energy groups within a single region in Australia. Midway through 2019, Hume is home to 13 community energy or environmental sustainability groups, working on energy projects. More groups are forming.

Community renewable energy projects are owned and run by local communities for the benefit of local people, with communities joining forces to share information and knowledge, and to develop, deliver and benefit from clean energy solutions.

Community energy projects are diverse and can include solar panels or hot water bulk buys, micro or mini grids, community-owned solar or wind farms or electricity retailers.

Renewable Energy Benalla (REB)

- Worked with Beyond Zero Emission to create a plan to make Benalla energy neutral by 2028.
- Supporting local communities with information sharing and ideas.
- Running a community solar bulk buy.

GV Community Energy (GVCE)

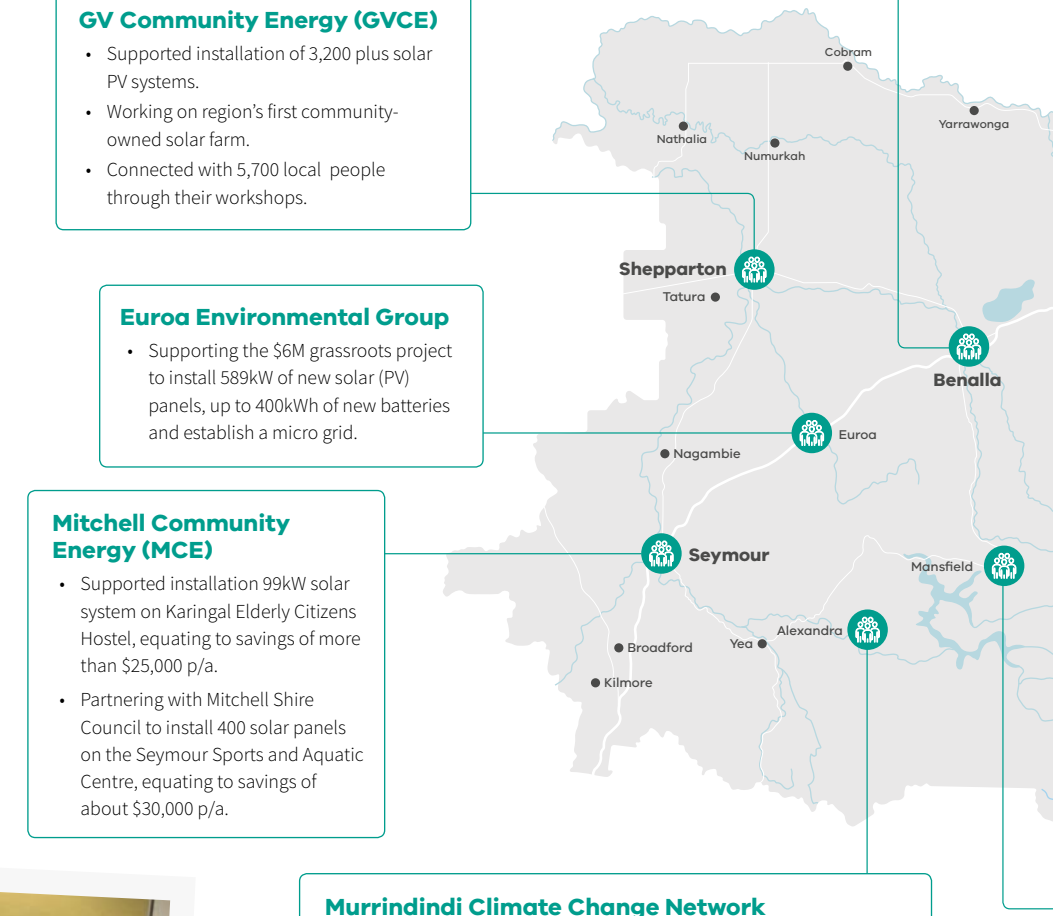
- Supported installation of 3,200 plus solar PV systems.
- Working on region's first community-owned solar farm.
- Connected with 5,700 local people through their workshops.

Euroa Environmental Group

- Supporting the $6M grassroots project to install 589kW of new solar (PV) panels, up to 400kWh of new batteries and establish a micro grid.

Mitchell Community Energy (MCE)

- Supported installation 99kW solar system on Karingal Elderly Citizens Hostel, equating to savings of more than $25,000 p/a.
- Partnering with Mitchell Shire Council to install 400 solar panels on the Seymour Sports and Aquatic Centre, equating to savings of about $30,000 p/a.



Murrindindi Climate Change Network

- Supported 40 local businesses with a free assessment and individualised report with tips to increase energy efficiency and lower their environmental footprint.

▼ *Youth renewable energy photo competition winners*

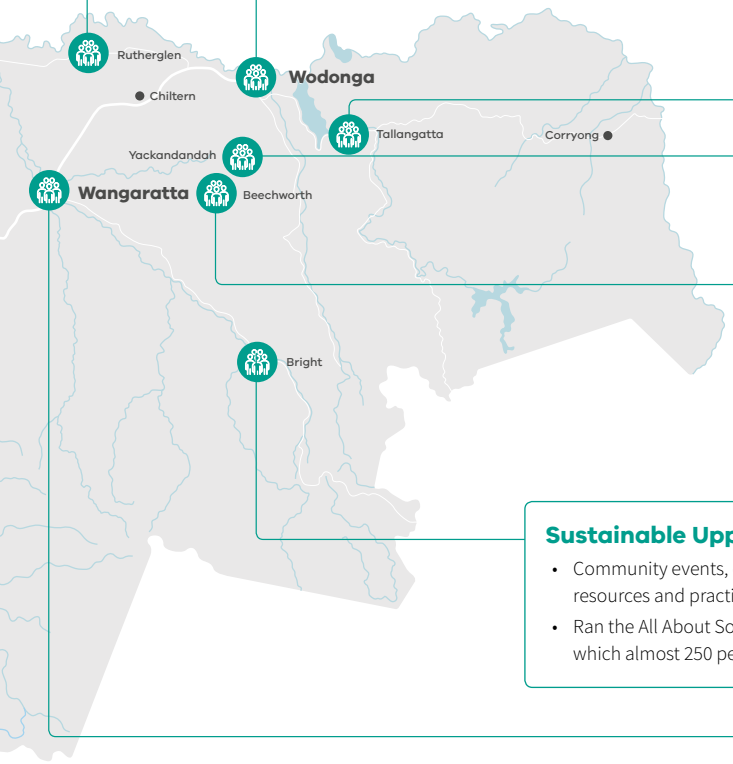
▼ *Wangaratta community energy roadshow*

Totally Renewable Rutherglen

- Newly formed - has joined the North East Community Energy Network.

Renewable Albury Wodonga (RAW) Energy

- Key achievements included having five solar PV systems installed on local Beyond Housing social housing units.
- Progressing the business case for building a minimum of a 2MW solar farm with direct benefit to those in the community unable to put solar on their own roofs.
- Installing 10 x 4kW solar power systems with full energy monitoring.



Totally Renewable Tallangatta

- Formed in 2018 and leading the charge for community energy in the Upper Murray.

Totally Renewable Yackandandah (TRY)

- Five step plan to make Yackandandah 100 percent renewable by 2022.
- 99kW solar PV array on community health service, saving more than $200,000 over next 10 years.
- Generation of 1GWh renewable energy, saving $1million in energy costs.

Totally Renewable Beechworth

- Aiming for their postcode to be totally renewable by 2030.
- Has run several community forums and planning more.

Sustainable Upper Ovens (SUO)

- Community events, online information resources and practical workshops.
- Ran the All About Solar Expo, June 2019, which almost 250 people attended.

Wangaratta Sustainability Group

- Recently hosted information sessions on opportunities for everyone to be part of the change to cleaner renewable energy.
- Energy efficiency workshops to interpret power bills.

Renewable Energy Mansfield

- Committed to providing affordable and sustainable energy to Mansfield residents in response to rising energy prices and community action on Climate Change.

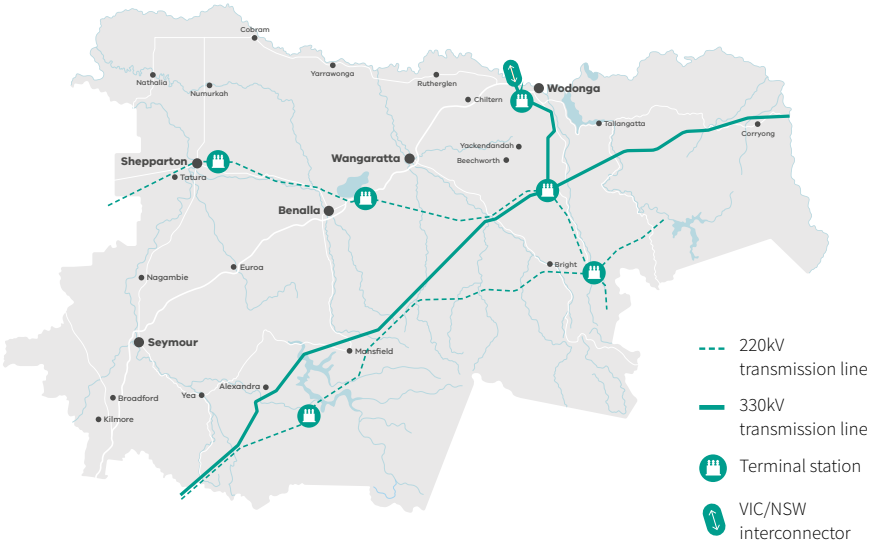
Beechworth community energy roadshow ▼

Transmission power lines near Winton Wetlands ▲

Hume's strong transmission infrastructure

Many Australian regions have plentiful solar and wind resources. The extensive supply of these resources, a range of incentives, and the falling cost of technology are driving the rapid uptake of renewables. Households, businesses and community groups have quickly built their distributed generating capacity, while large scale renewable energy developers continue to invest in connecting to the grid.

What is now being recognised is the need for adequate transmission to share these resources. Major network infrastructure can carry renewable power so it is available where and when households and businesses need it. It can also carry power to and from different places, time zones and types of generators, so it doesn't matter if the sun isn't shining or wind isn't blowing in a particular location[2].



Hume has two main high voltage transmission lines – a 220kV line from Shepparton to Wodonga via Glenrowan and Dederang, and a 330kV from South Morang on Melbourne's outskirts to Dederang and to New South Wales – and numerous 66kV sub-transmission lines.

There are five major electrical terminal stations in the region at Shepparton, Glenrowan, Dederang, Mt Beauty and Wodonga, with new renewable energy generation connection capacity of 400MW across the region's terminal stations[3].

This infrastructure has supported renewables growth to date, and is also expected to be augmented in the near future.

2. *Australian Energy Market Operator 2018 Integrated System Plan and 2019 Victorian Annual Planning Report.*
3. *Australian Renewable Energy Mapping Infrastructure web portal.*

Wind generation in Hume

Hume has 100m (height above ground) average wind speeds ranging from around 5m/s in the north, and as low as 3.5m/s in the sheltered alpine valleys, however, some areas in Hume's south have average annual wind speeds of 7-8m/s.

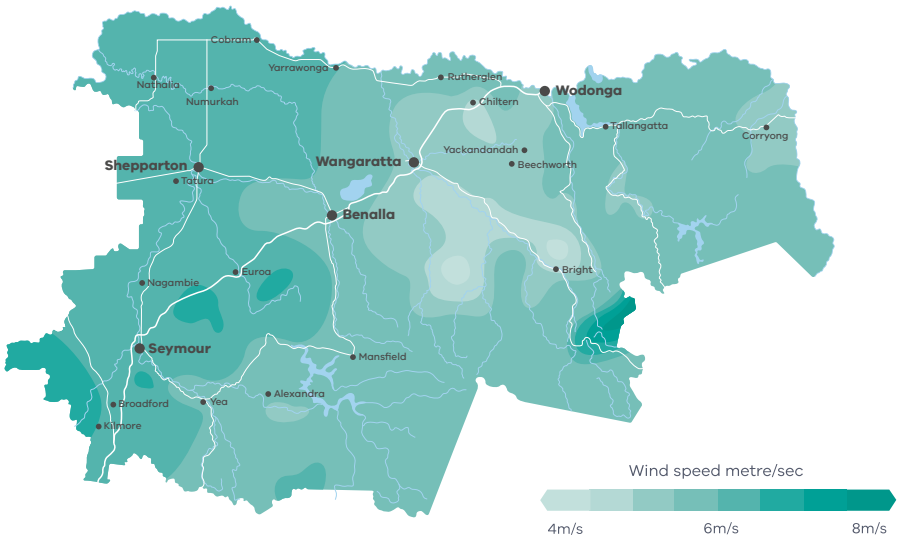
Much of the area of Hume with higher quality wind resources consists of state forests and national parks, in the southern and eastern parts of the region, which are also mountainous, difficult to access, and subject to bushfire risk. Social license to develop wind generation would also be expected to be a challenge in Hume's high amenity mountainous and alpine areas.

For these reasons, wind generation is likely to continue to have a lower profile in Hume compared to other parts of Victoria.

There is currently one wind farm in development in Hume, the 57.6MW Cherry Tree wind farm near Seymour.

While the prospects for future large scale wind projects in the region are constrained, the region does have specific areas where there is some accessible wind resource, and scope for smaller wind developments to meet local energy consumption.

Average wind speeds in Hume



CASE STUDY

Cherry Tree wind farm

Located near Seymour on four host farms, Cherry Tree wind farm is targeted for full commercial operation in the first half of 2020. Infigen is managing construction, and will purchase the electricity generated through a power purchasing agreement when Cherry Tree wind farm is operating. There will be 16 wind turbines with a generating capacity of 57.6MW, enough to power 37,000 homes. Tower height is 91m and rotor diameter 136m. Construction will create 80 jobs, with five ongoing.

▲ *Numurkah solar farm*

Solar generation in Hume

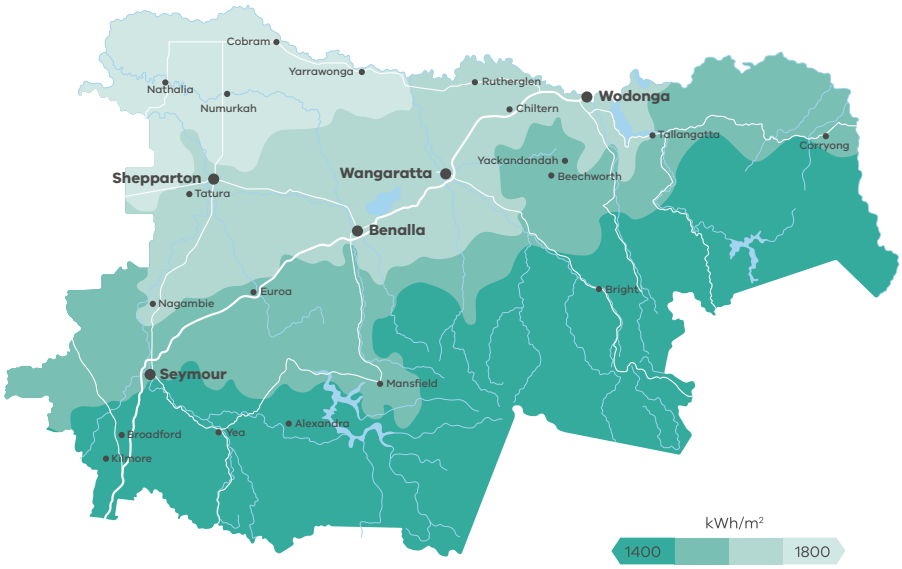
Our region enjoys outstanding solar resources. As this chart shows, Hume's solar radiation averages very high levels, second only in quality to the far north west of the state.

The Hume region generates a lot of energy from these solar resources, both through large scale solar farms connected to the grid, and through distributed ("rooftop") PV systems owned by homes and businesses across the region.

Currently there is 1.5MW of large (systems bigger than 99kW) rooftop solar capacity installed across Hume, in addition to more than 154MW of smaller rooftop solar systems installed. In total, our region generates around 280GWh of electricity from rooftop solar PV each year.

Large scale solar development – solar farms connecting to the electricity grid – is a significant part of our region's current and future renewable energy generation landscape. Development will be subject to the Solar Energy Facilities – Design and Development Guidelines that will be implemented through the Victorian Planning Provisions.

Solar Radiation in Hume

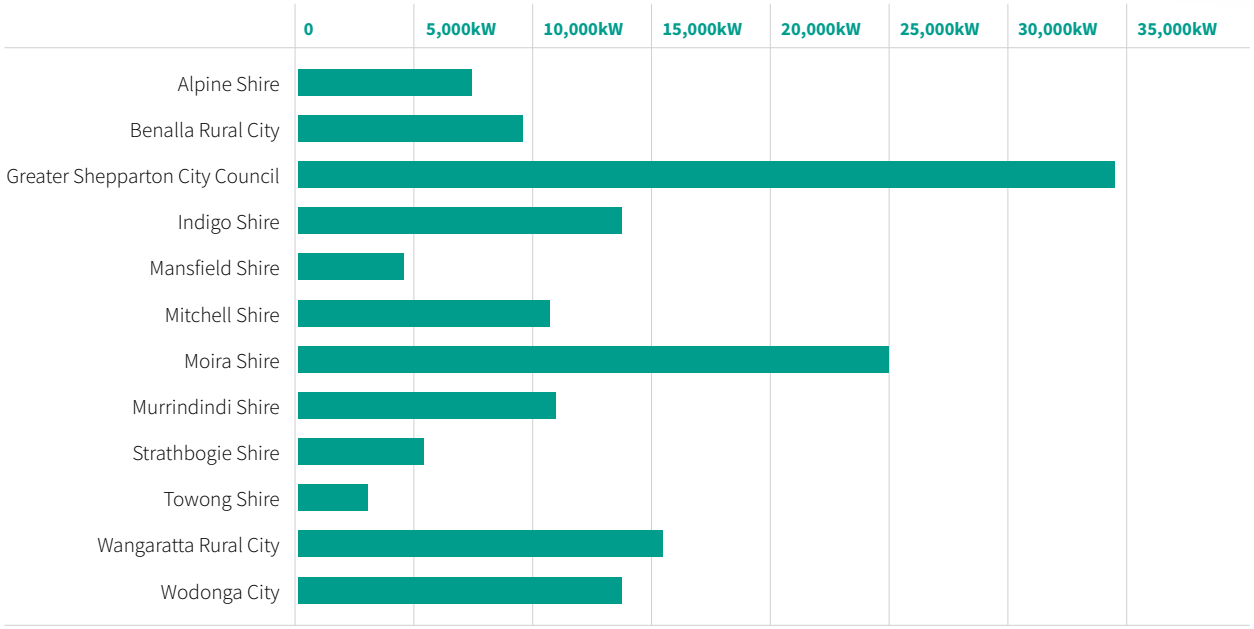


The 128MW peak Numurkah solar farm in Hume is currently undergoing commissioning. Four more connection applications have been made for large scale solar farms ranging in size from 22MW to 110MW. At least 12 other large-scale solar farm connection enquiries have been registered by the Australian Energy Market Operator (AEMO).

There is a total of over 2,700MW of expressed interest in further solar development connection interest in Hume, as investors recognise our high quality solar resources and transmission infrastructure capacity. This level of investment interest could be worth around $4 billion, but the cost of building large scale solar farms is variable, and this figure is based on a capital construction cost of $1.5 million per MW of capacity.

Yackandandah residents have now generated over 1GWh ► of roof top solar, saving the community over $1million dollars

Total rooftop solar PV generation capacity (2017)



CASE STUDY

Historic Beechworth Gaol now solar powered

In April 2019, Indigo Power switched on the first community-owned solar power system in north east Victoria. The 89 solar panels installed now provide 55 percent of the Old Beechworth Gaol's electricity needs. The gaol was also once home to the bush ranger Ned Kelly.

Hydroelectricity in Hume

Hydro generation has been and continues to be a major renewable development industry in the region. Presently there is 780MW of hydro generation in Hume, with another 1,500MW flowing through the region's transmission network from the Murray 1 and 2 power stations, just over our far eastern border with New South Wales.

The major hydro schemes in our region are:

Kiewa

Multiple power stations with 392MW total capacity and 404GWh annual output.

Dartmouth

The largest single hydro generator in Victoria with 180MW capacity and 217GWh annual output.

Eildon

Four generators with 120MW capacity and 184GWh annual output.

Hume

58MW and 220GWh average annual output.

Smaller hydro schemes in the region include:

William Hovell

1.6MW capacity with an annual output of 3.7GWh.

Eildon Pondage

4.5MW capacity with annual output of 15GWh

Rubicon

Commissioned in the 1920s, four small power stations, with total capacity of 13.5MW and annual output of 64GWh.

Yarrawonga/Mulwala

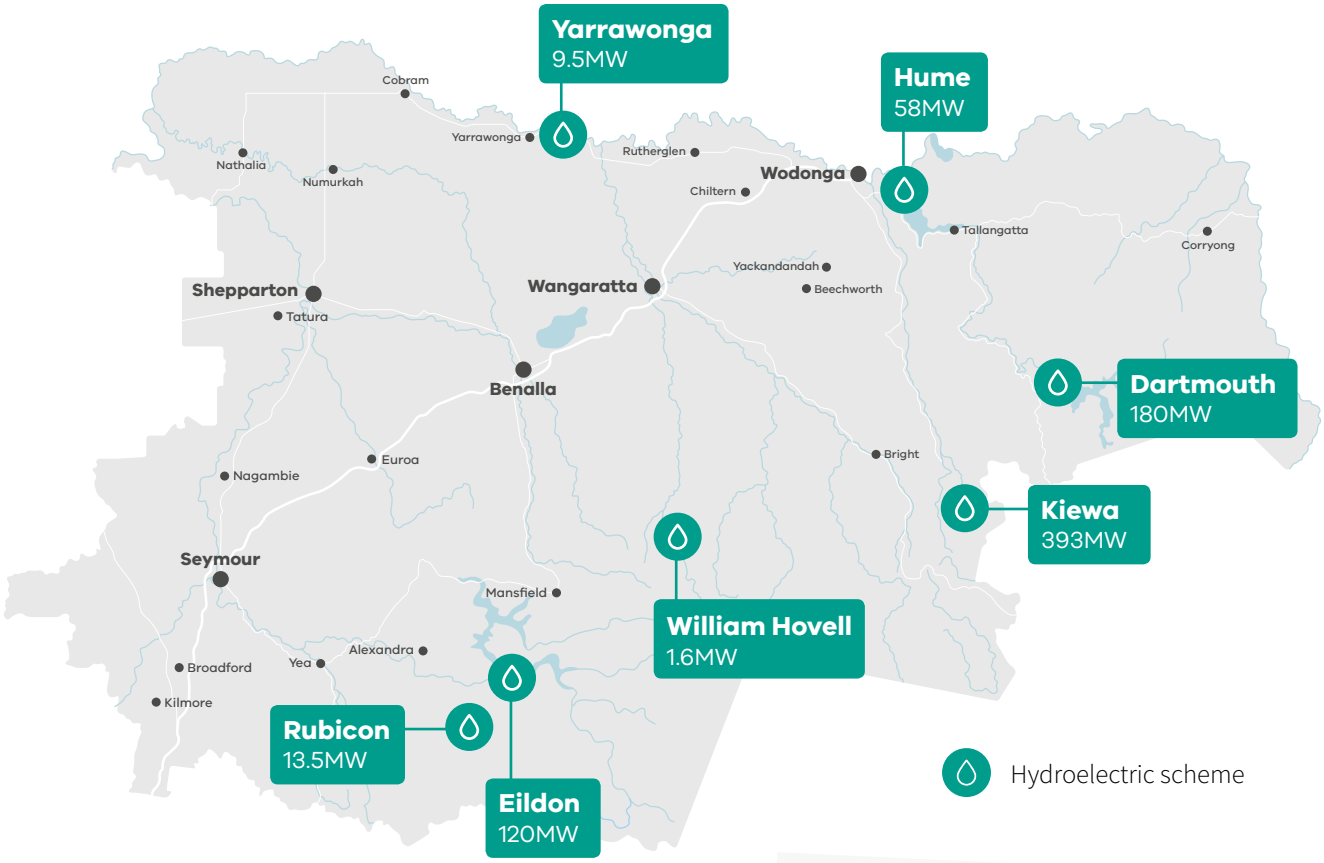
Total capacity 9.5MW and 50GWh output per annum.

Several very small run of river or micro hydroelectric turbines have also been developed in the region to power visitor infrastructure at Mt Stirling and at Steavenson Falls (near Marysville) both in the southern edge of the region.

▼ *Lake Mulwala weir gates*

▼ *Lake Hume, hydroelectric generator on left of the weir.*

*Presently there is **780MW** of hydro generation in Hume.*



Lake William Hovell hydroelectric scheme near Wangaratta ▶

Lake Mulwala weir, diverts water for irrigation and run of river hydroelectric generation ▼

Bioenergy in Hume

Bioenergy is derived from biomass (organic matter of recently living plant or animal origin) to generate electricity and heat, or to produce liquid fuels for transport. Biomass is available in many forms such as agricultural products, forestry products, municipal and other waste. Traditionally, woody biomass has been used for bioenergy, however more recent technologies have expanded the potential resources to include agricultural residues, oil seeds and algae.

Firewood has always been an important energy resource in the region, with over 1.3 million hectares of public land and firewood plantations providing this valuable energy resource. There are areas such as the Murray River forests which are running out of firewood.

Communities in these areas are starting transition to alternative forms of heating. Careful management of firewood into the future is important.

Currently Hume has several bioenergy plants operating, which collectively provide enough power to supply over 1,700 average Victorian homes or around 9.5GWh per year.

These bioenergy plants are all biogas plants which convert the gas into electricity through generators and feed that electricity into the grid. Three generators are:

- Shepparton Goulburn Valley Water waste water plant biogas = 1.1MW.
- Tatura Goulburn Valley Water waste water plant biogas = 1.1MW.
- Shepparton Cosgrove Landfill gas = 0.8MW (LMS energy).

Biodiesel – a renewable liquid fuel made from biomass, usually vegetable oil or animal fat – is seen as a green energy alternative to diesel.

In July 2019, Australia's largest renewable biodiesel producer reopened operations in Barnawartha in Hume. Just Biodiesel will produce up to 50 million litres of biodiesel each year, made mainly from tallow and recycled vegetable oil.

▼ *Diamond Energy's 1.1MW Shepparton biogas generator, Goulburn Valley Water supply biogas from the sewage works in the background*

▲ *Roof top solar at Buller Wines near Rutherglen.*

Uptake of renewable energy in business today

In addition to the uptake of rooftop solar by local business and industry, there are several other ways local businesses are taking advantage of renewable energy.

There are five local governments in Hume offering environmental upgrade agreements (EUAs) to provide local government, rates-based loan agreements to finance investments in renewables on commercial properties. EUAs are offered by:

- Greater Shepparton City Council.
- Indigo Shire Council.
- Mitchell Shire Council.
- Moira Shire Council.
- Rural City of Wangaratta Council.

In-front and behind-the-meter power purchase agreements and micro power purchase agreements are also being taken up across the region, by small and large energy consumers. Several regional manufacturing businesses have entered into these with large scale solar and wind farms, enabling them to source their renewable energy direct from the generator. This is a competitive, environmentally friendly way for energy customers to purchase electricity.

Artwork by Taungurung artist Mick Harding ▼

CASE STUDY

Indigenous Power

In 2019, a behind-the-meter power purchase agreement was negotiated between Taungurung Land and Water Council, Indigo Power and Department of Environment Land Water & Planning. The agreement benefits all parties and provides a model for government and community collaboration in renewable distributed energy resources. Through the agreement, DELWP's office in Broadford will be powered with Taungurung-owned renewable energy.

Hume's renewable energy **future**

We have several, distinct renewable energy generation opportunities and advantages in Hume. This section of the Roadmap expands on these future-focused renewable energy generation, distribution and storage opportunities, many of which are unique to our region. These opportunities are supported by the region's existing electrical transmission infrastructure, which will be further enhanced if potential upgrades proceed.

What are our significant opportunities, and how do we make them happen?

1. **Distributed energy resources** – building on our cultural and electricity system changes.
2. **Pumped hydro energy storage** – mass energy storage opportunities.
3. **Large scale solar** – development corridor across the region.
4. **Bioenergy** – Hume region is ranked third for potential in the state.

There are also emerging renewable energy technology opportunities in Hume – for example, solar thermal, and green hydrogen as a fuel. Hume contains nationally significant road and rail freight corridors which means we have the opportunity to benefit from the potential future decarbonisation of the transport and freight industries, as more environmentally friendly heavy transport fuels are introduced. Our region is expected to remain a significant transport hub and thoroughfare for east coast train networks, Hume Freeway, Goulburn Valley Freeway and transport through Shepparton, and Albury/Wodonga.

▼ *Students at Cathedral College Wangaratta learning about renewable energy technologies*

◀ *Grid connection insulators at Numurkah solar farm*

Improving our transmission infrastructure

Current renewable energy generator connection capacity in Hume is likely to become constrained due to thermal limitations, as existing connection capacity is used by early renewable energy generators (large scale solar PV farms). While this is a limiting factor on large scale solar, planned upgrades to the transmission grid at a state level may result in new opportunities for Hume.

These upgrades may enable future connection opportunities for large scale renewables in the Hume region. They will overcome constraints that are growing now, or are expected, on our two key high voltage transmission lines, and existing limits to new generation connection capacities[4] at the region's terminal stations (which are Shepparton: 320MW, Glenrowan: 400MW, Dederang: 400MW, Mt Beauty: 50MW, Wodonga: 400MW, and Eildon: 50MW).

How is transmission managed?

In Victoria, electricity transmission infrastructure (the big, high voltage powerlines) is controlled by the Australian Energy Market Operator (AEMO) but owned and run by Ausnet Services. Before making major infrastructure investments, AEMO undertakes a Regulatory Investment Test - Transmission (RIT-T) to assess the costs and benefits of alternative investment options.

4. *This capacity information was sourced from the Australian Renewable Energy Mapping Infrastructure platform. These figures are indicative only and actual connection capacity at one site is dynamic and needs to be assessed on a case by case basis.*

Transmission powerlines near Whitlands in the mountains ▲
Transmission powerlines near Goorambat ▶

AEMO is considering three separate network developments that could benefit Hume:

1. A 170MW upgrade to the 330kV transmission from South Morang to Dederang and over the border, to increase the capacity of the line to import and export more electricity between Victoria and New South Wales. Much of this 330kV line runs though the centre of many pumped hydro energy storage opportunity hot spots in Hume. AEMO identified this upgrade as an urgent need in its 2018 Integrated System Plan, and this proposal has been backed for action by the Council of Australian Governments (COAG) Energy Council.
2. Upgrades to 220kV transmission infrastructure to support massive renewable energy development in Western Victoria (2,000MW of committed generation in the region and another 3,000MW anticipated by 2025). This could also increase new generation connection capacity in Hume. The final RIT-T report in July 2019 outlined augmentations to be completed from now to 2025, costing an estimated $370 million and delivering gross market benefits of $670 million.
3. Increasing Victoria to New South Wales electricity transfer capacity by 1,800MW with a new interconnection between the two states, crossing the border near Kerang. AEMO has outlined the potential benefits of an additional interconnector as maximising the reliability and resilience benefits from Snowy 2.0 at lowest cost for Victorian consumers, as well as delivering other benefits. This RIT-T has not commenced but the need for one in the near future has been identified by AEMO and the Victorian Government as an emerging need. Advancing a RIT-T is seen as prudent insurance against any early closure of coal-fired generation or significant supply reduction.

Overall, the likely impacts of these proposed transmission upgrades on the Hume region are:

- Potential increased new generator connection capacity, especially in the area from Shepparton heading east towards Benalla and Wangaratta (i.e. the Shepparton to Dederang terminal stations and those sub transmission assets associated with the 220kV transmission line).
- Increased capacity of the 330kV transmission from South Morang (outskirts of Melbourne) to Dederang to support better Victoria to New South Wales interconnection may open up some smaller pumped hydro energy storage opportunities in the mountainous areas of the south and east of the Hume region.

▲ *Community funded rooftop solar at Yackandandah Health*

Opportunities for distributed energy resources (DER)

Currently, most energy is generated centrally at large scale and sent out to users across the transmission network. Increasingly, energy today is generated and stored locally, through smaller pieces of infrastructure in our homes, businesses and communities.

Resources that are created or stored locally and connected to the local distribution grid are called distributed energy resources, or DER.

Examples include rooftop solar PV, solar hot water, home batteries, and electric vehicles. DER also includes demand response (consumers being rewarded for reducing power use by switching off devices like air-conditioners and pool pumps). This response can help smooth out peak demand, and reduce maximum demand.

DER is growing rapidly and is forecast to play a huge role in Victoria's energy future:

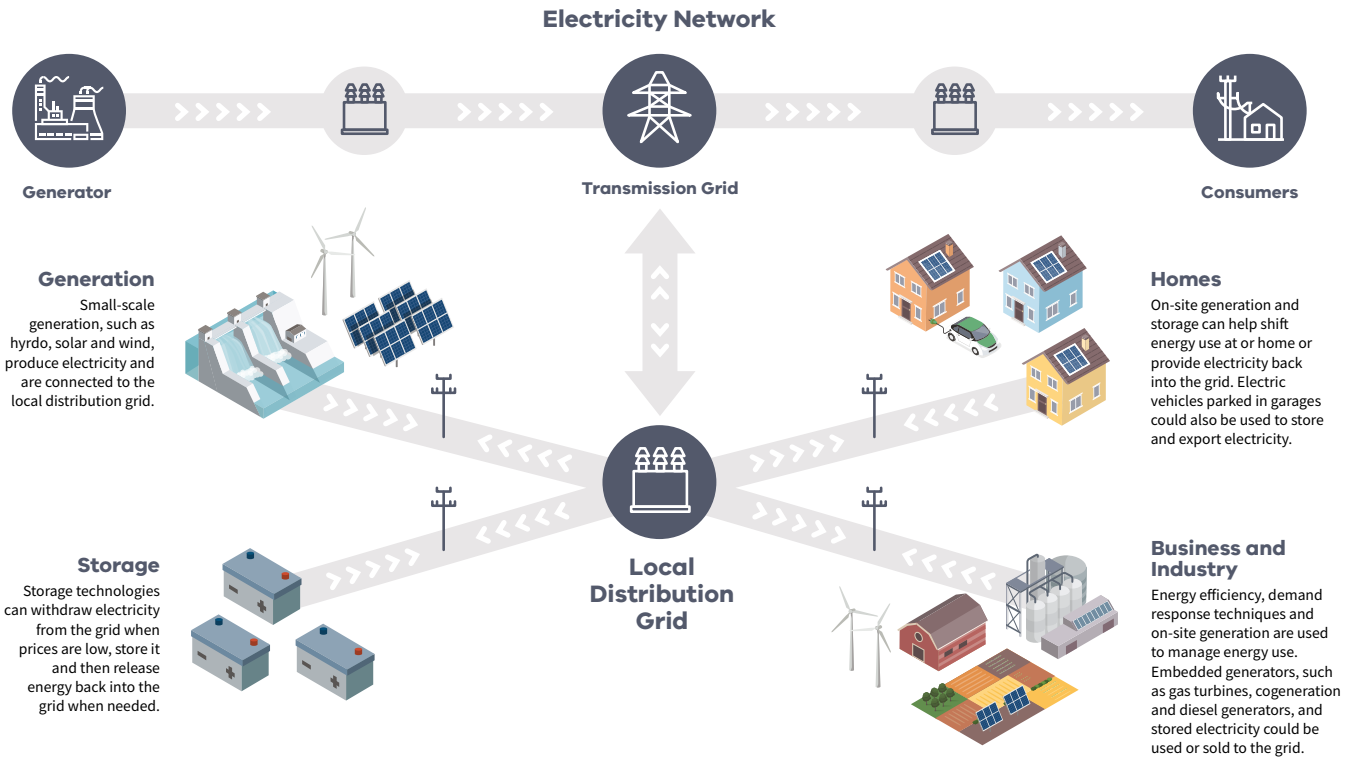
- AEMO's Integrated System Plan predicts that by 2039-40 25% of the state's energy will be supplied by roof top solar and batteries.
- Energy Networks Australia (ENA) and Commonwealth Science and Industrial Research Organisation (CSIRO) in their Electricity Network Transformation Roadmap predict up to 45 percent by 2050.

As well as offering immediate benefits to the consumers who choose to generate or store their own resources, DER can also have a much larger combined impact in a power system. DER enables more local grid capacity by increasing the local generation and consumption of renewable energy, and provides local coordination of small renewable energy resources to affect large grid responses. Collectively this will all lead to lower energy prices and more energy security.

In their 2017 Electricity Network Transformation Roadmap, Energy Networks Australia and CSIRO predict that by 2050 appropriately integrated DER can provide great consumer benefits:

- Average annual household energy cost savings of $414.
- Network Service Providers payment to DER owners for 'network services' up to $2.5 billion annually.
- $16.2 billion avoided network investment through coordination of DER.

How does distributed energy resources (DER) work?



AEMO's 2018 Integrated System Plan also identifies the transformative effect DER is having and will continue to have on Australia's energy network, particularly at the higher end of the predicted uptake levels. DER can support both the development of a renewable energy powered electricity network by lowering network building costs and reducing the net present value of wholesale renewable energy resource costs by $4 billion. AEMO clearly states that the full benefit of DER, for consumers and the power system, will only be realised when it is properly coordinated.

Why is DER important for Hume?

DER – and more specifically consumer-owned DER – provides huge opportunities to capture much of the economic and social value of renewables locally. These economic and social benefits are key drivers for a renewable energy future in Hume.

There is real potential for Hume's towns and communities to become a larger scale coordinated distributed energy network. Hume already has the highest density of community energy groups for any region in Australia, all of which have renewable DER as the central element of their missions/activities.

DER fits very strongly with several of our region's key values about a renewable energy future, including the potential local economic benefits, lower energy costs and the sense of "energy justice" a decentralised grid provides.

CASE STUDIES

North East Community Network

The North East Community Energy Network formed to support community energy groups in our region, to share knowledge and experiences. The network has, for the first time, started planning for a region-wide community solar hot water bulk buy. Two types of solar hot water will be included in the buy – heat pump and evacuated tube.

This bulk buy will bring the benefits of reducing house hold energy consumption for hot water heating by up to 70 percent, allowing for better use of rooftop solar PV generation, by increasing behind-the-meter consumption.

Furthermore, if this bulk buy is done at a large enough scale it has the potential to support increased penetration levels of solar PV, as it can substantially reduce the demand for off-peak electricity and decrease day time solar PV grid exports.

Indigo Power

Indigo Power is a registered social enterprise, community energy company, supporting delivery of the many renewable energy initiatives in Hume. The type of initiatives which have directly benefited from Indigo Power's support include behind-the-meter solar power purchase agreements and work is underway on local electricity trading and demand management opportunities. Indigo Power will also play an important part in Hume's DER future.

Common DER renewable energy sources in our region include:

- Rooftop solar.
- Solar hot water.
- Energy storage.
- Distribution scale in-front-of-the-meter renewable energy farms (solar, hydro, bioenergy).
- Micro grids.
- Demand response.

If we add up all the rooftop solar in the Hume region now, it's more than 154MW of total renewable energy generation – that's around the same as Numurkah Solar Farm and Cherry Tree Wind Farm combined!

When we consider the extent of our current DER, together with the growing number of battery installations, and demand response capabilities, the scope for Hume is significant.

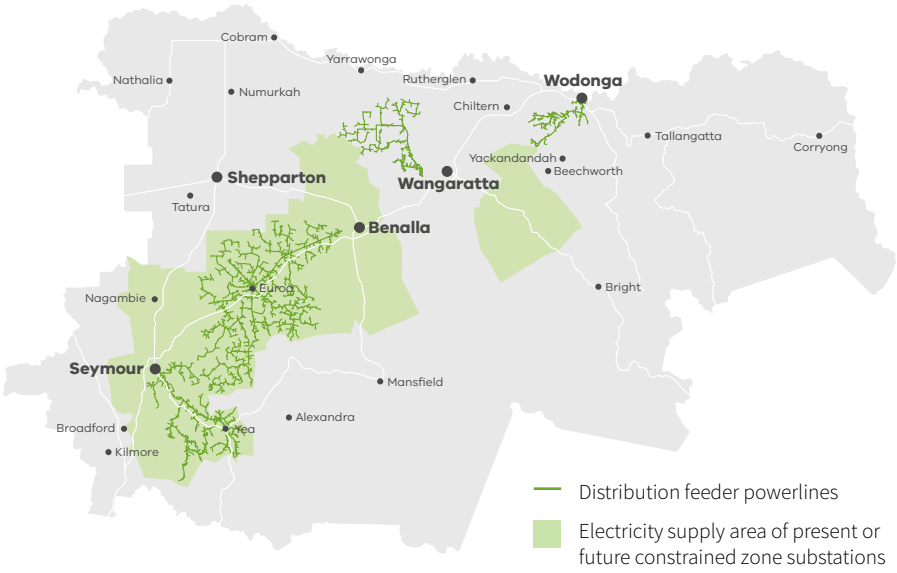
The fast growth of rooftop solar shows how quickly things can change when consumers take their energy choices into their own hands. The day will come soon in Hume, as it has already in many power systems around the world, when consumers will be paid by electricity companies for demand response, or for exporting rooftop solar energy at times that help support the grid and lower the need for new investment.

There are locations in Hume which present great opportunities for local people to invest in DER and coordinate their efforts (see areas from Mondo maps). Collaboration across community and with industry present opportunities to the region to benefit from local DER.

Hume is well positioned to become a national leader in DER due to our:

- Varied geography and range of renewable resources (solar at all scales, PHES, bioenergy).
- Local energy demand.
- Proximity to existing hydro plants and transmission infrastructure.
- High level of community interest, capability and social licence for action.
- Electricity grid being constrained, and pockets of the distribution grid being very constrained, leading to demand management opportunities.
- Population being dispersed across many settlements, with lots of small and medium towns and few regional cities.

Potential areas of the Hume electricity distribution network for demand management options



Constrained electricity feeders south of Wodonga, an area that could take advantage of demand management opportunities.

▲ *First household to sign up to a mini-grid in the region*

CASE STUDY

Mondo Power

Mondo Power is partnering with community energy groups in Hume to co-develop and deliver Australia's most effective and coordinated DER opportunities and projects. These initiatives, developing genuine regional energy hubs, are resulting from the trust and positive relationships Mondo and our local community are building, and the consistent, shared goals. Through community and industry collaboration, DER opportunities will be realised at a rate and scale not otherwise obtainable. This collaboration has already delivered the region's first two mini grids, with the critical orchestration capability so strongly identified in AEMO's Integrated Systems Plan.

Victoria's home of pumped hydro energy storage (PHES) opportunities

Hume provides a significant opportunity for pumped hydro energy storage. The Australian National University (ANU) confirmed this potential in a March 2019 study and subsequent report[5].

From an engineering perspective, Hume theoretically has 13 times the pumped hydro energy storage potential required to meet a 100 percent renewable energy grid (500GWh) for Australia[5]. Robust environmental assessment and community consultation would be required before proceeding with any development and only a subset of potential sites are likely to be viable once all factors are taken into account.

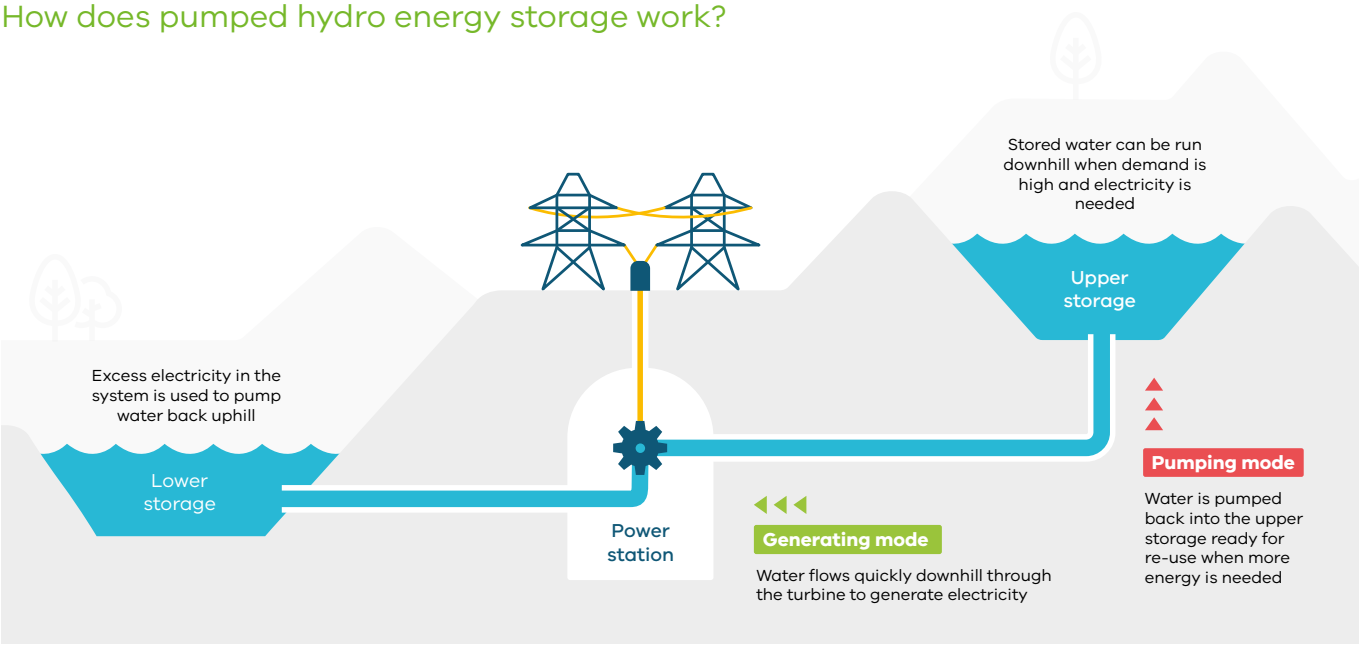
Leveraging this opportunity will require careful consideration of water availability. Water is an important and highly valued resource in the Hume region and its use is already competitive, especially in the Murray Darling basin of which Hume is part. Stream flows in the Hume region are projected to decline by around 20 percent by 2065, leading to increased competition for water[6].

Our region's pumped hydro energy storage (PHES) development opportunities can provide the energy storage needs of a renewable energy future, not just for Hume, but for Victoria and Australia.

Energy storage is an important part of a renewable energy future and will (combined with other changes to our energy network) help support wind and solar generation to meet our energy needs 24 hours a day. Technologies like PHES help shift renewable energy supply from times of low grid demand (like the middle of the day when rooftop PV is supplying plenty of power) to times of high demand (like the morning and evening, when rooftop PV generates less power).

▼ *Lake William Hovell dam*

How does pumped hydro energy storage work?



The research conducted by ANU is extensive, and has reported that, in our region[7]:

- There are 151 off-river sites technically suitable for PHES development, ranging from 2GWh to 150GWh sites and with a combined energy storage capacity of over 6,500GWh. These sites were identified using a geographic information system based research program, using algorithms which modelled the location and size of potential PHES development sites in the region.
- A subset of these sites (20 percent) are classed as high quality sites (based on an economic model which considered construction costs and power generation output) and provide potential energy storage capacity of 1,260GWh – still 2.5 times the required energy storage for a 100 percent renewable grid in Australia.
- A preliminary analysis highlights four clusters for potential development. These areas are key because they are co-located with the region's existing high voltage transmission network, so stored power can be readily transported when and to where it is needed.

Collectively, these four areas could store 570MWh of electricity, and the number of 15GWh for potential sites in each of the four areas can summarised as:

- Buxton – 22 class A+B sites (highest when sites were ranked from class A to class D).
- Toombullups – six class A+B sites.
- Tallangatta Valley – seven class A+B sites.
- Yackandandah – three class A+B sites.

5. *ANU College of Engineering & Computer Science June 2019, http://re100.eng.anu.edu.au/global/)*
6. *Reference Water for Victoria report page 37.*
7. *It is important to note that the identified potential PHES sites are theoretical, and were identified using modelled information. None of the sites have been the subject of commercial, geological, hydrological, environmental, heritage and other studies. Attention to these matters and consultation with land owners and managers would be essential prior to any development.*

Identification of potential PHES sites in Hume included analysis of:

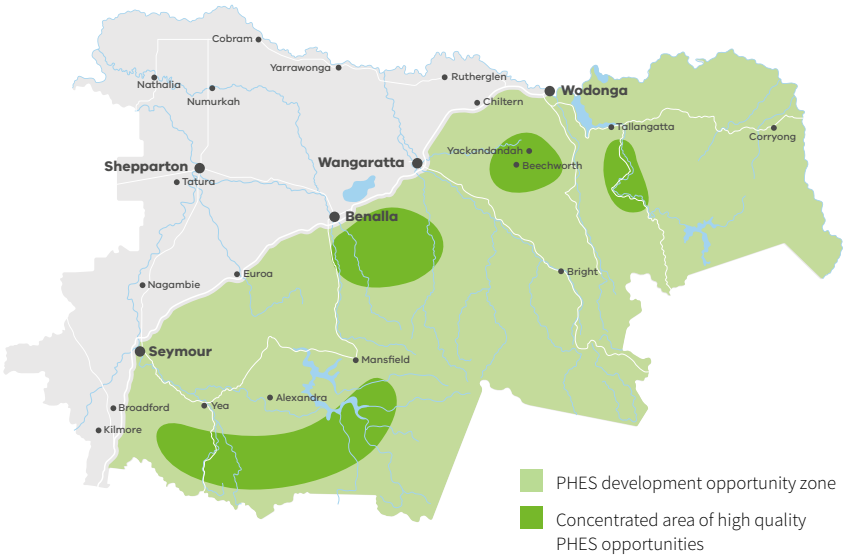
- Latitude, longitude, and elevation of the reservoir.
- Area of the reservoir (in hectares).
- Water volume of the reservoir (in gigalitres).
- Length of the dam (in metres).
- Dam wall height (in metres): the maximum height of earth and rock wall; different wall heights will produce different dam and reservoir shapes and volumes.
- Volume of rock in the dam wall (in gigalitres) based on a 3:1 upstream and downstream slopes.
- Water-to-rock (W/R) ratio: ratio between volume of the stored water and volume of rock in the dam wall; reservoirs with higher water-to-rock ratio are economically more competitive.

For each pair of upper and lower reservoirs the following attributes were also identified:

- Head (in metres): minimum altitude difference between potential upper and lower reservoirs.
- Distance (in kilometres): minimum horizontal distance between potential upper and lower reservoirs.
- Slope: ratio between the head and the distance.

Additional information is available from www.energy.vic.gov.au/renewable-energy/victorias-renewable-energy-roadmap/hume-renewable-energy-roadmap

PHES development opportunities in Hume



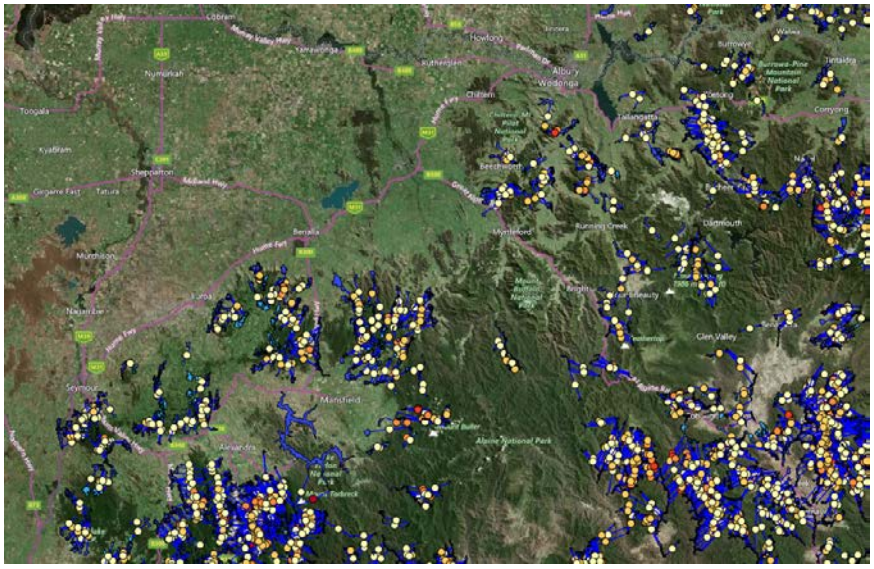
Like all new developments, further work on PHES opportunities will focus on the need for engagement and benefit sharing. The key next steps to further understand the region's PHES development potential are:

- Refine the location and number of high quality PHES sites.
- Investigate site specific characteristics including:
  - Land tenure.
  - Native resource management implications.
  - Hydraulic modelling.
  - Grid connection options.
  - Geological modelling.
- Shortlist priority sites through economic modelling and a determination of state wide renewable energy storage requirements.

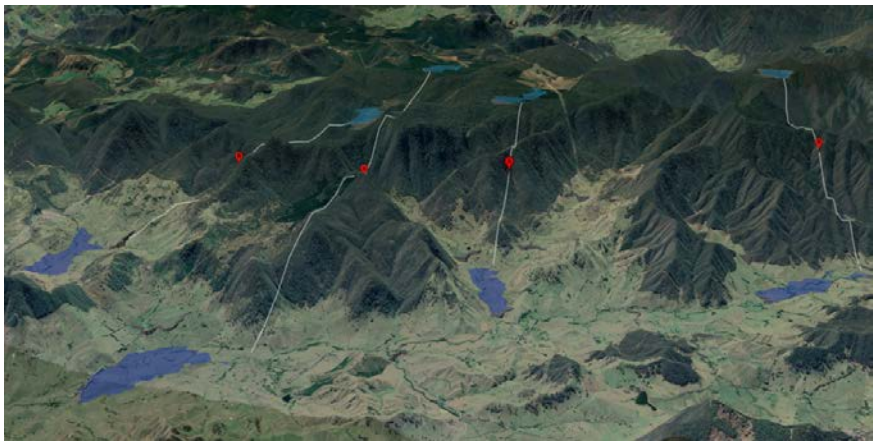
Once these processes have been undertaken, community and landholder consultation and market development activities can progress.

Pumped hydro energy storage developments are complex projects, and it is important potential developers:

- *Clearly identify and rank sites of development interest.*
- *Have early and continuing engagement with regulatory bodies including (Department of Environment Land Water and Planning, Catchment Management Authorities, Water Corporations and local government), well prior to any planning application.*



Map showing all the identified PHES potential development sites in Hume.



A cluster of high quality 15GWh PHES potential development sites. Here you can see the lower reservoirs in dark blue, paired upper reservoirs in light blue and the water conveyance (pipeline or tunnel) connecting the pairs of reservoirs.

Outside of the ANU study, other projects have examined smaller PHES opportunities in the region, often centering on adding value to existing water storage assets.

Euroa Environment Group and Mitchell Community Energy/BEAM Mitchell Environment Group have collectively explored two local small to medium scale PHES development opportunities. A potential project at Euroa could generate 2-4MW of power for 6-12 hours, and could store 25MWh, while another at Trawool could generate 6MW for 6-12 hours and store 36MWh.

CASE STUDY

Trawool

Trawool Reservoir is a decommissioned old town water supply dam, originally built in 1890s, in the south of the Hume region, near Seymour. The reservoir can hold ~100ML of water, and has a head height of ~260m to the Goulburn River below, which would act as the lower reservoir.

Trawool has the potential to store 36MWh of electricity with a power rating of 6MW. This is based on using half (50ML) of the reservoir's volume.

Bright future for large scale solar

Key drivers for the rise of large scale solar investment in Hume are:

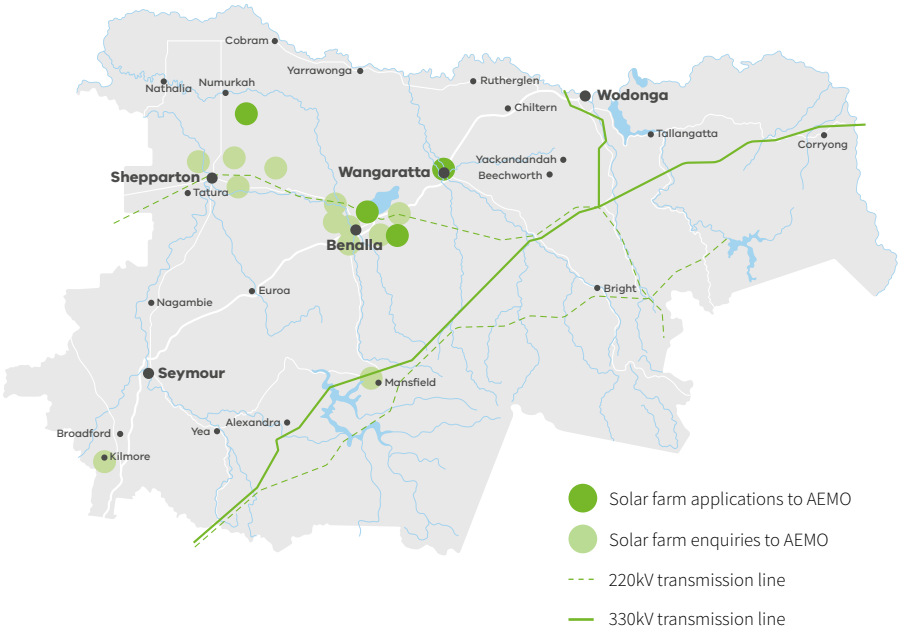
- Transmission infrastructure connection capacity.
- High quality solar resource.
- Regional electricity demand centres with increasing demand.

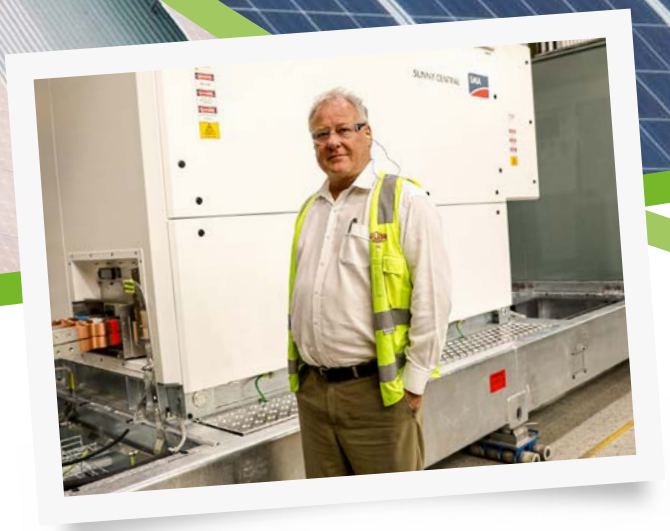
Other important considerations in large scale renewable energy developments include our regional values regarding strategically important agricultural land, regional amenity and local benefit.

Large scale solar has a place in Hume's renewable energy future, and is developing as our region's next renewable energy industry following Hume's existing hydroelectric generation industry.

There are already multiple large scale solar farms proposed in the region, with four connection applications for solar farms ranging in size from 22MW to 110MW, and at least 12 other solar farm connection enquiries registered by AEMO. The majority of proposals are in the municipalities of Shepparton, Moira, Benalla and Wangaratta.

Individual proposed developments range in size from under 100MW all the way to 500MW. Within Hume, and along the approximate route of the Shepparton to Wangaratta transmission power line corridor, current solar farm connection enquiries total over 2,700MW. Much of this development is being encouraged by the existing connection capacity of the transmission network, and anticipation about increased network capacity resulting from planned network upgrades.





◀ *Wilson Transformer Company in Wodonga are a local manufacturer of important renewable energy infrastructure*

Hume, and its two sub regions (the Goulburn Valley and the North East) have highly productive agricultural land, some of which is identified as strategically important agricultural land. This means the land has specific qualities not readily found elsewhere, or of a type or value in limited supply. The proposed locations of large scale solar farms need to carefully address the existing agricultural value of proposed sites.

The amenity, including visual impact, of solar farms also needs to be considered. This is particularly important in Hume, which is characterised by wide and relatively flat productive plains in the north near the Murray and Goulburn rivers, which run south and east to the northern slopes of the Great Dividing Range. The landscape amenity of the intersection of the productive plains and the northern slopes of the Great Dividing Range is relatively unique in Victoria.

Key considerations for development of large-scale solar PV farms in Hume:

- *Consideration of impact on strategic agricultural land*
- *Land scape amenity, areas of the region have important visual values to locals and visitors*
- *Benefit sharing with local communities*

Local social and economic outcomes from large scale renewables are an important value the community expect from large scale solar farms in Hume. The region expects local social and economic outcomes from developments, and there is appetite for benefits beyond short-term local employment and procurement.

Large scale developers looking to build solar farms along this corridor need to be aware of these key regional considerations and look to select appropriate sites and adopt appropriate development plans to account for them. The Solar Energy Facilities – Design and Development Guidelines released in July 2019 and to be implemented through the Victorian Planning Provisions, will help in this regard.

Taking these matters into consideration, large scale renewable energy generation development in Hume is achievable, affordable and will drive substantial economic benefits in the region.

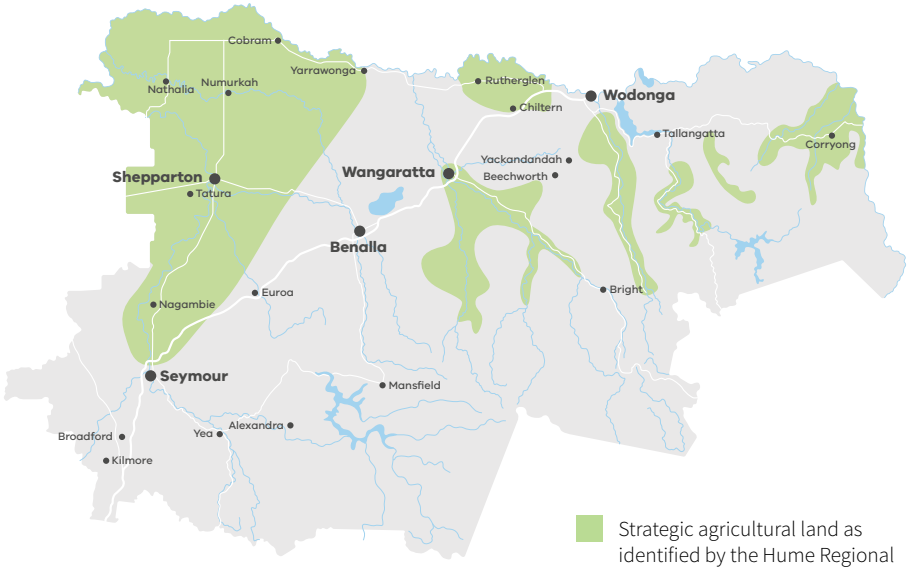
Community co-investment or co-ownership of developments should be explored, including examples in Victoria (Coonooer Bridge Wind Farm) and New South Wales (Sapphire Wind Farm) and possibly be emulated locally.

Strategic agricultural land

There are three areas of strategic agricultural land in Hume:

- Goulburn Murray Irrigation District (GMID) spans 27,000 km^2, and is particularly valuable, generating $5.9 billion worth of production annually. Irrigation infrastructure and existing regional industry in the GMID is sensitive to significant land use change. Solar developers active in the Greater Shepparton and Moira local government areas need to closely consider this.
- Rutherglen and surrounds.
- Alpine valleys south and east of Wangaratta and Wodonga.

Sustainable development of the renewable energy industry will need to factor in the strategic importance of this land through appropriate planning and regulatory frameworks such as the Solar Energy Facilities – Design and Development Guidelines to be finalised in 2019.



Strategic agricultural land as identified by the Hume Regional Growth Plan 2014

Large scale solar farms require between 200ha to 1500ha of land – the equivalent of at least 100 football fields.

▼ *Launch of Winton solar farm*

CASE STUDY

Winton solar farm

The FRV Winton solar farm is a $150 million development across 250 hectares and, when completed, will have a capacity of 98.8MW, producing enough energy to supply approximately 50,000 homes. This will avoid annual emissions of around 150,000 tonnes of CO2. At the time of this Roadmap's publication, construction was yet to commence on this solar farm.

The Winton solar farm was successful under the Victorian Renewable Energy Auction Scheme (VREAS) which was established to support achievement of Victoria's renewable energy target of 25 percent of Victoria's electricity generation being sourced from renewables by 2020.

As part of the auction scheme, proponents were required to submit community engagement and benefit sharing plans. The plans submitted for the Winton solar farm include support for the Benalla Sustainable Futures Group, Regent Honeyeater volunteers, Goulburn Ovens TAFE traineeships and provision of visual buffers and other support for adjoining landholders.

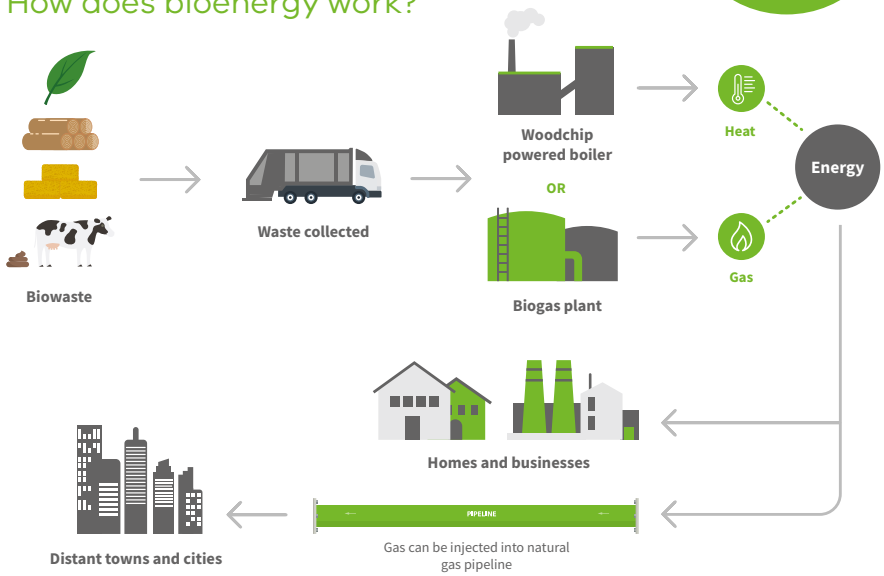
Bioenergy future opportunities

Bioenergy can provide valuable firming and other services to support solar and wind power. Firming means adding energy supply that can be relied on at particular times, to support generation that varies depending on its energy sources (sun and wind).

Hume is ranked third highest for availability of biomass residue generation in Victoria. The region generates 16 percent of Victoria's organic wastes, which is equal to more than 1.5 million tonnes each year[8].

Across our region, agricultural wastes such as straw and forestry wastes such as softwood plantation residues are the major organic/biomass resource that could power a local bioenergy industry. These resources could supply 18 million GJ per year. Forestry wastes are concentrated in the south and north east of the region, and agricultural wastes are predominantly in the Goulburn Valley.

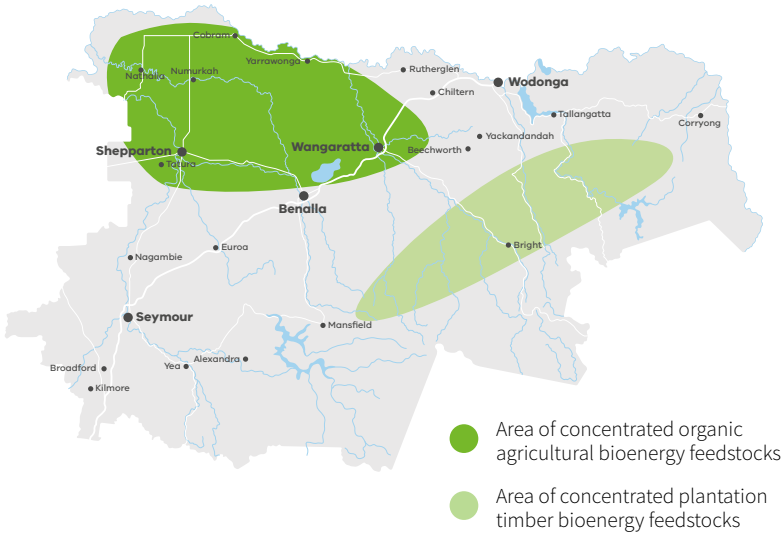
How does bioenergy work?



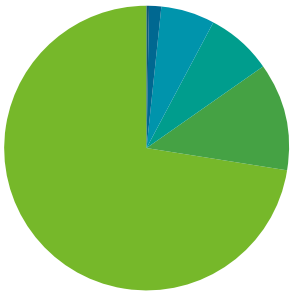
The region has power and gas dependent industries whose energy needs could be met by bio-gas or thermal biomass produced by bioenergy plants. There is also a good quality reticulated gas network which bodes well for bio-methane injection into the existing gas network.

The Victorian Organics Recovery Strategy emphasises the importance of co-location of bioenergy facilities with biomass feedstocks, because feedstock transport costs are an integral factor in bioenergy plants. For this reason, bioenergy can fit well into a distributed energy future.

Bioenergy feedstocks in the Hume



Composition of Hume's biomass feedstocks



0.03% Municipal solid waste	7.44% Forestry - plantations
0.46% Construction & demolition	12.40% Forestry - sawmills
1.25% Commercial and industrial manufacturing	72.24% Primary production
6.18% Commercial and industrial other	

8. *Data from Australian Biomass for Bioenergy Assessment project.*

Emerging technologies

Other renewable energy technologies also hold promise for Hume's renewable energy future. The technologies covered in this section are still emerging in Australia in terms of their commercial viability.

Green Hydrogen

Hydrogen produced from the electrolysis of water using renewable electricity can play an important role in our renewable energy future. In its National Hydrogen Roadmap of 2018, the CSIRO identifies big picture ideas of exporting liquid hydrogen to Asia, and the important role hydrogen can play as a transport fuel.

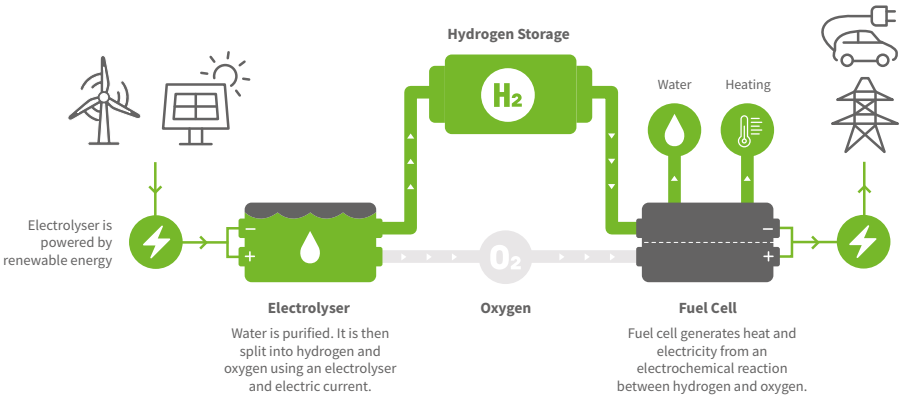
The two prerequisites for green hydrogen production are renewable electricity and water, both of which are accessible in Hume. Hydrogen can be produced by several processes, but the electrolysis of water using renewable electricity is the lowest carbon intensive.

According to the June 2019 report "The Future of Hydrogen" by the International Energy Agency 9 litres of fresh water are required to produce 1 kilogram of hydrogen, producing 8 kilograms of oxygen as a byproduct – so water supply would be a consideration to manage.

Green hydrogen can be used to store energy in time of abundant supply, to complement or 'firm' supply from wind, solar and other renewables.

Like biogas production, hydrogen production in Hume could also take advantage of the region's reticulated gas network. Hydrogen can be blended into existing gas network at 10 percent without pipeline or consumer change requirements[9].

How does green hydrogen work?



9. *Australian Energy Market Operator 2019 Victorian Gas Planning Report.*

Transport and hydrogen

Hydrogen can also be used as a transport fuel, in fuel-cell vehicles (1 kilogram of hydrogen has the same energy content as 3.2 kilograms (equivalent to about 4.3 litres) of petrol)[10].

Hydrogen has weight advantages over chemical batteries, especially for electric heavy transport vehicles.

Hume has three of Australia's most significant freight corridors running through it, and intra-regional freight movements are also very high. We have two substantial inland freight centres – Goulburn Valley and the future GV Link (located in and around Shepparton), and Logic Centre, co-located with the twin cities of Albury Wodonga – and 25 percent of Victoria's truck registrations are in the Shepparton area. The planning and future development of GV Link is a clear signal of the current and growing importance of inland freight though Hume.

Due to growth in population and consumption, freight is forecast to grow for Melbourne by 100 percent by 2030. Inter and intra-regional freight movements in regional Victoria, which increased by 180 percent from 1991 to 2007, are also projected to increase[11].

The Victorian Government's commitment to addressing climate change means our transport sector will also need to reduce its carbon intensity[12].

Hydrogen is future technology, and there are barriers to its uptake – including vehicle (heavy and passenger) cost, production cost and the development and availability of refueling infrastructure – which are beyond the scope of this Roadmap. The CSIRO projected that, by around 2025, hydrogen fueled vehicles could be at price parity with both internal combustion and battery electric vehicles.

Solar thermal

Solar thermal technology allows the thermal energy of the sun to be directly captured as heat, rather than converted to electricity as is the case with solar panels. This captured thermal energy can then be used in industrial processes where existing carbon based fuels are used.

Solar thermal is particularly good at providing both process heat and steam, along with lower grade heat for ancillary purposes such as cleaning.

Due to the cost and scale of solar thermal plants, deployment of this technology is not widespread, and currently there is only one Australian facility, in South Australia. It is not a new technology, as flat plate solar or evacuated tubes have been providing low cost renewable hot water for decades in Australian homes, but industrial scale solar thermal is untested in Victoria.

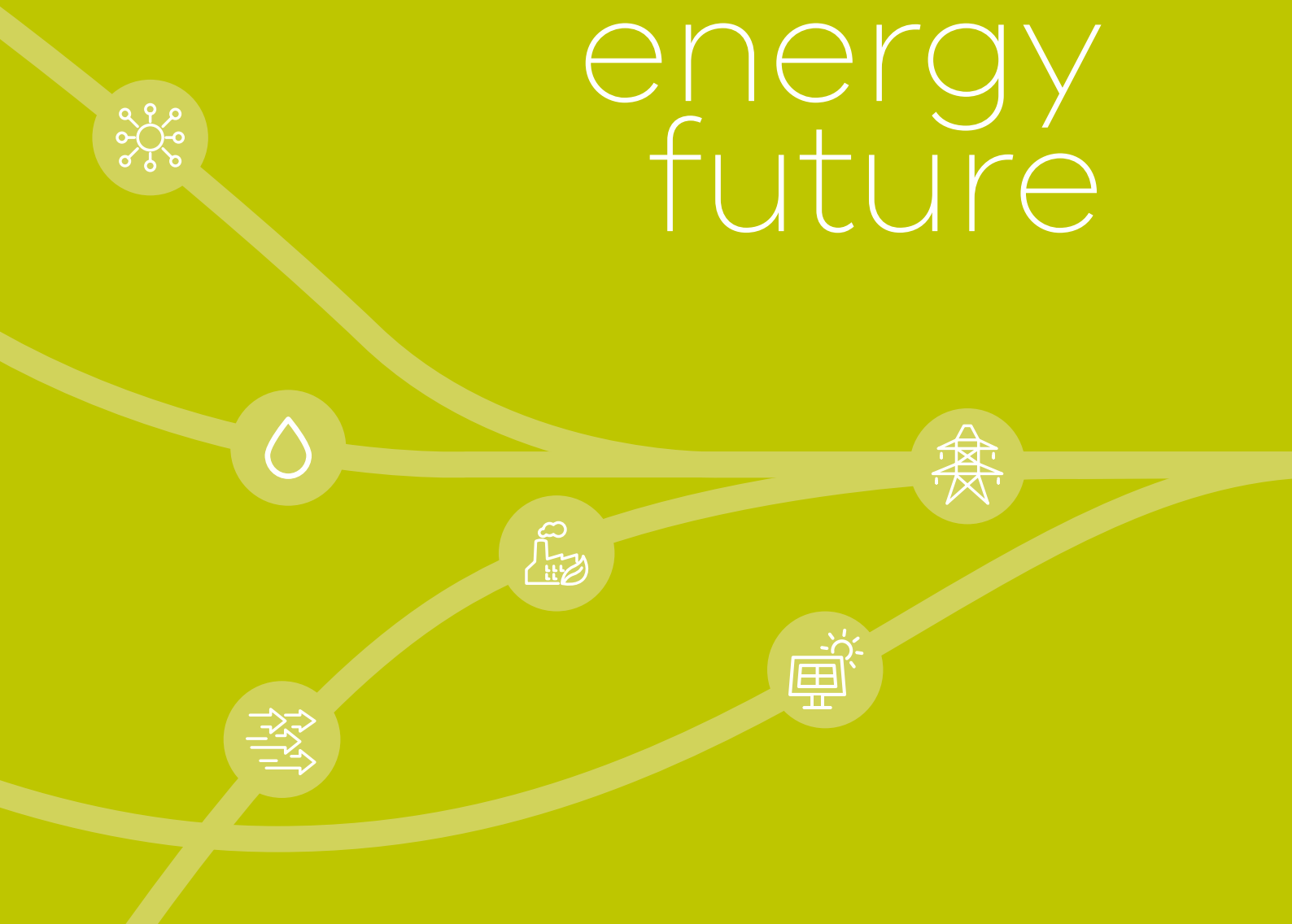
Existing industry in the Hume region has high thermal energy needs, along with electricity needs. Shepparton and Tatura, along with other food processing hubs like Cobram, Strathmerton, Wodonga and Wahgunah, all have existing industry which requires thermal energy.

The clustering of food processing industries in the Hume region provides the potential for co-ownership of solar thermal plants to supply local thermal energy requirements. Industrial ecology is often a term used to describe the mutually beneficial co-location of industry.

Further work is needed to better understand where and when industrial scale solar thermal could fit in Hume's renewable energy future.

10. *US Department of Energy*
11. *Victorian Freight Future Report 2008.*
12. *Victorian 2018 report Delivering the Goods.*

Keep it going ... next steps to a renewable energy future



Electrical transmission infrastructure

- Continue to monitor and understand changes to electricity transmission and distribution infrastructure, noting that many of these changes are likely to be outside of our region.
- Where opportunities emerge, such as increased renewable energy generator capacity, be ready with a plan to manage impacts and maximise local benefits.

Distributed energy resources (DER)

- Community energy groups and their industry partners and local government supporters are continuing to drive the evolution of regional DER resources.
- The potential value DER can bring to energy consumers is large and warrants continued support.

Pumped hydro energy storage (PHES)

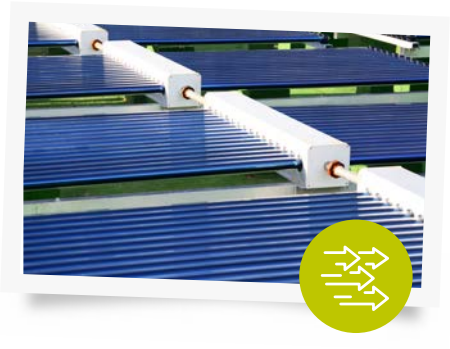
- There is potentially an exciting and large pumped hydro energy storage (PHES) opportunity in our region, but at this stage it is just that, a potential opportunity.
- Further work is needed to educate the community about PHES, and undertake investigations to understand constraints and develop a more detailed picture of the ‘best bet’ opportunities.

Large scale solar

- There is currently a place for large scale solar generation in the region, and the signs are pointing to that opportunity continuing.
- The release of the Solar Energy Facilities – Design and Development Guidelines will provide guidance on these large scale renewable energy facilities.
- Clustering of large-scale solar farms around available grid connection areas is a growing trend in the region. Understanding how we manage this demand and possible local impacts is important.
- Maximising local economic and social benefits from large scale solar farms is an opportunity in front of us right now. We need to continue to encourage renewable energy developers to work with local communities and share the benefits of solar farms.
- Exploring community co-ownership or co-investment is a logical next step to the existing community benefit sharing plans of existing and planned large scale solar farms.

Bioenergy

- Tonnes of bioenergy feedstocks are available in Hume, along with electricity and gas dependent business and industry.
- Small scale bioenergy plants are already operational in our region, co-located with feedstocks.
- Development of distributed bioenergy facilities across Hume, to use these feedstocks, is an opportunity to be pursued in conjunction with industry.
- Larger scale bioenergy facilities may be possible in regional centres where there is a high enough density of feedstocks and economic transport solutions.
- Waste management and recycling regulations and the impact of bioenergy projects needs to be considered very carefully to minimise barriers to this emerging industry.



Emerging technologies

- It's important that we keep looking towards new and emerging technologies and continue to monitor these opportunities.
- Green hydrogen and solar thermal are emerging technologies in Australia, and our region could be a strategic fit for them. Our transport and manufacturing industries currently rely on fossil fuels and we need to find viable alternatives.
- Further work is required to investigate the feasibility of local technology pilots, as test cases for large scale development.
- Local industry, technology suppliers, renewable energy developers and government should look for opportunities to collaborate on better understanding how these technologies could be part of Hume's renewable energy future.

The Hume Renewable Roadmap Project was a project of the Goulburn and Ovens Murray Regional Partnerships.

For more information please visit:

www.energy.vic.gov.au/renewable-energy/victorias-renewable-energy-roadmap/hume-renewable-energy-roadmap