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MOREE SPECIAL ACTIVATION PRECINCT

Renewable Energy Report

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NSW DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT (DPIE) MOREE SAP

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1 INTRODUCTION

On 3 December 2019, the NSW Government declared Moree a Special Activation Precinct (SAP) investigation area, delivered by the $4.2 billion Snowy Hydro Legacy Fund.

With a renowned, Australia-wide reputation and heritage of agriculture and farming, this SAP places the Moree region as the highest productive grain region in the country, capitalising on existing road and air freight, and the future Inland Rail as well as the high levels of solar irradiation in Moree.

The Department of Planning, Industry and Environment (DPIE) in NSW is leading the master planning process of the SAP that will be informed by the Structure Plan and a number of Technical Studies conducted by various organisations. DPIE has engaged Arcadis Australia Pacific (Arcadis) to prepare a series of technical studies, including a Renewable Energy Plan (this report) for the Moree SAP, which focuses on the Renewable Energy component of the Master Plan.

Two Enquiry by Design (EbD) workshops were organised as part of the SAP master planning process. A Preliminary Ebd (PEbD) was held on the 14 and 15 September 2020 to develop three initial land use scenarios. Following an interdisciplinary assessment of the three scenarios, a Final EbD (FEbD) workshop was held between 17 and 20 November 2020 to study the interdisciplinary constraints of the three scenarios, to identify and develop a final/ preferred land use scenario, which will be reflected in the Structure Plan.

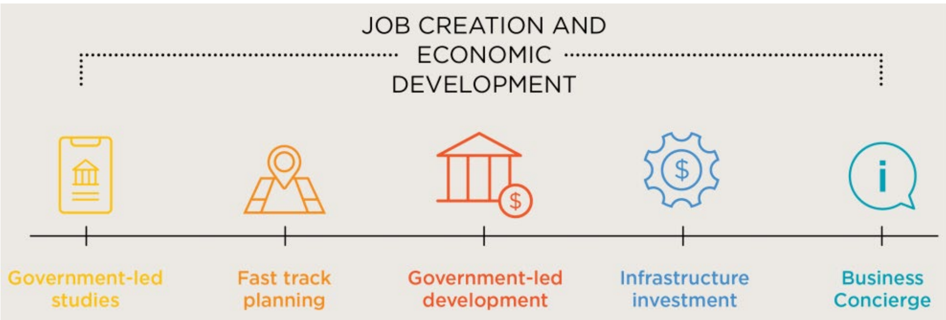
This report assesses the identified final land use scenario from the FEbD workshop from a Renewable Energy perspective.

1.1 Moree Special Activation Precinct

The establishment of Special Activation Precincts (SAPs) is a joint Government Agency initiative by the Department of Regional Growth NSW, DPIE and the Regional Growth NSW Development Corporation (RGDC) as part of the 20-Year Economic Vision for Regional NSW.

SAPs are a new way of planning and delivering infrastructure projects in strategic regional locations in NSW to 'activate' State or regionally significant economic development and jobs creation. They will be delivered as part of the $4.2 billion Snowy Hydro Legacy Fund.

Job creation and economic development through SAPs are underpinned by five core components (Figure 1).



Source: NSW Government,2019

Figure 1: SAP key elements

Table 1: SAP process

COMPONENT	DESCRIPTION
Government led studies	The Department of Planning, Industry and Environment conducts technical studies to inform the development of the Master Plan and to ensure land uses and development occurs in the right locations for each precinct. This up-front planning takes the burden away from investors wanting to grow or start up a business in the precincts.
Fast track planning	Once the Master Plan and other supporting planning instruments are endorsed, this will provide investors with streamlined planning and environmental approvals. This may include providing for land uses that suit complying development or approval exemptions.
Government led development	The Regional Growth NSW Development Corporation will lead and coordinate the delivery, through Delivery Plans according to the Master Plan for each precinct, that supports orderly development, sensitive to market drivers, landowners and infrastructure delivery.
Infrastructure Investment	Government will invest in new or upgrade roads, water, power, digital connectivity and social infrastructure for each precinct, removing barriers for investors to establish and grow.
Business Concierge	The Regional Growth NSW Development Corporation offers targeted business with concierge services to attract investment and support businesses to establish and grow in each precinct.

Source: NSW Government, 2019

Moree was chosen as it has a rich agricultural tradition dating back to the establishment of the initial pastoral land more than 150 years ago. There have been several step changes since, with the introduction of wheat, pecan nuts in the 1960s and cotton in the 1970s.

Moree is well placed in the freight network to be an intermodal freight hub as it is intersected by the Newell, Carnarvon and Gwydir Highways in addition to being located on the Inland Rail line.

The Moree SAP objectives include:

- Increasing the volume of freight mode shift to rail
- Enabling a broader cluster of freight and logistics-related activity
- Making Moree an attractive precinct for value-adding agribusiness
- Enabling businesses to establish on appropriate sites that would benefit from efficient access to freight and logistics networks
- Enabling businesses to establish that require access to a high quality and secure water supply
- Providing increased economic and enhanced social outcomes for the broader community with a focus on the local Indigenous population

The completion of Inland Rail, expected by 2025, has the potential to dramatically improve the efficiency of freight transport between Moree and key seaports, as well as large population centres (Figure 2). Moree is located on the Narrabri and North Star (N2NS) section and would provide more immediate freight savings.

Source: NSW Government, 2019

Figure 2: Moree transport connectivity

The presence of Inland Rail combined with the existing assets that Moree offers would enable for a more diverse range of industries to be established and for the national economy and Moree economy to be more productive and more resilient. Freight movements are primarily focused to the Port of Newcastle with other movements to Ports of Botany and Kembla.

Inland Rail would also enable access to the Port of Brisbane and other northern markets for bulk and containerised freight. The Moree SAP provides an innovative and effective program to capitalise on this potential.

The region is also blessed with one of the highest levels of solar irradiation in NSW, providing opportunities to maximise renewable energy generation in support of the SAP and future businesses, as part of the vision statement.

1.2 Vision statement and renewable energy aspirations

The vision for the Moree SAP is an evolving statement covering both vision and aspirations for the precinct.

The overall Moree SAP vision is as follows:

> With national and global connections, the Moree Special Activation Precinct enables diversification of Moree's proud agricultural economy by building on its strong connection to Country and sustainable water endowments and energy infrastructure. The Special Activation Precinct fosters world class opportunities to value-add, embrace new technologies and develop innovative and sustainable energy solutions.

The following aspirations have been recognised from a renewable energy perspective to ensure the success of the Moree SAP:

- Identify opportunities for renewable energy generation within the SAP (including new, extensions or intensification) and energy storage solutions to provide direct benefits to new businesses in the SAP and improve the reliability of supply.
- Capitalise on the high solar irradiation levels in Moree, and potential use of waste from the agriculture sector of the region for the purposes of energy generation.
- Encourage the use of innovative and renewable energy generation through solar, bioenergy and biogas opportunities.

- Identify opportunities where new or emerging technologies in the renewable energy sector have the ability to reduce congestion, improve reliability and achieve emissions reduction, and align these to the broader sustainability aspirations and outcomes for the SAP including achieving a Net Zero carbon target.
- Ensure renewable energy opportunities are aligned with the circular economy aspirations and outcomes for the SAP.
- Identify the opportunities for Green Hydrogen production (from Renewable Energy sources within the SAP), to provide alternative fuel for local transportation requirements, process gas and/or feedstock for local industries.

1.3 Report structure

The remainder of this report is structured as follows:

- **Strategic context**
  Outline of local, regional, and state-wide context of regulations and policies related to renewable energy and applicability for the Moree SAP.
- **Methodology**
  Description of the process used for undertaking the study, and list of stakeholders involved and information relied upon as part of the study.
- **Key findings and assessment**
  This includes the findings from the renewable energy baseline analysis which was undertaken, and assessment of the transmission network.
- **Constraints**
  Presentation and assessment of the broader transmission network with regards to connections of new large-scale renewable energy generation to the grid.
- **Renewable energy opportunities**
  List of opportunities identified and recommended to be pursued within and as part of the Moree SAP delivery phase.
- **Structure plan assessment**
  Review of the Structure Plan against the vision and aspirations of the Moree SAP from the context of renewable energy, assessment and comparison of the energy demand estimates from new businesses in the SAP, and of the energy generation estimates from new renewable energy sources in the SAP, and land-areas necessary to support the development of the opportunities.
- **Renewable energy assessment**
  Presentation of the renewable energy opportunities identified and recommended for development for the Moree SAP, types, size/scale, infrastructure constraints.
- **Delivery plan**
  Recommendations for the staged implementation of the identified renewable energy opportunities and upgrades of the transmission network.
- **Conclusions**
  Summary of recommendations for renewable energy within Moree SAP.

2 STRATEGIC CONTEXT

2.1 Planning framework

The new *State Environmental Planning Policy (Activation Precincts) 2020 (SEPP)*[1] under the *Environmental Planning and Assessment Act 1979* (NSW)[2] sets the planning framework through which SAPs will be delivered. The statutory component of the policy framework contains a Master Plan and Delivery Plan for each SAP and these documents are given statutory weight by the SEPP (Figure 3).

Figure 3: SEPP and SAP Plan inter-relationship (Source: NSW Government 2019)

2.2 NSW Renewable Energy Action Plan

The NSW *Renewable Energy Action Plan* supported the achievement of the national *Renewable Energy Target* of 20% renewable energy by 2020, and which has already been exceeded.

The Plan aimed to position NSW to increase the use of energy from renewable sources at least-cost to the energy customer and with maximum benefits to NSW.

NSW has excellent renewable energy resources, and particularly so in the Moree region being the highest irradiance levels compared to other locations in NSW. This was a key driver for the development of the existing Moree Solar Farm to the South of the investigation area.

The *Renewable Action Plan* and strategy is particularly relevant to the Moree SAP, and encompassed the need to work closely with NSW communities and the renewable energy industry to increase renewable energy generation in NSW, and it set the goals and actions to most efficiently grow renewable energy generation in NSW, including but not limited to:

- Attracting renewable energy investment and projects:
  - Improving the process of network connections
  - Considering a more strategic and integrated approach to assessment of renewable energy projects
  - Removing technology-specific barriers to investment
  - Create an information portal that provides information to investors

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[1] https://www.legislation.nsw.gov.au/view/html/inforce/current/epi-2020-0266

[2] https://www.legislation.nsw.gov.au/view/html/inforce/current/act-1979-203

  - Promoting and facilitating investment opportunities
  - Providing benchmark estimate ranges for a fair price for small-scale generated solar energy
  - Developing an information package for small-scale solar PV, solar hot water and wind generation
  - Supporting mid-scale solar PV to enable uptake of solar technologies
  - Engaging with Federal Government to facilitate construction of Solar Flagships Projects
- Building community support for renewable energy:
  - Implementing NSW energy planning guidelines
  - Engaging communities early and effectively in renewable energy projects
  - Facilitating community ownership of renewable energy projects
  - Promoting the benefits to consumers of switching to renewable energy.

2.3 United Nations Sustainable Development Goals

The United Nations *Sustainable Development Goals* (SDGs) are the blueprint to achieve a better and more sustainable future for all. There are 17 interconnected goals that intend to address challenges related to poverty, inequality, climate change, environmental degradation, peace and justice. These goals are shown in Figure 4.

Figure 4: UN Sustainability Development Goals

The Moree SAP will seek opportunities to align the Master Plan with these goals. The key goals that inform the Renewable Energy component of the Master Plan are:

GOAL 7: Affordable and Clean Energy

Goal 7 targets development of affordable clean energy, a critical component in a zero carbon objective, and essential in the growing a sustainable future. The Moree SAP will enable the use of existing resources, particularly the solar and biomass opportunities, to be realised.

GOAL 8: Decent work and economic growth

Goal 8 targets development of productive activities, job creation, entrepreneurship, creativity and innovation. Moree SAP will enable jobs generation in the renewable energy sector, focused on providing a platform for education and research and development for the Moree Plains Shire by teaming with technology developers.

GOAL 9: Industry, Innovation and Infrastructure

Goal 9 promotes development of “quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being”. Moree SAP will invigorate the industry in Moree as well as the wider region while supporting innovation and greater infrastructure resilience.

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

This goal highlights the importance of energy in sustainable and resilient cities. It aims to provide access to safe, affordable, accessible, and sustainable renewable energy sources including reducing transmission losses by providing energy close to where it is being consumed.

Goal 12 (Responsible Consumption and Production) and Goal 13 (Climate Action) are also related and are collectively addressed in the Sustainability Report, by others.

2.4 Targets for UN Goal 7: Affordable and Clean Energy

Energy is the dominant contributor to climate change, accounting for around 60 per cent of total global greenhouse gas emissions.

This goal has four targets, as listed below:

- 7.1 - By 2030, ensure universal access to affordable, reliable and modern energy services.
- 7.2 - By 2030, increase substantially the share of renewable energy in the global energy mix.
- 7.3 - By 2030, double the global rate of improvement in energy efficiency.
- 7.A - By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.

The renewable energy study for the Moree SAP aims to ensure that Goal 7 and its listed targets are focused considerations in the assessment of renewable energy opportunities in support of the Moree SAP.

2.5 Other relevant NSW Government policies

The NSW Government’s *Climate Change Policy Framework*[3] sets a target to zero net emissions by 2050. The Moree SAP has a high potential of achieving this, due to the abundance of solar energy resource in the precinct. There are also investments

[3] https://www.environment.nsw.gov.au/research-and-publications/publications-search/nsw-climate-change-policy-framework

already made in the region/ SAP with the establishment of the existing 56 megawatt (MW) Moree Solar Farm (MSF) that has been in operation since 2016.

Whether the existing Moree Solar Farm is considered in the context of the Net Zero carbon target, additional renewable energy generation opportunities identified as part of this study can undoubtedly achieve this target for the Moree SAP if sufficient land-area is allocated and set aside in the final Structure Plan as recommended in this report, for future development of new solar farms/extensions of the existing MSF.

The *NSW State Infrastructure Strategy 2018-2038*[4] has also identified energy as a key consideration for businesses and the cost of delivered energy has a direct impact on the viability of some businesses in the regional centres, and also to their competitiveness in general. Undoubtedly, reduction in energy costs within the region will help existing and new business to achieve faster growth and be more competitive.

The NSW *Clean Energy Strategy Guide for Businesses*[5] encourages businesses to source energy from renewable sources which could include:

- either procurement from off-site generators or renewable energy retailers in the form of Power Purchase Agreements (PPAs); or
- investing in on-site renewable energy generation technology which suits the businesses to reduce their energy demand from the grid or from conventional fossil fuelled or non-renewable energy sources.

The *NSW Electricity Strategy*[6] supports the development of new electricity generators to deliver reliable electricity at the lowest price while protecting the environment, reducing barriers for entry for new generators, reductions in emissions, coordinated delivery of renewable energy zones (REZs), and access to project funding through the Emerging Energy program. The strategy aims to achieve reliable, affordable and sustainable electricity systems for NSW that support economic growth by reducing electricity costs, and additions of new renewable energy generation to replace ageing coal power stations. The strategy encourages an estimated $8 billion of new private investment in NSW's electricity system over the next decade, including $5.6 billion in regional NSW.

Furthermore, the strategy aligns closely with the NSW Government's *Net Zero Plan Stage 1: 2020 – 2030*[7] which sets NSW's goal to reach net zero emissions by 2050, and outlines the Government's plan to grow the economy, create jobs and reduce emissions over the next decade. The Moree SAP vision aligns closely with this strategy and plan.

Renewable energy certainly has the potential to underpin development opportunities in the Moree SAP. The solar irradiation levels at Moree are the highest in NSW and Moree's thriving agricultural sector provides opportunities for additional solar power and new bioenergy generation from agricultural waste. This report presents a list of potential renewable energy generation options which were considered in the various studies.

Final development of the renewable energy solutions for the Moree SAP will need to take into consideration many factors including project economics, likely energy yield, reliability of feedstock from the agricultural sector, energy demand within the SAP, energy off-take arrangements, funding support from the RGDC, land availability and value, technical matters (including viability of connection to the grid), public perception, and a detailed commercial and technical risk assessment of each option.

The constraints within the existing transmission and distribution infrastructure will also be a key consideration in the final development of the renewable energy opportunities

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4 http://www.infrastructure.nsw.gov.au/expert-advice/state-infrastructure-strategy/

5 https://energy.nsw.gov.au/sites/default/files/2018-09/ATT%20A%20NSW%20Clean%20Energy%20Strategy%20Guide%20for%20Businesses.pdf

6 https://energy.nsw.gov.au/government-and-regulation/electricity-strategy

7 https://www.environment.nsw.gov.au/topics/climate-change/net-zero-plan

identified in this report, and the upgrades as recommended in this report would be an enabler to allow additional renewable energy sources to supply businesses in the SAP. The staging and funding of these works (whether by the Transmission Network Operator or partially funded from the Snowy Hydro Legacy Fund which is looked after by the Department of Regional NSW and funding allocations managed by the RGDC) are key considerations.

2.6 Corporate Power Purchase Agreements (PPAs)

The NSW Government's *Guide to Corporate Power Purchase Agreement (2018)*[8] provides assistance for Australian businesses to purchase renewable energy using this mechanism.

The Clean Energy Council (CEC) reported that corporate PPAs increased from 6.1 gigawatts (GW) purchased in 2017 to 13 GW in 2018. In Australia, 20 corporate PPAs were signed in 2018, contracting for a total of 931 MW and supporting projects with a total capacity of 2,600 MW. The key drivers for buyers were improving price certainty in volatile markets, the potential for energy cost savings, sustainability or renewable energy targets and improving their brand or social licence.

Corporate PPAs have now been signed in a wide range of sectors – led by manufacturing, local councils, universities, utilities and state governments for their own operations or infrastructure projects. Victoria is currently the leading state, with just under half of the new capacity from corporate PPAs, followed closely by NSW.

A scheme was set up by the NSW *Southern Sydney Regional Organisation of Councils (SSROC)* to facilitate the purchase of power in bulk under a group PPA with Origin, to source energy from the Moree Solar Farm, to supply power to 20 Sydney local councils in a new renewable energy agreement that will meet up to 35 per cent of their demand, which commenced from July 2019. The PPAs help the participating local councils to take advantage of the falling cost of renewables, to achieve significant cost savings and reduce their carbon emissions.

Indeed, group or corporate PPAs could be a key consideration for the ability for new businesses in the Moree SAP to access cheaper electricity prices through the bulk purchase of it from e.g. the extension of the Moree Solar Farm or from other new renewable energy generators in the precinct, through a Special Purpose Vehicle (which could incorporate the RGDC, Moree Plains Shire Council and/or private investors of embedded networks) to permit the purchase of energy in bulk under a PPA to underpin the investments in new renewable energy generation, for retail sale to the participating businesses in the Moree SAP.

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[8] https://www.energetics.com.au/media/1825/wwf1452-updated-nav-corp-ppas-web-21.pdf

3 METHODOLOGY

3.1 Overview

The methodology adopted for the assessment of the Structure Plan included the undertaking of a series of renewable energy studies conducted over the Moree SAP investigation area and reports prepared (including the Renewable Energy Baseline Analysis Report and Renewable Energy Scenario Testing Report) and was guided by the Enquiry by Design (EbD) process – a planning tool used to allow for key stakeholders to collaborate on the development of a vision for the Moree SAP.

3.2 Project timeline

Figure 5 shows the timeline of the Moree SAP project from commencement to forecast completion of the Final Master Plan.

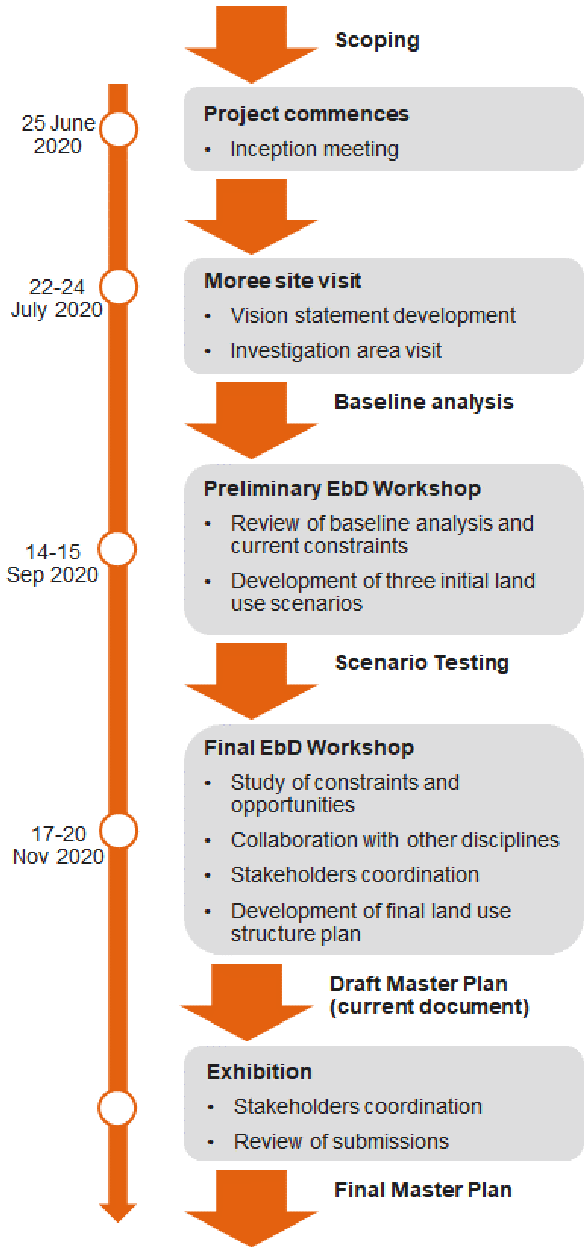

Figure 5: Methodology and timeline

3.3 Enquiry by Design Workshops

The following two EbD workshops were held:

- Preliminary EbD workshop – 14 and 15 September 2020 - to develop three initial land use scenarios, which would then be further developed in an interdisciplinary assessment.
- Final EbD workshop – 17 to 20 November 2020 - to study the interdisciplinary constraints and opportunities of each scenario and develop a final land use structure plan based on the assessment.

The participants and stakeholders in the Final EbD workshop included:

- Department of Planning Industry and Environment
- Regional Growth NSW Development Corporation
- Moree Plains Shire Council (MPSC)
- Department of Regional NSW
- Moree Local Aboriginal Land Council
- NSW Environment Protection Authority
- State agencies (including Transport for NSW)
- Australian Rail Track Operation (ARTC); and
- Various consultants and subject matter experts – covering engineering, environmental, economics, Indigenous and other matters.

During the EbD workshops, inter-disciplinary participants and subject-matter-experts worked collaboratively with all stakeholders, to present results of respective analyses, to provide input, to constructively debate ideas and options, to critique and challenge thinking, and to discuss the advantages and disadvantages of the various scenarios considered.

Interdisciplinary elements were recognised and incorporated to create robust, evidence-based reporting, as well as to challenge the status quo and to promote innovative and flexible ideas to challenging issues facing the SAP.

Overall, the streamlined approach to Master Planning enabled the contributions from all participants to be duly considered and resulted in the recommendation of a robust Structure Plan that embodies all of the inputs, considerations, constraints, suggestions and requirements from all respective parties.

The outcome of the FEbD is a Structure Plan that is well aligned with the Moree SAP vision and aspirations.

Of particular note, the outcomes from the discussions during the FEbD which are reflected in the Structure Plan include:

- Identification of a suitable location and orientation for the proposed Inter-Modal Terminal
- Long-term rail line relocation and routing, within the broader transport network
- Measures to protect biodiversity and heritage artifacts including preservation of the Travelling Stock Route (TSR)
- Determination of water volumes and sourcing to satisfy the increased demands from the SAP, including certainty regarding water availability to meet first movers into the SAP
- Measures to create early employment opportunities and priorities to create jobs for locals including Indigenous workers

- Staged land use development strategy to take advantage of existing infrastructure
- Allocation of sufficiently large land areas for new solar farms in the SAP to achieve a net zero outcome
- Proposed servicing and new supporting infrastructure development strategy for the SAP.

The outcomes of the various Renewable Energy studies which were undertaken by Arcadis, and the analyses of the strengths, weaknesses, opportunities, and constraints of the respective options that were identified and examined, were tendered during the EbD workshops. The renewable energy studies supported the Sustainability, Environmental, Water and economic assessments of the SAP investigation area, and active discussions were held around:

- Recommendations for the minimum land areas to be set aside for new solar farms in order to achieve the net zero target.
- Recommendations for the introduction of mandatory installations of roof-top solar photovoltaic (PV) systems as a potential planning/ development requirement for new commercial and industrial businesses in the SAP.
- Estimates of the energy demand/ consumptions of the new businesses in the SAP (based on initial and revised land area allotments and integrating outcomes of the CIE market sounding study).
- Estimates of energy production from all potential renewable sources in the SAP, including solar farms, roof-top solar, bio-energy, and energy-from-waste opportunities.
- Recommendations for the location of the proposed new solar farm(s), and constraints to be considered – e.g. avoidance of new solar farms directly adjacent to the Moree Regional Airport, and preferential location for the land parcels immediately to the south of the proposed Inter-Modal Terminal, and to the west of the existing Moree Solar Farm.
- Recommendations for the locations of potential bio-energy plants, adjacent to business precincts which are likely to require heat, gas and/or energy directly from new bio-energy facilities.
- Recommendations for the location of waste-recovery facilities (to process agricultural waste or similar, for use as combustible feed stock) adjacent to new bio-energy facilities.
- Estimates of electrical energy and water consumption for the purposes of green hydrogen production in the SAP.
- Examination of the transmission system capacity and constraints and recommended augmentation works to support the increased load demand of the SAP.
- Recommended staging of new energy-infrastructure to support the development of the SAP (including new substations, transmission lines.

Ultimately, the analysis, findings and recommendations in this report supports and defends the outcomes in the Structure Plan and Master Plan and the overarching development pathway which seeks to rezone land within the SAP (particularly for new solar farms, hydrogen production and bio-energy use) and to modify the planning pathways to allow the majority of new developments to be undertaken as exempt or complying developments.

3.4 Information relied upon

In undertaking the renewable energy studies, various information from key agencies and sources were relied upon, including:

- Information provided by MPSC on the waste volumes and types currently processed at the existing waste handling facility, and from information provided during the site visit to the facility and in the inception meeting on volumes and types of waste and its current usage, from the agricultural sector.
- Information published by the owners and operators of the Moree Solar Farm (Fotowatio Renewable Ventures, or FRV) and from additional information gathered during the site visit to the facility – including plant ratings and energy production levels, offtake arrangements and power purchase agreements, initial and possible future expansion plans.
- Information published by the Transmission Network Service Provider (TransGrid) in its Transmission Annual Planning Report(s) – showing bulk supply substation loads and forecasts, transmission line ratings and utilisation levels, proposed network augmentation works and overview of connections of new renewable energy generation facilities to the grid, and from information visually verified during the site visit.
- Information published by the Distribution Network Service Provider (Essential Energy) in its Distribution Annual Planning Report(s) – showing zone substation locations, loads and forecasts, sub-transmission line ratings and utilisation, and spatial information on distribution network assets.
- Information available from the AREMI website (a spatial data platform for the Australian energy industry that is funded by ARENA and developed by Data61 in partnership with Geoscience Australia and the Clean Energy Council) showing various information relevant to the assessment of renewable energy generation in the region, including solar irradiation levels, spatial information on transmission assets.
- Information published by the Australian Energy Market Operator (AEMO) in its website showing proposed new renewable energy projects, and in its 2020 Integrated System Plan (ISP) which outlined the augmentation works to support increased connections of renewable generation sources to the National Electricity Grid.
- Information published by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) on the National Hydrogen Roadmap for Australia.
- Information obtained from various academic sources on the potential for processing of cotton stalks from the cotton industry for energy production, and on other waste streams from the agricultural sector in general.
- Information provided from the market sounding exercise to gauge the level of interest from new businesses to locate and establish in the Moree SAP.
- Information published from the Energy Information Administration (EIA) on typical energy demands of various types of businesses and industries.
- Other relevant information readily available from various sources in the public domain.

Information relied upon are referenced as noted in the latter sections of the report.

4 KEY FINDINGS AND ASSESSMENT

The following reflects the findings from the Renewable Energy Baseline study, which assessed the current renewable energy generation facilities in Moree and the surrounding area, and the potential opportunities for new renewable energy generation for the SAP.

4.1 Existing renewable energy generation facilities

4.1.1 Large scale solar farm

The existing 56 MW Moree Solar Farm (Figure 6) located at the southern end of the Moree SAP investigation area is currently the only grid-scale renewable energy generation source located in the immediate Moree SAP area. It is connected to TransGrid's Moree 132/66 kV bulk supply substation via a single radial 66 kV feeder, which is rated for 70 megavolt amperes (MVA). The facility was developed for a total project cost of $200.8 million and has been in service since 2016.

Figure 6: Moree Solar Farm (source FRV)

The Moree Solar Farm uses solar photovoltaic-polycrystalline modules and a single-axis horizontal tracking system which allows the modules to follow the sun to maximise power output, and had attracted $101.7 million of funding from an ARENA grant and debt on commercial terms from the Clean Energy Finance Corporation when it was developed and constructed in 2013.

Some statistics about the Moree Solar Farm is shown in Table 2.

Table 2: Moree Solar Farm statistics

Element	Statistic
Nominal rating	56 MWac
Peak power rating	70 MWdc
Size and number of panels	222,880 x 315W JA-Solar panels
Rating and number of inverters	56 x 1000 MVA Ingeteam inverters
Tracking system	Mechanical, single axis NEXTracker
Annual energy production	210,000 MWh/year

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Element	Statistic
CO_2 avoided	150,000 tonnes/year
Households supplied	24,000 homes
Land area	306 hectares
Water savings (c.f. coal power station)	165,000 megalitres

Source: http://moreesolarfarm.com.au/about-us/

A long-term 15-year energy off-take agreement/ PPA is currently in place with Origin Energy for 100 per cent of the energy produced from the Moree Solar Farm when it was commissioned in 2016, for retail sales to its customers.

The energy produced from the Moree Solar Farm does not presently provide the energy needs for the Moree SAP, Moree residents or businesses **directly**, unless the energy is purchased through Origin Energy through a retail supply contract.

The estimated energy delivered via the Moree 66/22 kV zone substation of 104,850 MWh to the Moree SAP investigation area is **about 50 per cent** of the total 210,000 MWh of energy produced by the 56 MW Moree Solar Farm located within the Moree SAP.

According to its website [9] , Origin will supply solar power to 20 Sydney local councils in a new renewable energy agreement that will meet up to 35 per cent of their demand. In a group PPA led by the *Southern Sydney Regional Organisation of Councils* (SSROC), the participating councils will be supplied with solar power from the 56 MW Moree Solar Farm from 1 July 2019 with around 39,000 MWh of renewable energy (or 18.5 per cent of its total energy generated) from the Moree Solar Farm until the end of 2030. The balance of their electricity needs will be supplied as regular grid electricity to 2022.

The PPAs help the participating local councils to take advantage of the falling cost of renewables, to achieve significant cost savings and reduce their carbon emissions.

The 20 participating local councils are Bayside, Campbelltown, Canada Bay, Canterbury-Bankstown, Georges River, Hunters Hill, Inner West, Ku-Ring Gai, Lane Cove, Liverpool, Mosman, North Sydney, Parramatta, Randwick, Ryde, Singleton, Sutherland Shire, Waverley, Willoughby and Woollahra. **Moree Plains Shire Council is not a participant in the renewable energy program with Origin**.

It is understood that the Moree Solar Farm was originally planned to be developed over a larger land area (about 1,200 hectares) but was scaled back from its original development footprint due to various reasons including project economics, transmission connection capacity and changes to the transmission system losses (Marginal Loss Factors [MLF]) at the time of project development. From information disclosed by FRV to ARENA as part of the project's lessons-learned publication[10]:

- The project was conceptualised as a much larger (150 MWac) facility, prior to finally selecting the "optimal size" of 56 MWac.
- It did not specifically state that there were any environmental constraints that limited the project size, and states instead "the land is highly suitable for PV installations: it is flat and mostly cleared of vegetation, providing a relatively smooth planning consent process and mitigating [the need for] environmental offsetting".
- The original 150 MW project size was selected to meet the specific requirement of the Solar Flagships Program, which required a minimum project size of 150 MW. At the time of Solar Flagships, various State governments were also offering funding support to projects participating in the Solar Flagships program. NSW in

[9] https://www.originenergy.com.au/blog/delivering-renewable-energy-direct-to-nsw-councils/
[10] https://arena.gov.au/assets/2017/05/MSF-Lessons-Learned-FINAL.pdf

particular indicated support for projects of 150 MW within NSW and decreased support for smaller projects. This pushed the original project development leader to propose the 150 MW project size.

- One of the most important parts of the early development stages of the project was to choose the “ideal project size” given the location and the point of connection. The objective was to ensure that electrical losses within the electricity network were balanced against having a project size with “attractive economies of scale”.
- The MLF had a direct impact on the energy that the solar farm was able to sell in the National Electricity Market (NEM) and therefore influenced the project’s revenues and studies conducted concluded that the “optimal size” of the PV plant should be 56 MWac. The loss factors were such that they provided “significant commercial pressures” on the project economics for the initial 150 MW size.

It was understood from discussions during the site visit, that the owners of the Moree Solar Farm (Fotowatio Renewable Ventures or FRV), are still considering the possible expansion of the Moree Solar facility towards the west of the current development footprint, subject to further considerations that include the assessment of transmission network constraints/ upgrade and viability of securing a higher capacity transmission line and grid interconnection, PPAs for off-take agreements with interested parties which could include the RDGC (set up as a Special Purpose Vehicle or SPV to supply and deliver the energy to the Moree SAP), proponents looking to secure renewable energy for green hydrogen production, and/or other large consumers of power or energy retailers. However, no formal application to expand the existing facility is understood to be in place.

New or additional solar farms would certainly be a key opportunity that must be pursued for the Moree SAP, to offset the energy demand from the new businesses and industries, and to achieve a net zero target. Hence, it is critical to ensure that sufficient land-area as shown in the Structure Plan is allocated for this purpose.

4.1.2 Smaller scale solar installations

During the site visit, it was observed that there were several installations of roof top solar systems on various premises, including residential, commercial and industrial buildings and facilities outside of the Moree SAP investigation area.

It is understood that MPSC had installed solar panels at the Moree Artesian Aquatic Centre (MAAC) to help reduce the facility’s operating costs that is anticipated to result in tens of thousands of dollars in savings. MPSC had approved the installation of a 180 kW total solar energy system.

Figure 7: Moree Artesian Aquatic Centre

In general, the uptake of solar PV installations in Moree however, was observed to be **low**, compared to other regional centres and postcodes in Australia. Despite the high solar irradiance levels in Moree, roof top solar installations were more of an exception rather than the norm. This presents opportunities to increase the level of roof top solar installation on new commercial and industrial premises in the SAP, and should be a key consideration for incorporating this as a planning or development requirement for all new facilities and premises in the SAP in future, as was discussed during the FEbD. As most roof-top installations would typically have demonstrable economic payback by offsetting the energy consumption of the premises, it is not anticipated that the impact would be a limitation for prospective new businesses.

An observation made during the site visit is that almost exclusively, there were no visible solar PV installations on the many grain bulk-storage and handling facilities in the Moree SAP investigation area despite having large roof spaces and ground areas. This provides opportunities to reduce the energy consumed by each facility through the installation of new 'inside the fence' renewable energy generation sources using solar PV, or through the aggregation of renewable energy generated from various distributed solar PV installations on suitable premises not currently fitted with solar PV, and managed using a Virtual Power Plant (VPP) model as explained later in the report.

Figure 8: Typical grain storage and handling facility in Moree

4.1.3 Energy from waste

There are no operational energy-from-waste facilities currently in the Moree SAP.

The current waste from residents, industry and commercial operations which are directed to the Moree Waste Management Facility are sorted and removed for recycling or disposal by other commercial facilities outside of the Moree SAP or otherwise directed to landfill. Volumes of respective waste streams (from both construction and demolition as well as Municipal sources) are as listed in Table 3[11]:

Table 3: Waste processed at the MPSC Waste Management Facility

Type of waste	Volumes (tonnes per annum)
Mixed waste	5,473
Vegetation or garden	2,259
Wood, trees or timber	318
Rubber tyres	8

Green waste removed during the waste sorting process is stockpiled and/ or turned to mulch or composted on site (257 tonnes per year) but is otherwise not used for other purposes.

[11] Information from MPSC provided during the site visit for the Waste Management Facility

Waste that is directed to landfill is currently not suitable for anaerobic digestion as it is stripped of bio-degradable green content and is also relatively dry and of very low volumes, making it unsuitable nor cost-effective for bio-gas production.

It was also understood that there was little interest in importing waste from outer-lying regions or heavily populated centres into Moree for the purpose of waste recovery and bio-energy production purposes. The *NSW Energy from Waste Policy Statement,* recognises that the recovery of energy and resources from the thermal processing of waste has the potential, as part of an integrated waste management strategy, to deliver positive outcomes for the community and the environment, and that thermal treatment of suitable waste provides an opportunity to recover the embodied energy from waste, to offset the use of non-renewable energy sources, and avoid methane emissions from landfill.

MPSC has provided information on a proposed project which was submitted for approval in 2015 for a proposed single stream energy-from-waste facility which planned to utilise rubber tyres from local industries, neighbouring mining operations and possibly imported from outer-lying regions into Moree, as feedstock to the facility. The facility was proposed to be located close to the Moree Waste Management Facility, on a 5.14-hectare land parcel.

The Waste Receiving and Processing Facility (WRPF) proposed to initially process 20 tonnes of tyres as feedstock per day, with future expansion to process up to 100 tonnes per day. The facility proposed to recover recyclable material from waste streams such as steel before processing to recover energy via a Continuous Fast Pyrolysis process. Energy was proposed to be recovered in the form of:

- Syn-gas
- Fuel oils
- Heat.

Figures from the development application suggested that 20 tonnes of tyre feed stock could typically produce 8 to 9 tonnes of fuel oils, 4 to 5 tonnes of char, 3 to 4 tonnes of steel, 3 to 5 tonnes of Syn-gas and 2 MW/hr into the grid. Also, residual char from the facility had a number of industrial uses and could be either directly used or processed into a range of value-added products, instead of being diverted to landfill.

The proposed WRPF development was not approved by the EPA at the time of its submission in 2015, understood to be related to the uncertainty in the emissions levels from the plant's operations.

A compliant plant which addresses all the EPA requirements and comply with the *NSW Energy from Waste Policy Statement*[12] including resource recovery criteria and reference facility requirement, could demonstrate the sustainability and commercial viability for syn-gas and fuel oil production within the SAP from processing of suitable waste.

The general opportunity for energy-from-waste may be broadly illustrated in the diagram shown in Figure 9[13] :

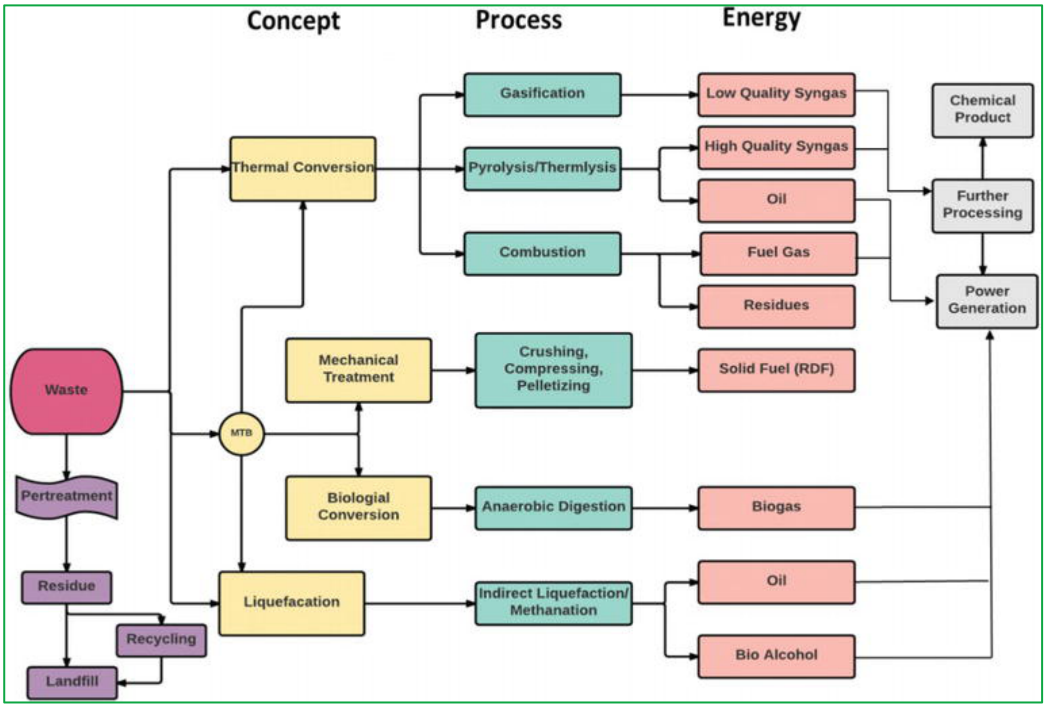

Figure 9: Types of Products from Waste Processing

The range of products that can be derived from biomass is wide using different types of thermal conversion technologies, including pyrolysis, gasification, torrefaction, anaerobic digestion and hydrothermal processing.

The ultimate viability of an energy-from-waste facility in Moree SAP is dependent on various factors, which include:

- Volumes of feedstock and sources
- Cost of feedstock (including freight/ transport)
- Revenue from tipping fees and waste levy incurred from disposal of residue materials (if the source material comes from the levy-paying area)
- Variation of feedstock levels – seasonally and dependability
- Suitability of feedstock to be converted to the targeted end-product, whether it be bio-gas, solid-fuel, syn-gas, bio-alcohol, etc.
- Capital cost of the facility
- Project economics
- Delivered energy prices, compared to alternatives.

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12 https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/epa/150011enfromwasteps.pdf?la=en&hash=50211762E1746B2E444D3869E5E409183312B5BB
13 https://www.intechopen.com/books/pyrolysis/pyrolysis-a-sustainable-way-to-generate-energy-from-waste

4.1.4 Bio energy

There are no operational bio-energy facilities currently in the Moree SAP.

It was advised by MPSC representatives during the site visit that there is currently no waste from the existing agricultural businesses from the Moree region which are currently being stockpiled or used for the purposes of bio-energy production.

Furthermore, there are no pelletising facilities processing combustible agricultural waste for the purposes of producing pellets that may be used as feed-stock and incinerated in bio-energy plants.

It was also explained that farmers currently re-use a lot of waste generated from farming within the farms themselves – e.g. waste from the cotton industry (cotton trash) is typically mulched at the cotton gins and reintroduced back to the soils as a preference by cotton growers. There has been no program to explore the directing of waste from farms to be brought to a central facility for bio-energy purposes.

This presents an opportunity for the SAP for bio-energy production from cotton stalks harvested from the cotton industry in the region, and processed in a pelletising facility, and fed through a combustion process. This is discussed later in this report.

Furthermore, there isn't any livestock waste readily available near Moree to aid in bio-gas or bio-energy production (waste would need to be imported from the saleyards or feedlots north of Moree near the Queensland border).

The existing Wastewater Treatment Plant (WWTP) is understood to have a capacity which is nearly twice the current treatment levels. Conservative estimates of potential energy production from bio-gas captured from the treatment of waste water is about 12 kWe per megalitre per day, from the combustion of bio-gas in reciprocating engines or micro-turbines, captured through anaerobic digestion of biosolids from filtration and clarification processes within a suitably designed WWTP.

It is unknown if the existing MPSC WWTP can be cost-effectively modified to capture biosolids for anaerobic generation and to also include on-site power generation using reciprocating or micro-turbines, within the footprint of the current facility operations, or whether any engineering studies have been undertaken by MPSC to assess the potential of this. However, based on the renewable energy study undertaken for the Wagga Wagga SAP, the following assumptions could be applied to the Moree SAP:

- A WWTP constructed to treat 5 ML/d including energy recovery equipment is approximately 50,000 m^2
- A high-level indicative capital cost for this WWTP (including wastewater processing equipment, anaerobic digester and energy recovery equipment) is approximately $42 million
- Based on the operating costs for several wastewater treatment plants in NSW, the annual operating cost for the WWTP may be approximately $700 per megalitre of wastewater processed
- Maintenance of the energy recovery equipment may be in the order of $50,000 to $100,000 per year
- The Wagga Wagga SAP WWTP facility proposed for the ultimate treatment of 5 ML/d was estimated to generate 60 kWe of electricity, and about 420 MWh/yr (or 0.42 GWh/yr, which is 0.4 per cent of the estimated energy consumed in the immediate Moree township)

The conclusion is that a new WWTP (or modifications to the existing WWTP) to generate bio-gas and onsite power based on the high capital costs and low estimated energy yield is unlikely to be economically justifiable nor recommended for the Moree SAP.

4.1.5 Hydropower

There are no hydro facilities in Moree.

The potential for a hydro scheme centred around the Moree SAP is considered to be zero and has not been considered further:

- The topography surrounding Moree SAP is largely and relatively flat
- The Mehi River (a watercourse that is part of the Barwon catchment within the Murray–Darling Basin) passes outside of the Moree SAP to the North
- Halls Creek passes through the Moree SAP
- Apart from occasional flooding, neither watercourse above has the necessary prerequisites for economically viable hydropower production which relies on a combination of both volume flow (i.e. river flow) and elevation differences.

4.1.6 Geothermal

There are no geothermal facilities in Moree.

Within the Moree region there are artesian thermal pools utilising the groundwater extracted directly from the Great Artesian Basin (GAB) aquifer. The Moree Artesian Aquatic Centre is the largest of these, with several other motels also providing thermal springs.

The use of thermal water is generally a one-time pass-through. Once extracted, it is not permitted to be released into the freshwater system, and in most cases it is piped to evaporating ponds installed by MPSC, located close to the Moree Municipal Waste Facility. Other options include water treatment, or reinjection but are unlikely to be cost effective.

The temperature of extracted water is only around 43ºC, and temperatures from the artesian layer of the GAB are under 50ºC as shown in Figure 10. High temperature geothermal resources used for the production of electricity generally require steam temperatures in excess of 150ºC, although the use of binary cycle geothermal plants can utilise temperatures as low as around 60ºC where a secondary fluid is utilised (however the efficiency of such a plant is very low, between 10 and 13 per cent).

The potential for geothermal power generation is considered to be zero for Moree.

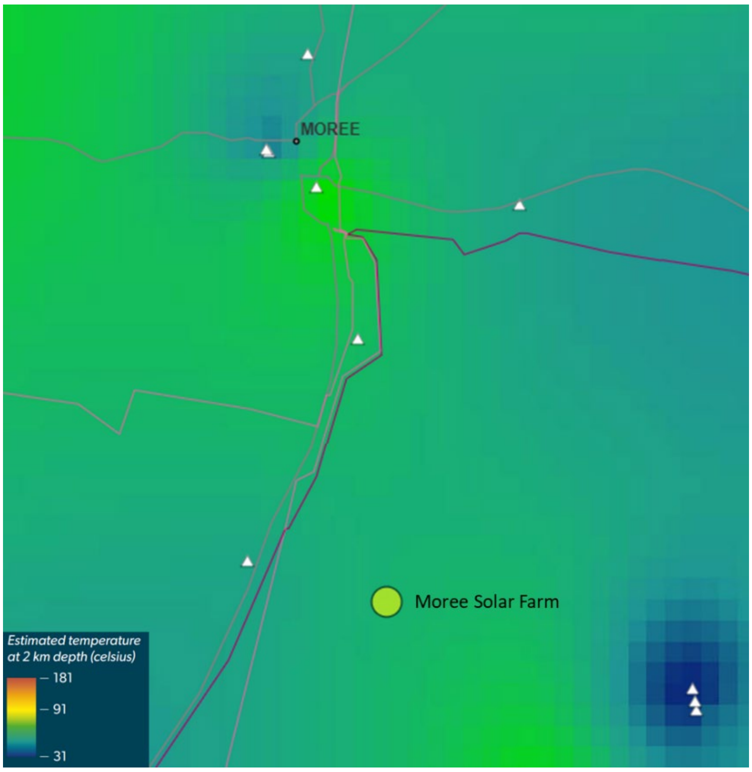


Figure 10: Geothermal temperature at 2km depth[14]

4.1.7 Wind energy

There are no wind-energy generators in commercial operation in Moree.

Wind Speed data from NSW Planning and Environment's Resources and Geoscience Division[15] and also the AREMI website[16] for the Moree region as shown in Figure 11 and Figure 12 (at 100 metres height), suggests that there is a **low** potential for wind energy generation, with average wind speeds in the range of about 6 m/s.

This is significantly lower than and compares unfavourably with the average wind speeds at other commercial wind farms locations elsewhere in NSW.

There are no proposed wind-farms in the Moree region in the most current renewable energy project database maintained by Alt-Energy[17] or indicated on the AEMO website, which further suggests that commercial scale wind-farms are not viable for the Moree SAP.

[14] https://oeh.maps.arcgis.com/apps/webappviewer/index.html?id=4aa2febf15964dc5951729d8d1dade84

[15] https://oeh.maps.arcgis.com/apps/webappviewer/index.html?id=4aa2febf15964dc5951729d8d1dade84
[16] https://www.nationalmap.gov.au/
[17] https://altenergy.com.au

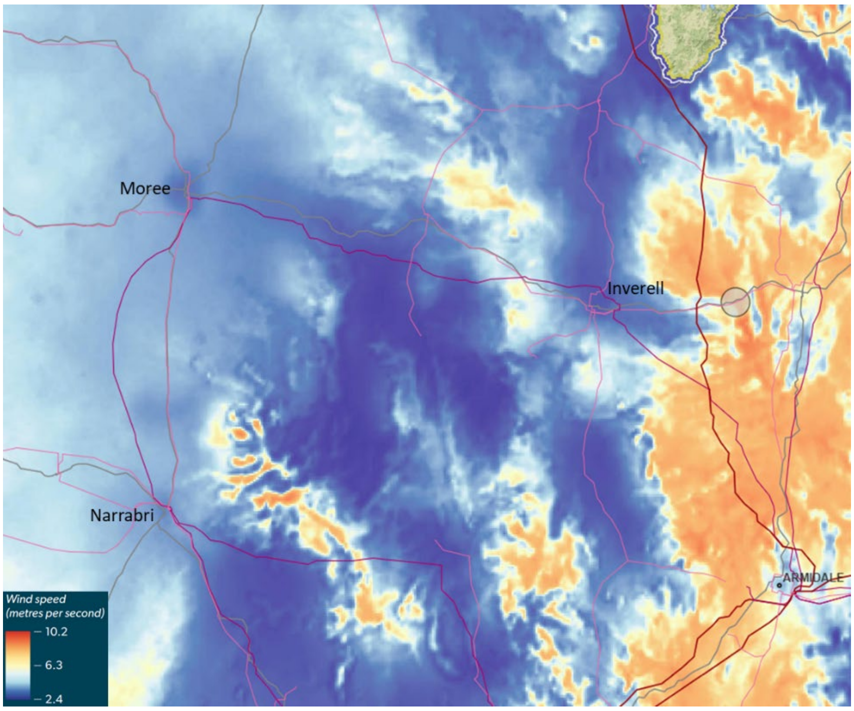
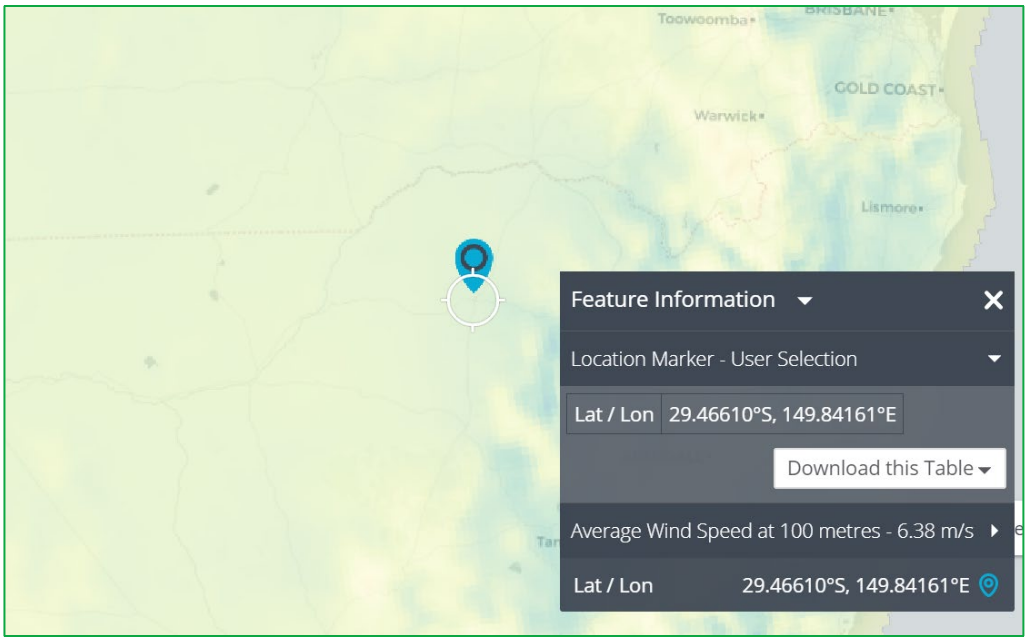


Figure 11: Wind data (NSW Planning and Environment – Resources and Geoscience)



Source: AREMI

Figure 12: Average wind speeds around Moree

4.2 Renewable energy generation outside of Moree

The closest renewable generation facilities which are in operation outside of Moree are:

- The 9 MW Kanowna Solar Farm located 95 kilometres west of Moree
- The 16 MW (and future expansion to 22 MW) Wilga Park Solar Farm, which is connected to the Narrabri network. It is located some 115 kilometres to the south of Moree

- The 7 MW Keepit Hydropower plant, which is connected to the Gunnedah network. It is located approximately 250 kilometres to the southeast of Moree.

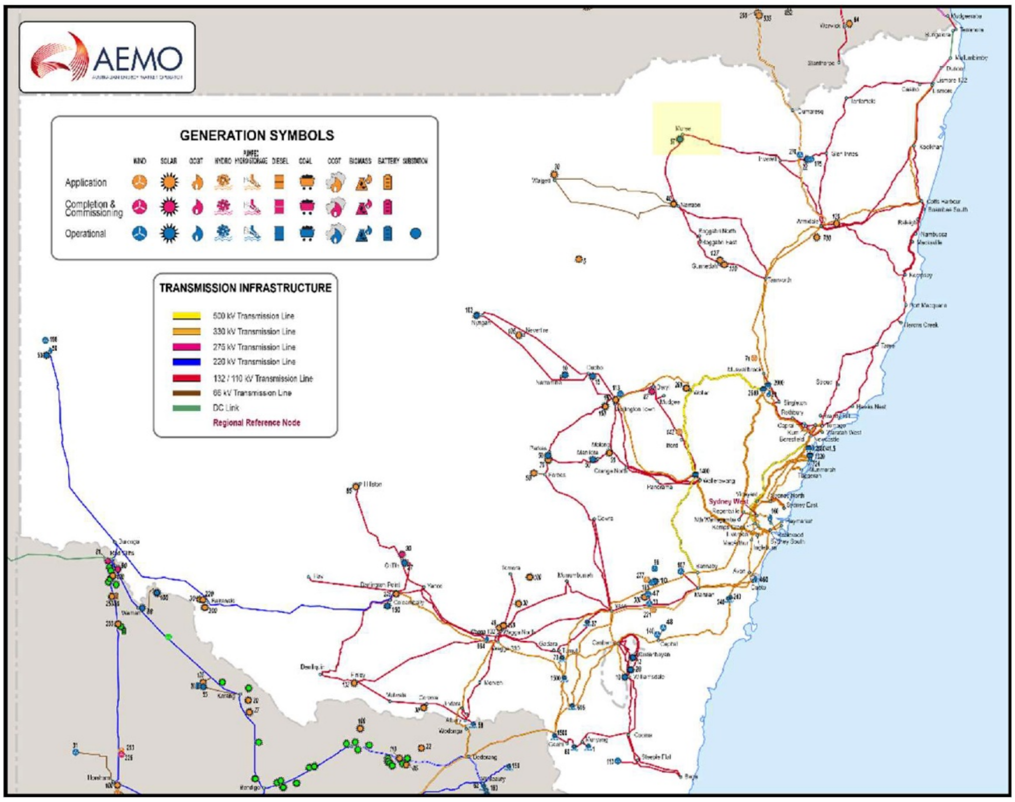
4.3 Planned renewable energy projects

Information from AEMO shown in Figure 13 indicates that there are several renewable energy solar generators which have applied for connection in the general area (within a 200-kilometre radius of Moree) but there are none which are planned to be developed and connected within the immediate Moree SAP area.

The notable renewable energy generation projects (listed by name/ type, capacity, location and developer) which are currently listed as “planned and/ or approved” include:

Boggabilla Solar Farm	5 MW	Boggabilla	Kinelli
Bonshaw Solar Farm	500 MW	Bonshaw	GAIA Australia
Sapphire Solar Farm	200 MW	Kings Plain	CWP Renewables
Silverleaf Solar Farm	120 MW	Narrabri	Engie
NSW Energy Cluster	480 MW	Tamworth	Wind Farm Developments
Hills of Gold Wind Farm	410 MW	Nundle	Wind Energy Partners.

There are also several other renewable energy projects around Dubbo and further south of it (Figure 14), but are considered to be well and truly distant (greater than 200 kilometres) to the Moree SAP for the purpose of this report.



Source: AEMO

Figure 13: Map of generators (including renewables) in NSW

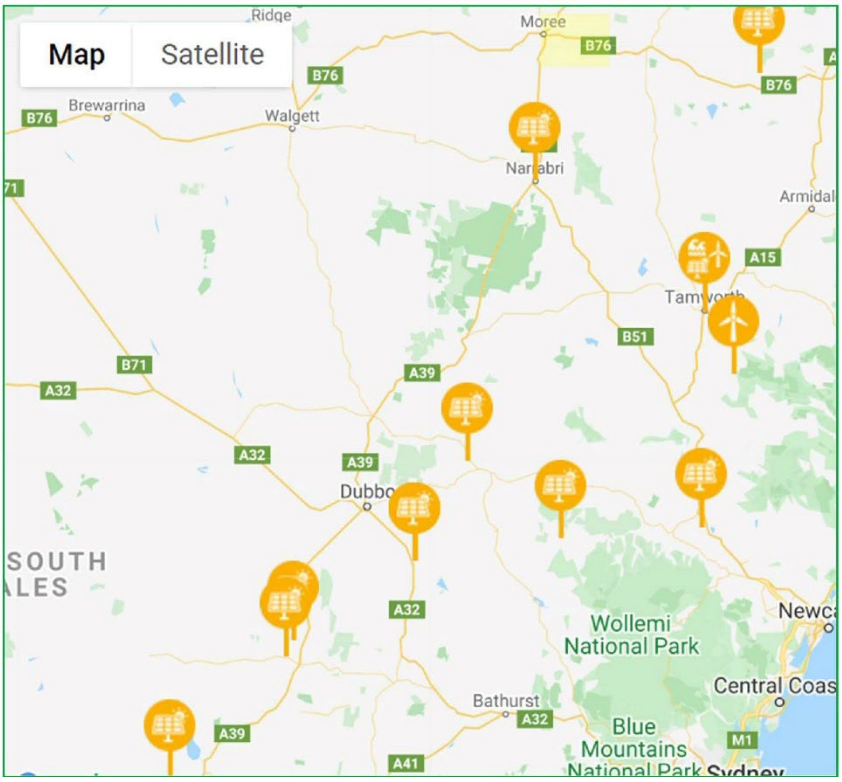
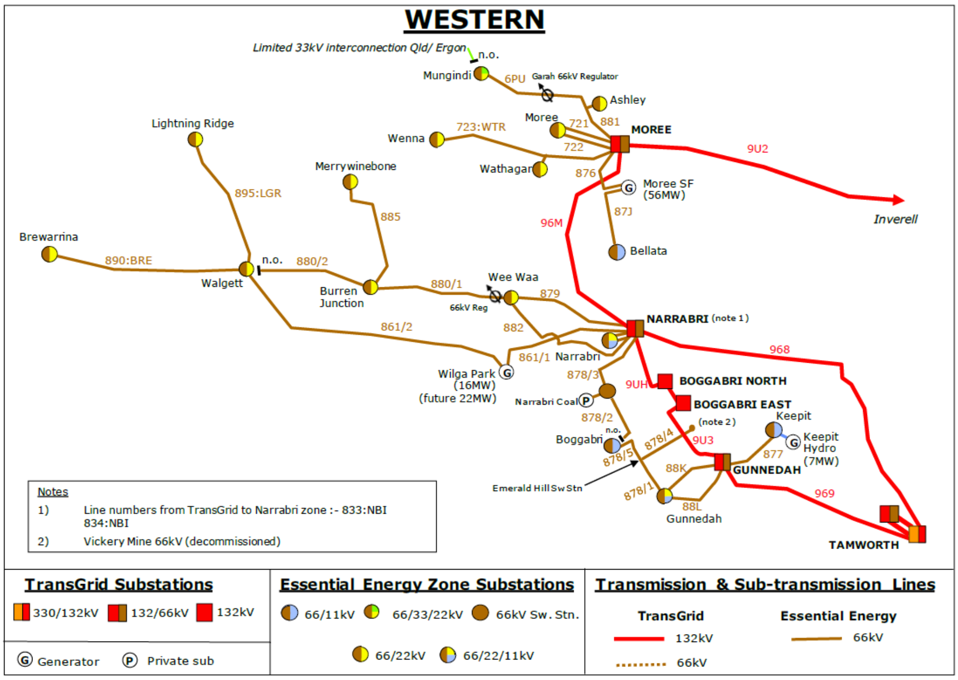


Figure 14: Map of proposed renewable energy projects near Moree

4.4 Existing transmission network infrastructure

4.4.1 General

The Transmission Network surrounding the Moree region is as shown below in Figure 15. The Moree region is serviced from the 132 kV transmission and 66 kV sub-transmission networks via several substations owned by TransGrid and Essential Energy.



Source: Essential Energy

Figure 15: Electricity network in the western area

4.4.2 Transmission lines and substations

Bulk power for the Moree region is supplied from the TransGrid bulk supply point (Moree 132/66 kV substation).

The loads and major high voltage consumers are supplied via the 22 kV and 11 kV distribution networks owned by Essential Energy from various 66/22 kV and 66/11 kV Zone Substations as listed below:

- Moree 66/22 kV
- Wenna 66/22 kV
- Wathagar 66/22 kV
- Ashley 66/22 kV
- Mungindi 66/33/22 kV
- Belata 66/11 kV.

The Essential Energy Moree 66/22 kV zone substation is the only substation that directly supplies the Moree SAP area, with all other remaining substations being outside of the investigation area.

4.4.3 Load demand (winter and summer)

The demand for electricity for the Moree region is generally higher in Winter than in Summer. This is evident from the Load Forecasts from Essential Energy's *Distribution Annual Planning Report (DAPR)* for the substations and distribution feeders servicing the Moree region.

The present load forecast as used by Essential Energy for its network planning purposes, is essentially flat, year-on-year, as shown below in Table 4:

Moree special activation precinct

Table 4: Summer and winter substation loads

SUMMER	Moree Supply Area POE50 Indicative Demand Forecast												
Substation	kV	Transformer Rating (MVA)			Firm Normal Cyclic Rating (MVA)	Forecast PF	Forecast (MVA)					Embedded Generation (MW)	95% Peak Load Exceeded (Hrs)
		Tx.1	Tx.2	Tx.3			19/20	20/21	21/22	22/23	23/24		
Ashley	66/22	8			0	0.98	2.0	2.0	2.0	2.0	2.0	0.34	1.5
Bellata	66/11	2.8	2.5		2.75	0.98	1.0	1.0	1.0	1.0	1.0	0.41	7
Moree	66/22	15/30	24/30		33	0.98	19.0	18.8	18.7	18.5	18.3	8.10	2
Mungindi	66/22/33	8			0	0.95	2.4	2.4	2.4	2.4	2.4	0.71	8
Wathagar	66/22	5			0	0.95	2.8	2.8	2.8	2.8	2.8	0.00	8
Wenna	66/22	7.5			0	0.98	0.4	0.4	0.4	0.4	0.4	0.04	4

WINTER	Moree Supply Area POE50 Indicative Demand Forecast												
Substation	kV	Transformer Rating (MVA)			Firm Normal Cyclic Rating (MVA)	Forecast PF	Forecast (MVA)					Embedded Generation (MW)	95% Peak Load Exceeded (Hrs)
		Tx.1	Tx.2	Tx.3			2020	2021	2022	2023	2024		
Ashley	66/22	8			0	0.98	5.5	5.5	5.6	5.6	5.6	0.34	35.5
Bellata	66/11	2.8	2.5		3	1.00	0.8	0.8	0.7	0.7	0.7	0.41	4
Moree	66/22	15/30	24/30		36	1.00	19.0	19.1	19.2	19.4	19.5	8.10	6
Mungindi	66/22/33	8			0	0.95	4.3	4.3	4.4	4.4	4.5	0.71	15.5
Wathagar	66/22	5			0	0.95	5.4	5.4	5.4	5.4	5.4	0.00	124
Wenna	66/22	7.5			0	0.98	0.4	0.4	0.4	0.4	0.4	0.04	1

Source: Essential Energy

The 2019 load demand of the Moree 66/22 kV zone substation (which directly supplies the Moree SAP) is 19MVA. The substation has two transformers (one 15/30MVA and one 24/30MVA) but a stated 'firm normal cyclic' summer rating of 33 MVA and 36 MVA for winter.

Essential Energy load data suggests a current utilisation of only 58 per cent of its firm normal cyclic summer rating with a potential ability to service an additional 14 MVA of new load (or an increase of 73 per cent above its current peak summer demand level of 19 MVA) before necessitating upgrades of transformer and of feeder circuit capacity.

There are two 66 kV sub-transmission lines from the TransGrid bulk supply point to the Moree 66/22 kV zone substation (Feeder numbers 721 and 722), with each line rated for 64 MVA in summer, and 71 MVA in winter – but with current demand levels of only 8 to 10 MVA each. This suggests there is ample spare capacity to support the ultimate substation summer rating of 33 MVA and winter rating of 36 MVA at the Moree 66/22 kV Zone Substation, or potentially if a third transformer is installed at the substation to service additional new loads from the Moree SAP.

Table 5: Sub-transmission feeder load forecast

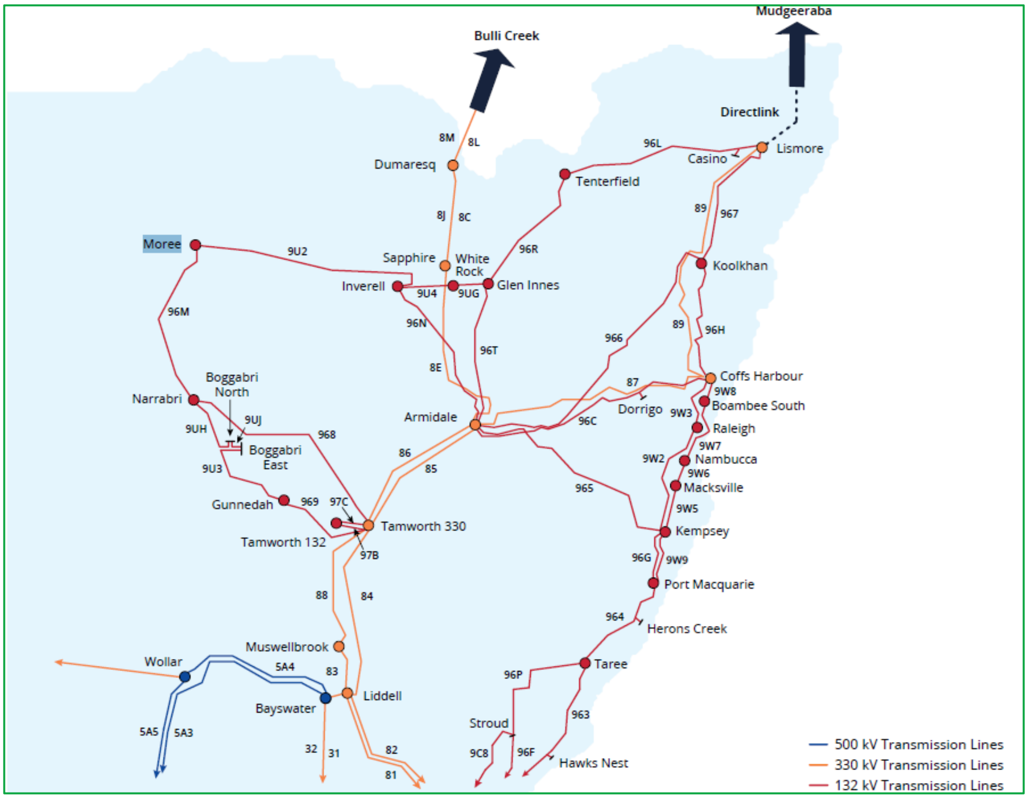
Sub-transmission feeder load forecast

Feeder #	Feeder Voltage kV	Feeder Origin	Feeder Destination	Summer						Winter					
				Line Rating MVA	Line Forecast MVA					Line Rating MVA	Line Forecast MVA				
					19/20	20/21	21/22	22/23	23/24		2020	2021	2022	2023	2024
876	66	TransGrid Moree 132/66kV STS	Moree Solar Farm	70	57.3	57.4	57.4	57.4	57.4	78	56.3	56.4	56.4	56.4	56.4
87J	66	Moree Solar Farm	Bellata ZS	25	0.9	0.9	0.9	0.9	0.9	27	0.7	0.7	0.7	0.7	0.7
721	66	TransGrid Moree 132/66kV STS	Moree ZS	64	10.0	10.0	9.9	9.9	9.9	71	8.1	8.1	8.1	8.1	8.1
722	66	TransGrid Moree 132/66kV STS	Moree ZS	64	10.5	10.5	10.5	10.5	10.5	71	8.5	8.5	8.5	8.5	8.5
881/1	66	TransGrid Moree 132/66kV STS	Ashley Tee	15	4.6	4.6	4.6	4.6	4.6	25	10.0	10.1	10.1	10.2	10.3
881/2	66	Ashley Tee	Ashley ZS	10	2.0	2.0	2.0	2.0	2.0	16	5.5	5.5	5.6	5.6	5.6
6PU	66	Ashley Tee	Mungindi ZS	10	2.4	2.4	2.4	2.4	2.4	16	4.3	4.3	4.4	4.4	4.5
723:WTR/1	66	TransGrid Moree 132/66kV STS	Wathagar ZS	12	2.3	2.3	2.3	2.3	2.3	19	4.5	4.5	4.5	4.5	4.5
723:WTR/2	66	Wathagar ZS	Wenna ZS	15	0.7	0.7	0.7	0.7	0.7	25	0.7	0.7	0.7	0.7	0.7

Source: Essential Energy

Moree special activation precinct

The greater Transmission Network further upstream of the Moree region is as shown in Figure 16:



Source: TransGrid

Figure 16: Transmission network in northern area NSW

The peak load demand at the TransGrid Moree 132/66 kV bulk supply point substation is shown to be 28 MVA in summer and 36 MVA in winter, and is forecast to be relatively flat from 28 to 31 MVA (in summer) and from 36 to 37 MVA (in winter) over the next 10 years by TransGrid (refer to Table 6 and Table 7). Note however, that this is before the consideration of any load increase in the region due to new industries and businesses expected to be established in the Moree SAP in future.

Table 6: TransGrid bulk supply substations summer loads

	2019/20			2020/21			2021/22			2022/23			2023/24			2024/25			2025/26			2026/27			2027/28			2028/29		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Armidale 66 kV	28	5	28	28	5	28	28	5	28	28	5	28	28	5	28	28	5	28	28	5	29	28	5	29	28	5	29	28	5	29
Boambee South 132 kV	18	2	18	18	2	18	18	2	18	18	2	18	18	2	18	18	2	18	18	2	18	18	2	18	18	2	18	18	2	18
Casino 132 kV	27	7	28	27	7	28	27	7	28	27	7	27	26	7	27	26	7	27	26	7	27	26	7	27	25	7	26	25	7	26
Coffs Harbour 66 kV	61	11	62	62	11	62	62	11	63	62	11	63	63	11	63	63	11	64	63	11	64	64	11	65	64	11	65	64	11	65
Dorrigo 132 kV	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2
Dunoon 132 kV	6	-1	6	7	-1	7	7	-1	7	7	-1	7	7	-1	7	7	-1	7	7	-1	7	7	-1	7	7	-1	7	7	-1	7
Glen Innes 66 kV	10	-2	10	10	-2	10	11	-2	11	11	-2	11	11	-2	11	11	-2	11	11	-2	11	11	-2	12	12	-2	12	12	-2	12
Gunnedah 66 kV	29	-6	29	29	-6	29	29	-6	29	28	-6	29	28	-6	29	28	-6	29	28	-6	29	28	-5	29	28	-5	29	28	-5	28
Hawks Nest 132 kV	11	1	11	11	1	11	11	1	11	12	1	12	12	2	12	12	2	12	13	2	13	13	2	13	13	2	13	13	2	14
Herons Creek 132 kV	11	3	11	11	3	11	11	3	11	11	3	11	11	3	11	11	3	11	11	3	11	11	3	11	11	3	11	11	3	11
Inverell 66 kV	35	-3	35	35	-3	35	35	-3	35	35	-3	35	35	-3	35	35	-3	35	35	-3	36	35	-3	36	36	-3	36	36	-3	36
Kempsey 33 kV	31	5	32	32	5	32	33	5	33	33	5	34	34	5	34	35	5	35	35	6	36	36	6	36	37	6	37	37	6	38
Koolkhan 66 kV	53	8	53	53	9	54	54	9	54	54	9	55	55	9	55	55	9	56	56	9	56	56	9	57	57	9	57	57	9	58
Lismore 132 kV	82	22	85	82	22	85	83	22	85	83	22	86	83	22	86	83	22	86	84	22	86	84	22	87	84	22	87	84	22	87
Macksville 132 kV	10	2	10	10	2	10	10	2	10	10	2	10	10	2	10	10	2	10	11	2	11	11	2	11	11	2	11	11	2	11
Moree 66 kV	28	3	28	28	3	28	28	3	29	29	3	29	29	3	29	29	3	29	30	3	30	30	3	30	30	3	30	31	3	31
Mullumbimby 132 kV	47	-3	47	47	-3	47	48	-3	48	48	-3	48	49	-3	49	50	-3	50	50	-3	50	51	-3	51	51	-3	51	52	-3	52
Nambucca 66 kV	7	1	7	8	1	8	8	1	8	8	1	8	8	1	8	8	1	8	8	1	9	9	1	9	9	1	9	9	1	9
Narrabri 66 kV	58	8	58	59	8	59	60	8	60	61	8	62	62	9	63	63	9	64	64	9	65	65	9	66	66	9	67	68	9	68
Port Macquarie 33 kV	73	12	74	75	12	76	77	12	78	78	12	79	80	13	81	82	13	83	84	13	85	85	13	86	87	14	88	89	14	90
Raleigh 132 kV	11	2	11	11	2	11	11	2	11	11	2	11	11	2	12	12	2	12	12	3	12	12	3	12	12	3	12	12	3	13
Stroud 132 kV	36	-3	36	37	-3	37	38	-3	38	39	-3	39	40	-3	40	41	-3	41	41	-3	42	42	-3	42	43	-3	43	44	-3	44
Tamworth 66 kV	113	24	115	113	24	115	113	24	115	113	24	115	113	24	115	113	24	115	113	24	115	113	24	115	113	24	115	113	24	115
Taree 33 kV	29	6	30	30	6	31	31	6	31	31	6	32	32	6	32	33	6	33	33	6	34	34	6	34	34	7	35	35	7	36
Taree 66 kV	55	9	56	56	10	57	57	10	58	58	10	59	59	10	60	60	10	61	61	11	62	63	11	63	64	11	65	65	11	66
Tenterfield 22 kV	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Terranora 110 kV	97	7	98	98	7	98	99	7	99	103	7	103	104	7	104	104	7	104	104	7	104	103	7	104	103	7	104	103	7	103

Source: TransGrid

Table 7: TransGrid bulk supply substations winter loads

	2019			2020			2021			2022			2023			2024			2025			2026			2027			2028		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Armidale 66 kV	41	3	41	41	3	41	41	3	41	41	3	41	41	3	41	41	3	41	41	3	41	41	3	41	41	3	41	41	3	41
Boambee South 132 kV	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19
Casino 132 kV	20	2	20	20	2	20	20	2	20	20	2	20	20	2	20	19	2	19	19	2	19	19	2	19	19	2	19	18	2	18
Coffs Harbour 66 kV	62	-8	62	62	-8	63	63	-8	63	63	-8	64	63	-8	64	64	-8	64	64	-8	65	64	-8	65	65	-8	65	65	-8	66
Dorrigo 132 kV	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	0	2	2	0	2	2	0	2
Dunoon 132 kV	6	0	6	7	0	7	7	0	7	7	0	7	7	0	7	7	0	7	7	0	7	7	0	7	7	0	7	7	0	7
Glen Innes 66 kV	13	-2	14	13	-2	14	13	-2	14	13	-2	14	13	-2	14	13	-2	14	13	-2	14	13	-2	14	13	-2	14	13	-2	14
Gunnedah 66 kV	24	-6	25	24	-6	25	24	-6	25	24	-6	25	24	-6	24	24	-6	24	24	-6	24	23	-6	24	23	-6	24	23	-6	24
Hawks Nest 132 kV	8	-1	8	9	-1	9	9	-1	9	9	-1	9	10	-1	10	10	-1	10	10	-1	10	11	-1	11	11	-1	11	11	-1	11
Herons Creek 132 kV	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11
Inverell 66 kV	32	-8	33	32	-8	33	32	-8	33	32	-8	33	32	-8	33	32	-8	33	32	-8	33	32	-8	33	33	-8	33	33	-8	33
Kempsey 33 kV	31	4	31	32	4	32	33	4	33	33	4	33	34	4	34	35	4	35	35	4	35	36	4	36	37	5	37	37	5	38
Koolkhan 66 kV	44	-5	44	44	-5	44	43	-5	43	43	-5	43	43	-4	43	42	-4	43	42	-4	42	42	-4	42	42	-4	42	41	-4	42
Lismore 132 kV	78	13	79	78	13	79	78	13	79	78	13	79	79	13	80	79	13	80	79	13	80	79	13	80	80	13	81	80	13	81
Macksville 132 kV	10	1	10	10	1	10	10	1	10	10	1	10	10	1	10	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11
Moree 66 kV	36	4	36	36	4	36	36	4	36	36	4	36	36	5	36	36	5	37	36	5	37	37	5	37	37	5	37	37	5	37
Mullumbimby 132 kV	55	-3	55	55	-4	55	56	-4	56	56	-4	57	57	-4	57	57	-4	58	58	-4	58	59	-4	59	59	-4	59	60	-4	60
Nambucca 66 kV	9	1	9	9	1	9	9	1	9	9	1	9	9	1	9	9	1	9	10	1	10	10	1	10	10	1	10	10	1	10
Narrabri 66 kV	57	5	57	58	5	58	59	5	60	61	5	61	62	5	62	63	5	63	64	5	64	65	5	65	66	5	66	67	5	67
Port Macquarie 33 kV	76	10	77	78	11	79	80	11	81	82	11	82	83	11	84	85	11	86	87	12	87	88	12	89	90	12	91	92	12	93
Raleigh 132 kV	10	1	10	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	12	1	12	12	1	12	12	1	12	12	1	12
Stroud 132 kV	33	-5	33	34	-5	34	35	-5	35	36	-5	36	36	-5	37	37	-5	38	38	-5	38	39	-5	39	40	-6	40	41	-6	41
Tamworth 66 kV	96	8	97	96	8	97	96	8	97	96	8	97	96	8	97	96	8	97	96	8	97	96	8	97	96	8	97	96	8	97
Taree 33 kV	27	4	27	27	4	27	28	4	28	28	4	29	29	4	29	30	4	30	30	4	30	31	4	31	32	4	32	32	4	32
Taree 66 kV	55	5	55	56	5	56	57	5	58	58	5	59	60	6	60	61	6	61	62	6	62	63	6	63	64	6	64	65	6	65
Tenterfield 22 kV	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4
Terranora 110 kV	84	-5	84	87	-6	87	87	-6	87	87	-6	87	92	-6	92	92	-6	92	92	-6	92	92	-6	92	92	-6	92	92	-6	92

Source: TransGrid

The current utilisation of the 132 kV transmission lines to the Moree region/bulk supply point, is indicated to be at **50 to 53 per cent**, as shown in Figure 17, but Arcadis understands that the transmission lines are actually rated for around 100 MVA based on previous power systems studies undertaken for the Narrabri region. This suggests that there is sufficient capacity in the transmission network to support load growth in the Moree SAP up to the capacity of the existing assets (not considering any contingency event).

This conclusion, however, is made on the basis of a desk-top assessment only of the line ratings but must be confirmed through the undertaking of detailed load flow analysis by TransGrid, including examination of contingency events, as part of the concept design for the Moree SAP (outside the scope of this report).

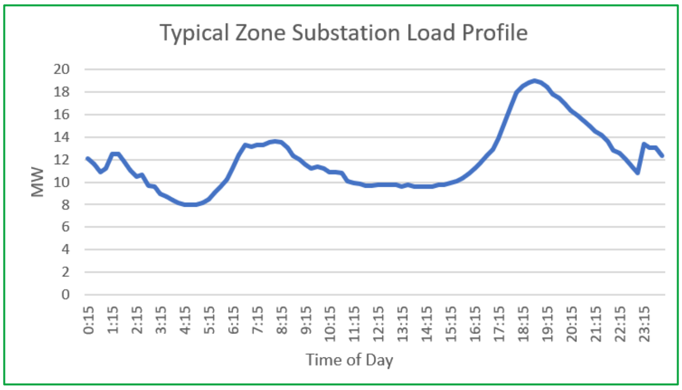
Source: TransGrid

Figure 17: Transmission line utilisation factors

4.4.4 Current energy consumption in Moree SAP

Total energy delivered to the whole of the Northern Tablelands part of NSW in 2019 was 1,239 GWh. There is no split shown of this total energy figure for the Northern Tablelands that was delivered through the various Essential Energy substations serving the Moree region.

A rough estimate of the energy delivered through the Moree 66/22 kV substation which directly supplies the Moree township and loads in the SAP investigation area, based on the 19 MVA recorded maximum demand of the substation and assuming a typical zone substation load profile as shown in Figure 18 below, with a load factor of 0.63 (being the ratio of average to peak load), suggests an annual energy delivered figure of approximately **105 GWh**.



Source: AusGrid

Figure 18: Typical zone substation daily load profile

4.5 Summary of key findings

Table 8 summarises the key findings from a renewable energy perspective, including assessment of the transmission network.

Table 8: Summary of key findings - Renewable energy and transmission network

Description	Details of existing	Identified opportunity for future SAP	Comments
Large scale solar farm	56MW, Moree Solar Farm, connected at 66kV to the Transmission Network, generating 210GWh/yr	Additional/new large scale solar farms are recommended and will be essential for the success of the Moree SAP. Plants to be sized to meet or exceed the estimated energy demand from new businesses in the SAP to achieve net zero target.	Adequate land-area to be allocated in the Structure Plan. Uncertainty in connection approvals to the grid due to current limitations until upgrade works are undertaken, or when power system studies are undertaken for each proposed farm to be connected.
Smaller solar installations (on commercial or industrial premises)	Generally low uptake in Moree compared to other regions or postcodes – rooftop solar installations are more of an exception rather than the norm	New premises (and existing larger premises) in the SAP should be fitted with solar PV wherever possible or economically justifiable, to improve the sustainability position.	Incorporate the stipulation of roof-top solar installation as part of the development approval and sustainability requirements of new premises in the SAP.
Bio-gas	Existing WWTP not suited for bio-gas production.	Not recommended.	High capital cost for very small energy production, economically not viable.
Energy from waste	Insufficient volumes of municipal solid waste currently being processed to warrant an E-f-W plant in Moree. Waste is	Possibility of an energy-from-waste tyre recycling plant to produce fuel oils, Syn-gas, char and recovery of steel.	Project was rejected in 2015 due to uncertainty in the emissions.

Description	Details of existing	Identified opportunity for future SAP	Comments
	unsuitable for anaerobic digestion.	Char could be directly used or processed into a range of value added products, instead of being diverted to landfill	
Bio-energy	There are no bio-energy plants in Moree.	Potential to process Cotton Stalks and other waste from the agri-sector, which could be processed into pellets and used in a bio-energy plant to produce heat and electricity,	Currently no waste from the existing agri-businesses are being stockpiled or used for the purposes of bio-energy production.
Hydropower	There are no hydropower plants in Moree.	Not recommended.	Nil potential due to local conditions – insufficient water flow rates and insufficient elevation differences.
Wind power	There are no commercial wind generators in Moree.	Not recommended.	Insufficient wind speeds in the region.
Geothermal power	Warm water from the Artesian basins are used in hot-pools for recreation purposes.	Not recommended.	Insufficiently high temperatures of the extracted water, to be able to be used for electricity production. Need to contain the used water in evaporating ponds, and to keep it separate from other waste water sources, exacerbates this.
Moree 66/22kV zone substation	Supplied from the TransGrid bulk supply substation. 66kV lines rated for 64MVA, loaded to 10.5MVA. 2 x power transformers, firm rating of 33MVA, loaded to 19MVA.	14MVA of surplus capacity exists now.	Augmentation works needed when new loads in the SAP exceeds this – including a 3rd transformer, and the establishment of a new 66/22kV zone substation further South in the SAP.
Transmission network upstream of Moree	132kV lines rated for ~100MVA, loaded to 18MVA	82MVA of surplus capacity exists now	Augmentation works unlikely for new SAP load supply purposes (subject to confirmation of contingency events, by TransGrid).

5 CONSTRAINTS

5.1 General

The main challenge for developers of new renewable energy projects has been to secure grid access.

While NSW has a pipeline of some 116 large-scale renewable energy proposals for more than 18,000 MW of capacity, fewer than one in 20 are currently able to connect to the network due to transmission network constraints and other system stability issues which are outlined in AEMO's 2020 Integrated System Plan (ISP).

A $2 billion agreement signed by NSW and the Federal governments earlier in 2020 aimed in part to underwrite the increase of new transmission to support the rush of renewables.

5.2 AEMO Integrated System Plan (ISP)

5.2.1 Renewable energy zones

Development of large number of potential renewable projects in the Renewable Energy Zones (REZs) will be dependent on and influenced by the recommended designs for projects to augment the transmission network. The REZs are likely to require system strength remediation to accommodate the projected future amounts of Variable Renewable Energy (VRE) in the areas, in addition to network upgrades.

In some cases, the anticipated REZ developments will lead to, and create the need for, concurrent coordinated augmentation of the transmission network. In other cases, network augmentations being undertaken for other reasons will, if suitably designed, enable further development of VRE in specific REZ.

Developers of VRE will always decide where and when to invest based on their own commercial criteria. If these investments are not aligned with this ISP development path, then there may not be a sufficiently strong economic case to build transmission necessary to support these VRE developments until much later, such as eventual exit of coal-fired power stations. Simply building VRE does not necessarily create the case for regulated network augmentation. It is very important to consider the overall needs of the power system and take a highly coordinated approach to the development of REZs and augmentations of the power system.

A particular consideration for Moree is that MPSC has a moratorium on the production of Coal Seam Gas (CSG) in the region, which exacerbates the challenge of sourcing alternatives using renewable energy in lieu of fossil fuelled options.

In July 2020 [18], the NSW government unveiled plans for NSW's second REZ at New England, including an investment target which is almost triple the 3000 MW earmarked for its first REZ in the Central West. The New England REZ, shown in Figure 19 aims to attract 8000 MW of new renewable generation capacity, nearly the size of NSW's entire fleet of coal-fired power plants.

The New England REZ will be able to power 3.5 million homes and, when coupled with Central-West Orana REZ, sets the state up to become the number one destination across Australia for renewable energy investment and also marked the biggest commitment to clean energy in NSW history by the NSW Government.

The NSW government will spend $79 million to assist with the acceleration of new grid connections needed to absorb the expected jump in new wind and

[18] https://www.abc.net.au/news/2020-07-10/new-england-renewable-energy-zone-solar-panel-wind-turbine/12441674#:~:text=The%20New%20South%20Wales%20Government,coal%2Dfired%20power%20stations%20combined.

solar farms for the region (about twice the investment for Central-West Orana REZ). The money will also help pay for community consultation efforts.

NSW Deputy Premier highlighted the zone's benefits in terms of regional jobs and also lower power prices that would likely follow as new capacity is added to the grid. And the new zone is expected to attract $12.7 billion in investment, support 2000 construction jobs and 1300 ongoing jobs, and to lower energy prices and future-proof the surrounding regions.

NSW now has about 10,000 MW worth of coal-fired power stations, a figure that will drop to about 8240 MW assuming AGL's Liddell plant closes as scheduled in 2023.

While intermittent electricity sources are typically available for fewer hours across the year than coal, gas or hydro plants, more solar and wind farms are likely to be built with battery storage options, making them readily dispatchable at night or when the wind isn't blowing.

The New England zone alone could meet about 30 per cent of NSW's existing annual use based on the 2019-20 figures, or about double Liddell's output. Large-scale renewables met about 9 per cent of supply last financial year, rising to 13.5 per cent when rooftop solar is added in.

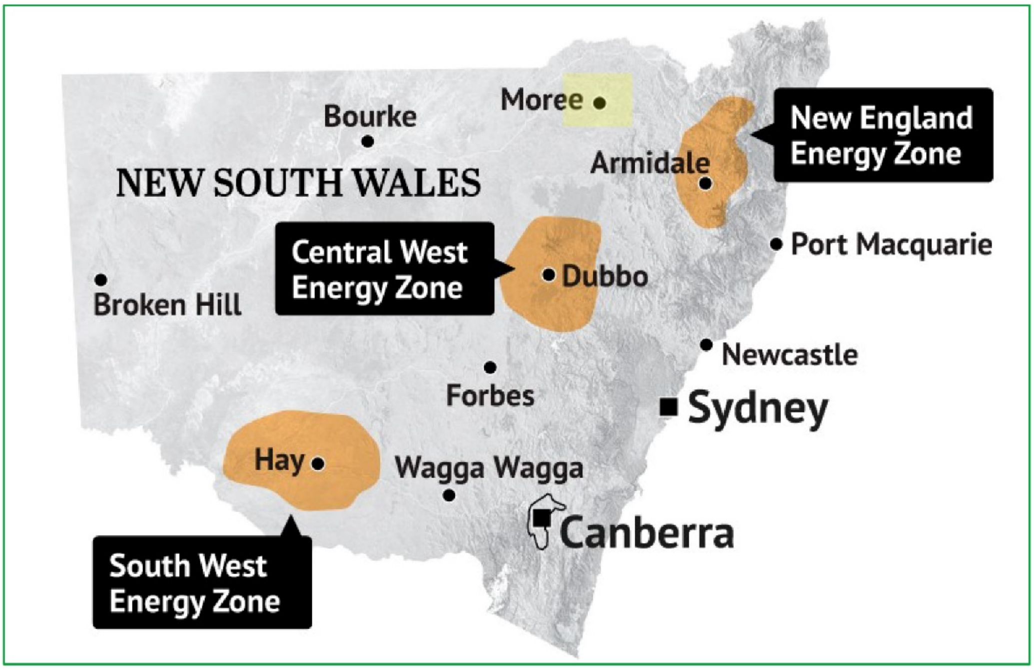


Figure 19: Renewable energy zones (REZs) in NSW

AEMO’s 2020 ISP discusses the need for a coordinated and integrated approach, with development of additional VRE in REZs across the NEM to occur in three overlapping development phases. It states that staging of the identified REZ developments must be coordinated with recommended augmentations of the network and system strength remediation, to allow for these opportunities to take advantage of additional network capability provided by new interconnectors where possible.

The development phases are:

- **Phase 1**, to help meet regional Renewable Energy Targets (RETs) (such as VRET and QRET) and other policies (such as the New South Wales Electricity Strategy) until those schemes are complete and/or where there is good access to existing network capacity with good system strength within the current power system, good resource potential, and strong alignment with community interests. Note that the NSW Electricity Strategy, which aims to develop 3 GW of VRE in the central west REZ with associated transmission infrastructure by 2028, may require accelerated development of this REZ. Subject to further policy detail becoming available, AEMO intends to assess the impact of this policy in the Final 2020 ISP.

- **Phase 2**, to replace energy provided by coal-fired generators that are scheduled to exit, to be ready when coal plant is retired (assumed to occur from the late 2020s) and/or where additional development is supported by the recommended transmission projects in Group 1 and 2 of the optimal development path.
- **Phase 3**, to accompany group 3 transmission projects that are being developed specifically to support VRE development in these REZs to meet the needs for large-scale replacement of coal when it exits (currently expected from late 2020s to 2040s).

These development opportunities are outlined in the Table 9.

Table 9: Renewable energy zone development phases

Phases of REZ Development	REZ
Phase 1 To help meet regional RETs (such as VRET and QRET) and other policy initiatives (such as the NSW Electricity Strategy) until those schemes are complete and/or where there is good access to existing network capacity with good system strength, good resource potential, and alignment with community interests.	**Queensland:** Darling Downs (wind and solar), Fitzroy (wind and solar), and initial development of Far North Queensland (wind) **New South Wales:** Initial medium level development of Central West (wind and solar) **South Australia:** Roxby Downs (solar) **Victoria:** Western Victoria (wind) and South West Victoria (wind), Central North Victoria (wind).
Phase 2 To replace energy provided by retiring coal-fired generators – announced to occur from the late 2020s and/or where additional development is supported by the recommended transmission projects in Group 1 and 2 of the optimal development path.	**Queensland:** Larger development of Darling Downs (wind and solar), supported by QNI medium development **New South Wales:** North West (wind and solar), South West (solar), and Wagga Wagga (solar), supported by expansions including QNI Medium, Project EnergyConnect, HumeLink, VNI West and associated works. **Victoria:** Murray River (solar), supported by VNI West and Project EnergyConnect **South Australia:** Riverland (solar), supported by Project EnergyConnect, **Tasmania:** Midlands (wind), supported by Marinus Link
Phase 3 To accompany recommended group 3 transmission projects that are being developed specifically to support them.	**Queensland:** Larger development of Far North Queensland (wind), Isaac (solar), and larger development of Fitzroy (wind and solar) **New South Wales:** Larger development of Central West (wind and solar), New England (wind and solar), and North West (wind and solar) **South Australia:** Roxby Downs (solar), Mid-North (wind), and South East (wind)

Source: TransGrid

As noted above, the development of the New England REZ (which is closest to the Moree SAP) will require the acceleration and construction of the transmission projects listed as "Group 3", shown in green in Figure 20, which includes various transmission network augmentations projected from the late 2020s to support REZs, including augmentation of northern New South Wales transmission network if the larger upgrade of the Queensland-NSW Interconnector (QNI) does not proceed.

However, since Moree's location is well outside of the New England REZ, it is assumed that the augmentation works needed to support increases in new and large-scale renewable energy generation connections in the Moree SAP may additionally require further network augmentation works than may be stipulated in the AEMO ISP.

Until such time as the development phases and capital works are completed, it is uncertain as to whether additional large scale solar farms can be permitted to be connected in the Moree SAP, unless the connection applications are made and the prerequisite and detailed interconnection studies are undertaken by developers of proposed solar farms. The undertaking of the connection enquiries and detailed connection studies are outside of the scope of this renewable energy report.

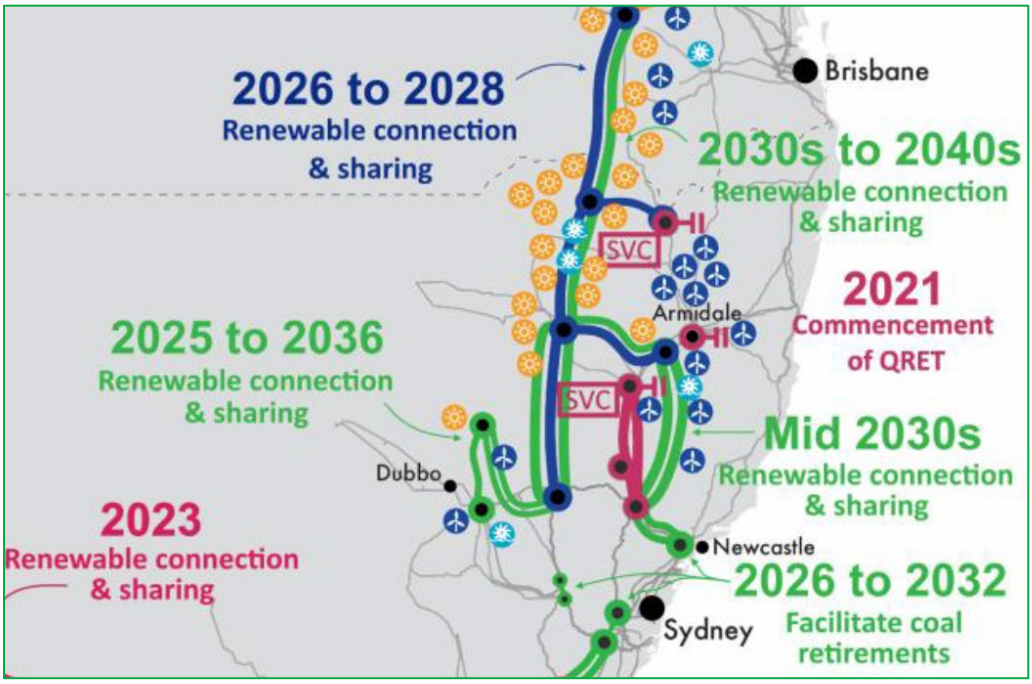


Figure 20: Transmission network upgrade phases in support of REZs (AEMO)

5.3 Transmission and sub-transmission network plans

5.3.1 General

The National Electricity Rules (NER) Clause 5.12.2(c)(3) requires reporting of the forecast of constraints and inability to meet the network performance requirements set out in NER Schedule 5.1 or relevant NSW legislations or regulations over one, three and five years.

Both TransGrid's as well as Essential Energy's Network Planning groups have analysed the expected future operation of its transmission networks over a 5 to 10-year period, taking into account the relevant forecast loads, any future generation, market network service, demand side and transmission developments and any other relevant data to determine the anticipated constraints over one, three and five years.

TransGrid's and Essential Energy's network planning groups conduct annual reviews which includes the following activities:

- Incorporation of the forecast loads as submitted or modified by relevant registered participants in accordance with NER Clause 5.11.1
- A review of the adequacy of existing connection points and relevant parts of the transmission system and planning proposals for future connection points
- Taking into account the most recent AEMO system planning updates, including the 2018 reviews of the Integrated System Plan (ISP), the National Transmission Network Development Plan, and the issue of the 2018 System Strength Impact Assessment Guidelines
- Consideration of the potential for augmentations, or non-network alternatives to augmentations, that are likely to provide a net economic benefit to all those who produce, consume and transport electricity in the market
- Consideration of the condition of network assets
- Consideration of the potential for replacements of network assets, or non-network options to replacements of network assets, that are likely to provide a net

economic benefit to all those who produce, consume and transport electricity in the market.

These activities form the basis by which TransGrid and Essential Energy reviews and updates their forecast constraints information provided in their *Transmission Annual Planning Report* (TAPR)[19] and *Distribution Annual Planning Report* (DAPR)[20].

5.3.2 Essential energy network plans

The current Network Development Plans for the electricity infrastructure (i.e. substations, overhead lines) owned by Essential Energy for the Moree load area has not identified any constraints nor capacity limitations based on their current **flat load forecast** which has been assumed by Essential Energy over the next 5 years.

If the ultimate load demand for the Moree SAP exceeds the 33 MVA summer rating, then augmentation of the Moree 66/22 kV zone substation (e.g. third transformer) would be needed, or the establishment of a new zone substation within the Moree SAP with new 66 kV sub-transmission supply lines to it from the TransGrid bulk supply point Moree 132/66 kV substation.

5.3.3 TransGrid network plans

The TransGrid *Transmission Annual Planning Report* (TAPR)[19] states that thermal and voltage constraints may arise in the Gunnedah area (to the south of the Moree region) leading to an emerging risk to reliability if large increases in loads (e.g. from mining or gas developments) were to proceed in the area. This assessment had not considered any significant load increases in the Moree area due to the SAP.

The planned developments to improve security of supply to customers in the northern region are shown in Table 10 and Table 11.

The only current planned works at the Moree bulk supply point includes transformer replacements (due to aged asset condition).

Table 10: Planned substation developments in northern system

Project description and location	Area	Operational date required	Total estimated cost ($ million)
Armidale 330 kV substation No.2 reactor renewal	Northern	Sep 2020	4.1
Sydney East 330 kV substation No.2 and No.3 transformer replacements	Sydney	Jun 2021	20.6
Wellington 330 kV substation No.1 reactor replacement	Central	Dec 2021	4.9
Forbes 132 kV substation transformer replacements	Central	Feb 2022	8.8
Transformer renewals at Ingleburn, Kemps Creek, Liverpool, Moree, Murray, Murrumburrah, Panorama, Sydney North	Across NSW	By Jun 2023	13.6
Various steelwork renewals – (Overall programs currently being reassessed)	Across NSW	By Jun 2024	TBD

[19] TransGrid Transmission Annual Planning Report 2019
[20] Essential Energy Distribution Annual Planning Report 2019

Table 11: Planned transmission developments in the northern region

Project description	Planned date	Total cost ($million June-18)	Purpose	Project justification
Gunnedah-Narrabri 66 kV Voltage Control	Aug 2020	<0.1	Provide Automatic Voltage Control of Capacitor Banks at Gunnedah. There is an opportunity to avoid the loss of load by implementing smart auto-tripping of the Gunnedah capacitors following a critical contingency.	Economic benefits
Capacitor bank to increase NSW to QLD transfer limit	Mar 2021	5.3	Installation of a 330 kV, 120 MVAr shunt capacitor bank at Armidale 330/132 kV substation to increase voltage stability limits on QNI.	Improve transfer capability
Armidale capacitor transfer tripping scheme	Mar 2021	0.2	Implementation of a transfer tripping scheme for the Armidale 132 kV capacitor bank to improve QNI transfer capability during an outage of an Armidale 330/132 kV transformer.	Improve transfer capability
Taree 132 kV bus capacity augmentation	Nov 2021	1.1	A trip of any 132 kV busbar section at Taree 132/66 kV substation will interrupt supply to the Taree area. Installation of a new circuit breaker bay to allow two busbar protection zones at Taree substation will allow continued supply to customers in the Taree area during a bus section outage.	Economic benefits
Armidale North Coast Line Overload Load Shedding (LOLS) expansion	Jan 2022	<0.1	Modification of the LOLS tripping scheme to include Essential Energy's Koolkhan to Maclean 66 kV feeder.	Economic benefits
Transposition of 330 kV lines 87 (Coffs Harbour to Armidale) and 8C/8E/8J (Armidale to Dumaresq)	May 2022	1.4	These transpositions are to make the network more resilient to negative-sequence voltage levels greater than 0.5% within the northern NSW transmission network.	Economic benefits
Install capacitor banks at Narrabri substation	By Jun 2023	4.9	Required to manage voltage constraints if large mining or gas developments proceed in the area.	Load driven
Reconductor the Gunnedah to Tamworth 132 kV line (969)	By Jun 2023	6.3	Required to manage a thermal constraint due to the rating of the 969 line if large mining or gas developments proceed in the area.	Connection driven
Northwest NSW 330 kV smart grid controls	By Jun 2025	3.6	Installation of a special protection scheme to protect against trips of two or more of the 330 kV lines between Armidale and Liddell. For multiple circuit trips, the scheme will run back generation and load to avoid cascading outages and further loss of load in the network.	Economic benefits

5.3.4 Renewable energy connection applications

TransGrid has received applications for a number of generator connections to the North Western NSW transmission system. Some of these projects are proposed to connect at 132 kV and 66 kV, increasing the power flow from the local 132 kV network to 330 kV network.

TransGrid has received significant ongoing interest from renewable energy proponents seeking to connect to the network in this area, which are all competing for capacity within the network.

As previously stated, the NSW Government has identified the New England area as a prospective large-scale renewable energy zone. AEMO has also identified the North West NSW, Northern NSW Tablelands and the New England area for targeted development as renewable energy zones in their ISP.

Presently, there is approximately 520 MW of renewable generation connected in the area. A further 115 MW is committed to connect and more than 1,180 MW is at an advanced stage in the connection process.

However, the limited capacity of the current 330 kV and 132 kV networks will result in output export limitations of connecting generators as the pool of generators in the area increases. This will likely inhibit the economic viability of connection of additional generation in the area.

Increasing transmission capacity would maximise the existing renewable energy generation opportunities, and facilitate new generator connections in northern NSW that would deliver substantial additional market benefits.

These benefits would be derived from:

- Lower costs for meeting the supply reliability standard in NSW, through facilitating access to the output from these generation connections
- Lower market dispatch costs (and hence lower prices for consumers).

5.3.5 Transmission network development costs

The projects to support renewable energy development in north western NSW was included in TransGrid's revenue proposal to the AER. This project has a cost estimate ranging between $**500 million to $945 million**.

The AER determined that these projects may be reasonably required within the current regulatory period.

Subject to evaluation of economic benefits, a project is expected to be initiated with the timing determined by the economic evaluation. The project may be staged if required to maximise economic benefits.

5.3.6 System strength

System strength is provided by synchronous rotating generators, and can also be provided by network assets such as synchronous condensers. SVCs can contribute to system strength by providing dynamic voltage control, but not fault currents.

According to the TransGrid TAPR, there is sufficient system strength in most parts of the NSW transmission network at present. However, the system strength in south-western NSW is low and requires operational measures to manage system stability under contingency events.

Wind, solar and other inverter-based generators require adequate levels of system strength to operate correctly. As the penetration of inverter-based generators increases, there will be a need to install network assets such as synchronous condensers or SVCs to provide additional system strength, but none have been flagged as being needed in the Northern Region including the Moree area.

5.3.7 Likely augmentation works

If the load in the Moree SAP were to increase significantly (due to the activation of the precinct), then the current Electricity Network Plans for both Essential Energy and TransGrid will likely be changed since this will alter their forecast data, and augmentation works in support of the future ultimate Moree SAP load will be needed.

The latter sections of this report discuss the likely augmentation works to the transmission infrastructure, based on the assessment of the estimated energy demand and supply from the expected new businesses and industries in the SAP.

5.3.8 Connection voltages

Connection voltages typically vary from low voltage (230/400 V) for simple roof top residential solar PV installations, or commercial premises up to about 500 kW, and 11 kV or 22 kV for generation facilities typically exceeding 1 MW, and up to 66 kV or even 132 kV for generation facilities generally in excess of 10 MW, depending on the proposed point of connection to the existing network.

It is anticipated that the connection of new large-scale solar farms such as the Moree Solar Farm, in the SAP, would likely be connected to the TransGrid bulk supply point at either 66 kV or 132 kV.

5.4 Application process for grid-connection of new renewable generators

5.4.1 General

The requirement to undertake specialised grid connection assessment studies for any proposed generation connection generally greater than 1 MW, is a statutory requirement as part of the connection process and the impact of the proposed generation facility on the altered power flows and voltage levels on the network to which it is connected, and its ability to 'do no harm' or degrade the network performance or quality of supply to its users is a fundamental requirement of compliance of any proposed new generation facility.

These studies need to be undertaken when proponents of new plant make application for connection, and must take into account the specifics of the particular plant proposed for each project.

It is impossible to generalise on the likelihood of connection of any generic type of new renewable energy generation plant in the SAP since the impact of each plant could be very different on the network – depending on the size of plant, type of generator, controls, connection location on the grid, network stiffness, etc.

5.4.2 Connection application process

The process for connection of generators to the National Electricity Grid is provided by AEMO in its publication "Connection Process Application Diagram" and shown in Figure 21.

The process aims to assess:

- If the generator can adversely affect network capability, quality or reliability of supply, or the network's transfer capability
- If the generator will adversely affect the use of the network by other users; or
- If the generator performance has an 'adverse impact' on system strength; or vice-versa, which would lead to a Full Impact Assessment (conducted by the NSP).

The process covers the various stages, from pre-feasibility, connection enquiry, detailed application, through to finalisation/ completion (of connection agreements).

Typical timelines are also shown in the process, which suggests that connection applications can be **very lengthy**, and may typically take anywhere **between 10 to 40+ months**, depending on the size and complexity of the proposed connection and particulars of the network in the area to be connected (most notably, related to available network capacity, as well if there are any "system strength" issues which may be prevalent, and which may warrant Full System-Strength Impact Assessments to be undertaken if the network is classified as a 'weak system'.

Any effort by the RGDC in 'activating' the Moree SAP by accelerating the planning/development approval process for new renewable energy plants, must also be cognisant of the time lags (and also the costs) associated with proponents obtaining the connection agreements.

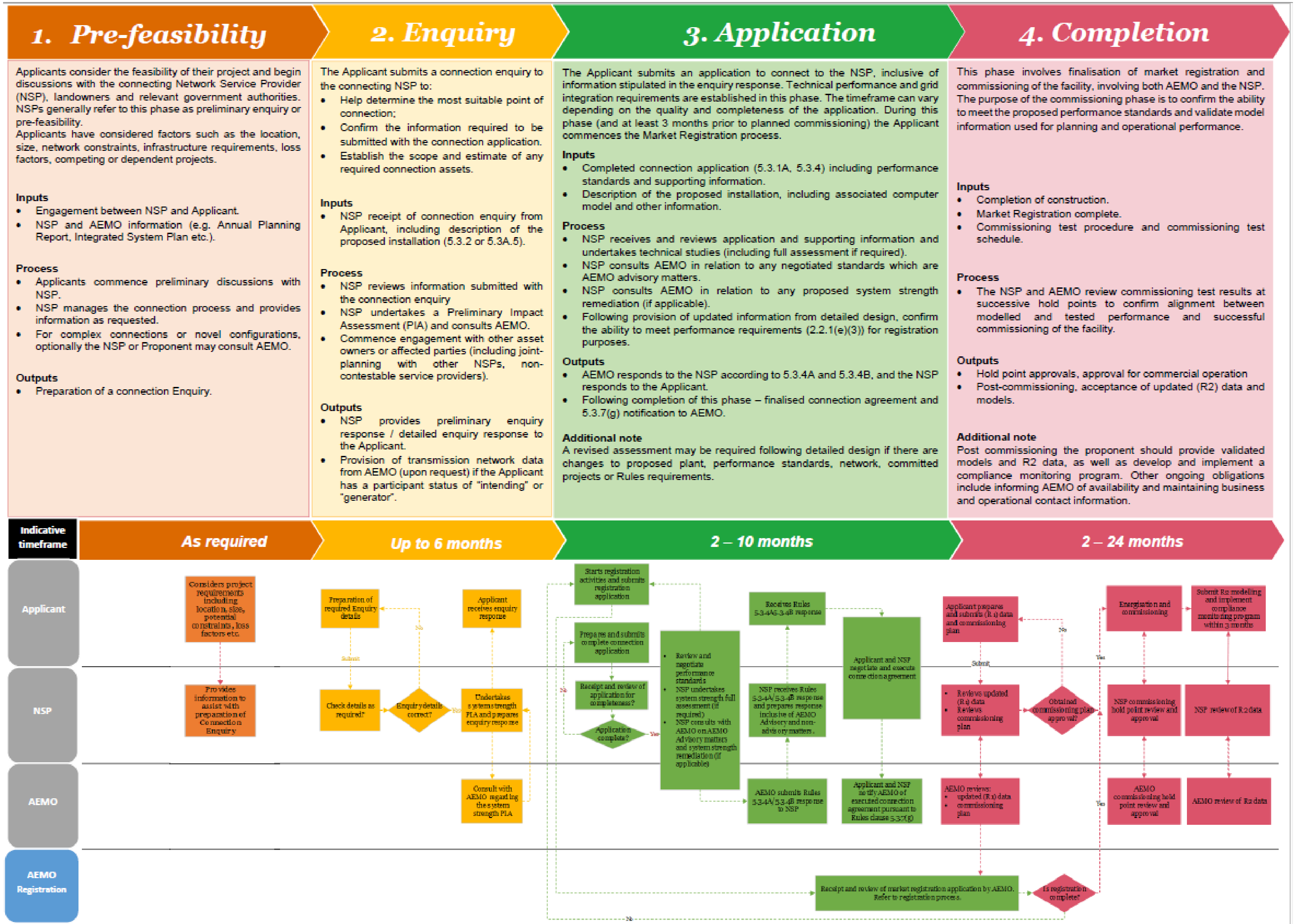


Figure 21: Connection application process for new *generators* (Source: AEMO)

5.5 Summary of constraints

Table 12 summarises the key constraints from the assessment of the broader transmission network and of the connections of new renewable energy generation sources.

Table 12: Summary of constraints

Category	Description	Detail of constraint	Comments
General	NSW has a pipeline of some 116 large-scale renewable energy proposals for more than 18,000MW of capacity,	Fewer than one in 20 are currently able to connect to the network due to transmission network constraints	Transmission augmentation works needed to support additional generation in REZ's.
Availability of natural gas	For industrial and domestic use.	Nil – Narrabri Gas Fields are adjacent, but yet to be developed. There is currently no gas transmission infrastructure to service the SAP. MPSC has a moratorium on the production of Coal Seam Gas (or CSG) in the region.	This exacerbates the challenge of sourcing alternatives using renewable energy in lieu of fossil fuelled options. The Hunter Gas Pipeline (HGP) that is proposed to run east of the SAP investigation area, is one of several options that Santos can consider for their transmission infrastructure solution for gas in the Narrabri region.
New England REZ	The New England renewable energy zone (REZ), shown in Figure 19 aims to attract 8000MW of new renewable generation capacity	Moree is remote to the New England REZ.	NSW Government will spend $79 million to assist with the acceleration of new grid connections needed to absorb the expected increase in new renewable energy generation. The augmentation works needed to support increases in new and large scale renewable energy generation connections in the Moree SAP may additionally require further network augmentation works than may be stipulated in the AEMO ISP.
Essential Energy network plans	Nil planned upgrade works over the next 10 years.	Current forecast is for a flat load projection, and has not considered the impact of the Moree SAP.	When the ultimate load demand for the Moree SAP exceeds the 33MVA summer rating of the Moree zone substation, augmentation (e.g. 3rd transformer) would be needed, or the

Category	Description	Detail of constraint	Comments
			establishment of a new Zone Substation within the Moree SAP
TransGrid network plans	Only an aged transformer is planned to be upgraded in the Bulk Supply Point.	Current forecast is for a flat load projection, and has not considered the impact of the Moree SAP.	New 66kV sub-transmission supply lines to the new Zone Substation in the Moree SAP will be needed. In addition, either 66kV or 132kV connection assets for any large-scale solar-farms in the Moree SAP will be necessary.
Renewable Energy connection applications	There is approximately 520MW of renewable generation connected in the NW area. A further 115 MW is committed to connect and more than 1,180MW is at an advanced stage in the connection process.	These projects are proposed to connect at 132 kV and 66 kV, increasing the power flow from the local 132 kV network to 330 kV network.	Limited capacity of the current 330 kV and 132 kV networks may result in output export limitations of new generators as the pool of generators in the area increases. This will also likely inhibit the economic viability of connecting additional generation in the general area.
Transmission network development	Planned upgrade works to support new renewable energy generation in NW area, estimated at $500-945 million.	Uncertainty on timing and completion of these projects as listed in the AEMO ISP.	Timing uncertainty.
System strength	For weak networks (where the SCR is < 3.0), additional works may be needed such as synchronous condensers or SVCs to provide additional system strength.	No system strength remediation issues had been flagged in the ISP as being needed in the Northern Region including the Moree area.	Subject to confirmation following the connection application of any large scale renewable energy facility in the Moree SAP.
Connection process for new renewable energy generators	Process requires formal enquiry and application to be supported by detailed technical studies to assess the potential impact of the proposed plant on the network, to gauge compliance with the NER requirements.	Process is lengthy – all connections of generators > 1MW would require to undergo this. Timing is between 10-40+ months, and also relatively expensive.	It is impossible to generalise on the likelihood of connection of any generic type of new renewable energy generation plant in the SAP since the impact of each plant could be very different on the network – depending on the size of plant, type of generator, controls, connection location on the grid, network stiffness, etc.

6 RENEWABLE ENERGY OPPORTUNITIES FOR MOREE SAP

6.1 Development criteria for new renewable generation projects

6.1.1 General

Irrespective of the renewable energy opportunity identified, project developers of new renewable energy generation projects in the Moree SAP would be seeking the following criteria to be met or addressed:

- Energy yield and variations in time of day and months of year – this may vary considerably for bio-energy plants which rely upon waste volumes and its suitability from the agricultural sector, but less so for solar farms
- Cost to acquire land and its suitability for development for the generation project, be it a solar farm (including topography, soil geo-technical conditions, clearing of vegetation/trees, flooding constraints, etc.)
- Capacity and ability of the existing transmission infrastructure to support the connection of the new facility
- Ease of obtaining a development approval
- Ease of securing a grid connection for the full proposed output of the project
- Transmission system marginal loss factors and anticipated changes in future years, and its impact on the project economics
- Grid/ system stability/ system strength issues, transmission constraints and any additional capital works needed to address this and remediation options for system strength issues
- Energy export curtailment and export limitations which may be placed by the network operators due to transmission network constraints
- Financial risk (including merchant/wholesale electricity market pricing)
- Risk mitigation options (including PPAs for energy produced)
- Construction risks
- Project financing and overall economics/returns on investment
- Availability of local skilled workforce for construction, as well as ongoing operations and maintenance
- Project timing/ scheduling - particularly if the plants were to be constructed ahead of the established demand for the energy from new businesses in the SAP
- Off-take arrangements or PPAs for the energy purchased.

6.2 Opportunities for additional solar generation in Moree SAP

6.2.1 General

New or additional solar farms would certainly be a key opportunity that must be pursued for the Moree SAP, to offset (meet or exceed) the energy demand from the new businesses and industries, and to achieve a net zero target. Hence, it is critical to ensure that sufficient land-area is allocated for this purpose in the Structure Plan.

Typically, as a rule of thumb, a 1 MW solar farm will occupy approximately 2 to 3 hectares of land for fixed tilt ground mounted panel arrays, but larger areas would be needed for solar farms with tracking systems with variable tilt angles requiring further separation distances between arrays (as per Moree Solar Farm, which occupies 306 hectares and produces 56MW, or about 6 hectares per MW).

6.2.2 Solar irradiation levels in Moree

On average[21], Moree is blessed and receives one of the highest levels of solar irradiation in NSW, of around 5.23 kilowatt hours per square metre daily, or about 1,959 kWh/m^2/year.

The Moree Solar Farm statistics[22] suggest a higher than normal annual energy output level of 210,000 MWh from the installed 70 MWdc (56 MWac) solar PV generating plant with trackers, or **about 3,000 kWhr/kWdc/yr**. A more conservative estimate would suggest an annual energy output level of about 120,000 MWh instead.

Ideally, fixed tilt solar panels installed in Moree should face a Northerly direction. Acceptable panel tilt angle range is 14° to 24° and the optimal angle is 19°.

Alternatively, tracking systems with panels tilted to face the rising and falling sun (from East to West) could be considered to produce additional amounts of energy (typically about 25 per cent higher than fixed tilt arrays), but need to be carefully considered based on scale to offset the higher installation and operations/maintenance costs of tracked systems with its moving parts and more complicated systems compared to simpler fixed tilt ground mounted systems.

Furthermore, the prevailing reactive-soil conditions in the Moree SAP needs to be considered in the designs, as it may result in ground subsidence issues (as encountered in the existing Moree Solar Farm) which can cause misalignment of array-tilting mechanisms and supporting structures, resulting in premature failures.

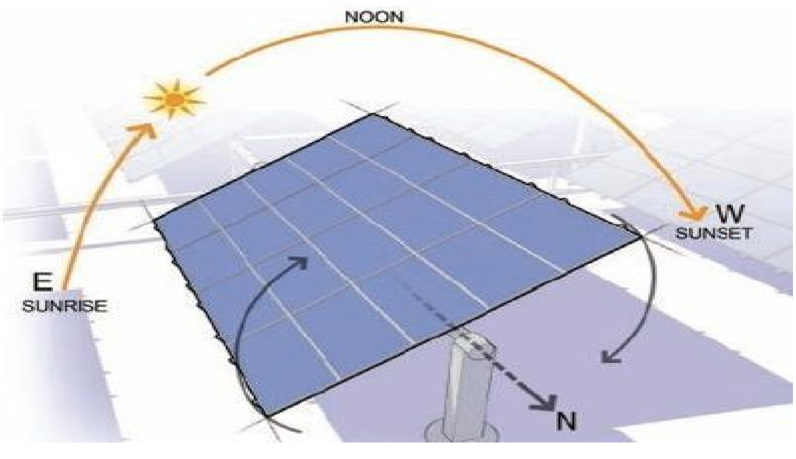


Figure 22: Single axis tracking system

A typical 5.3 kWdc residential fixed tilt solar PV system (comprising 20 x 265 Watt solar panels), would produce an average output of about 25kWhr/day or about 9,100 kWhr/year or a **normalised 1,716 kWhr/kWdc/yr**. This would provide both financial justification as well as sustainability benefits to the occupants/owners of the residential solar systems.

The benefits of larger solar PV installations on commercial and industrial facilities on either roof-tops or ground mounted arrays, could equally provide financial and sustainability benefits, depending on the energy consumption levels and profile of the

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21 Data from SolarGIS

22 http://moreesolarfarm.com.au/about-us/

energy usage over a 24 hour period within the premises, scale of the solar installation, suitability of the premises for the installation of the solar panels (roof pitch/ tilt angle and compass facing direction of the roof, strength of roof structure to support additional weight),etc.

There is an opportunity to incorporate the stipulation for the installation of roof-top solar PV on new facilities and premises in the SAP in future, as a planning or development approval/sustainability requirement.

Roof-top solar installations on large warehouses provide excellent opportunities to not only reduce the energy consumed by each facility through the installation of 'inside the fence' renewable energy generation sources, but also through the aggregation of renewable energy generated from various distributed energy resources/roof-top solar PV installations in the precinct, and managed using a Virtual Power Plant (VPP) model as explained later in this report.

6.2.3 Planned solar generation projects in Moree

It is envisaged that the connection approval to permit the expansion of the Moree Solar Farm to its full development potential of 150 MWac, or the connection of new large-scale solar farms in land-areas allocated as part of the Structure Plan for this purpose, is likely to be 'challenging' under the current circumstances due to transmission network constraints as noted in the AEMO ISP and in TransGrid's TAPR, unless the proposed transmission upgrade works in support of additional large-scale solar farms are undertaken by the transmission network operator.

The viability of expanding the Moree Solar Farm or to connect any new large-scale solar farm in the SAP to the grid can only be ascertained after a formal connection application is made and after specialised power system studies are undertaken to examine the available transmission system capacity and assess the impact of the connection of the additional solar-farms on the network, and to identify if there are any prevailing system strength remediation requirements to support an increased level of generation in the Moree SAP. This level of assessment is outside of the scope of this report.

6.3 Opportunities for bio energy plant in Moree SAP

6.3.1 General

According to the NSW Renewable Energy Action Plan, there are a number of plants currently producing biofuels in NSW:

- At Bomaderry, near Nowra on the south coast of NSW, the Manildra Group operates the largest of the three distilleries in Australia manufacturing ethanol, primarily for use as a transportation fuel
- At Rutherford, near Maitland in the Hunter Valley, Biodiesel Industries Australia produces biodiesel, mainly from used cooking oil and tallow feedstocks
- National Biofuels Group at Port Kembla is developing a new plant to produce biodiesel from soybeans.

Several pre-commercial advanced biofuels facilities are also operating:

- At Somersby, on the NSW Central Coast, a demonstration plant operated by Licella, converts woody materials and other bio-mass into liquid bio-crude oil that has refining potential for use as petrol, diesel and aviation fuel
- At Bomaderry, Algaetec has commenced production of algae biomass on an industrial scale from its showcase biofuels facility

- At Harwood sugar mill, near Maclean on the far north coast, Ethtec operates a pilot plant for the production of ethanol from cellulosic feedstocks such as bagasse and forestry residues.

6.3.2 Bio Energy Potential at Moree

A primary consideration for bio-energy opportunities at Moree SAP is the availability of suitable feedstock.

The opportunities for bio-energy at Moree could include:

- **Agriculture Waste** - composting, gasification, pyrolysis, fermentation (ethanol), anaerobic digestion and direct incineration. Cotton biomass waste is understood to be relatively abundant from current agricultural production in the Moree region.

  Cotton stalk plant residue left in the field following harvest is typically buried or burned to prevent it from serving as an overwintering site for insects which can incur economic costs and detrimental environmental effects. A common use of cotton trash by cotton farmers in Moree, is to mulch it at the cotton gin and reintroduce it back to the soil. After harvesting the cotton lint, the remaining stems and leaves, called cotton stalks are currently mixed with soil to avoid future pest infestation and to facilitate soil preparation for the next cropping season. Mulching cotton stalks into the soil not only incurs additional cost to cotton growers but also promotes soil erosion due to disruption of the soil structure and potentially contributes to airborne dust. Some studies report that mixing cotton stalks into the soil had negligible benefits in improving soil organic matter.

  Studies indicate that un-debarked cotton stalks are unsuitable for the production of fine paper and dissolving pulps, and cotton stalks and other agricultural residues are unsuitable for hardboard and particle board due to their high water absorption and thickness swelling.

  cotton stalks contain lignin (21.4 per cent) and carbohydrates, like cellulose (58.5 per cent) and hemicellulose (14.4 per cent), which makes it a particularly attractive feedstock for thermochemical conversion processes, which can be converted into a variety of usable forms of energy. Thermochemical or biochemical processes are considered technologically advantageous solutions.

  The potential usage of cotton waste as an energy feedstock has been studied in recent years, with researchers generally focusing on the production of biogas, ethanol, and the production of fuel pellets or briquettes. Several studies on the subject of cotton waste pyrolysis indicate that pyrolysis of cotton stalks is deemed to have potential as one of the technological solutions for its management. Moreover, some products from the conversion (e.g., biochar from pyrolysis) can be used as soil additive to recover nutrients and carbon to the soil. The latter can additionally act to improve the water storage ability for the soil.

  Solid cotton gin waste cannot be directly reused on-farm due to farm hygiene risks. Composting either on-farm or at the gin is a typical method for disinfection and pesticide degradation. On-farm cotton residues are fundamental for minimising losses in soil carbon, organic carbon content and surface protection. Converting these wastes to energy using various treatments such as gasification, pyrolysis and anaerobic digestion minimises the land required for processing.

  Studies to examine the size of cotton industry in Australia and the associated by-products produced have been undertaken by the University of Southern Queensland[23]. The strengths, weaknesses, opportunities and threats of different

[23] https://eprints.usq.edu.au/30016/

options for utilising cotton wastes throughout processing were examined. The technical, environmental and economic aspects of waste management were considered from the cotton industry and concluded that pyrolysis of cotton stalks is a good option, and also using cotton gin trash (CGT) for ethanol production.

Cotton stalks possess high amounts of carbon (47.05 per cent) and oxygen (40.77 per cent) and its composition is relatively similar to wheat straw and wood. The presence of these elements in biomass leads to more char formation as well as to the high calorific value of the product. Therefore, because cotton stalks, wheat straw, and wood have high carbon and oxygen contents, they are suitable for energy production and could be combined with the supply of biochar.

Studies have also shown that raw cotton stalks provide higher combustion efficiency and longer burn time than some other agricultural residuals; furthermore, the energy needed to collect and process these residues is a small percentage of the energy contained within them.

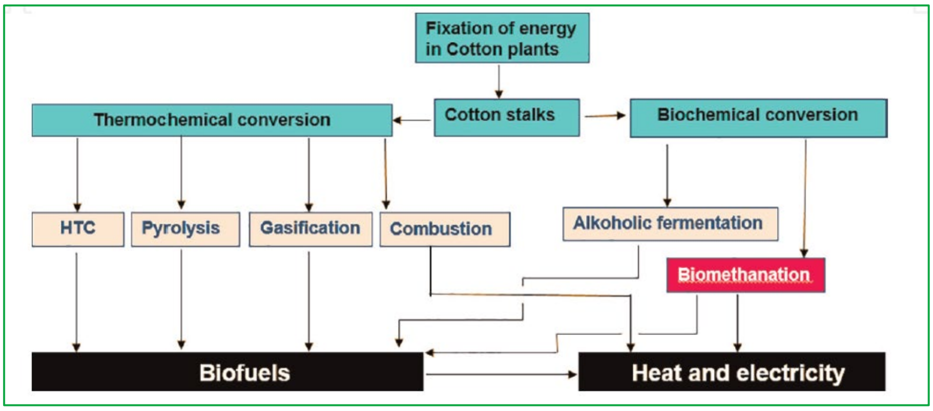

Figure 23: Diagram of the processes of energy conversion of cotton stalks

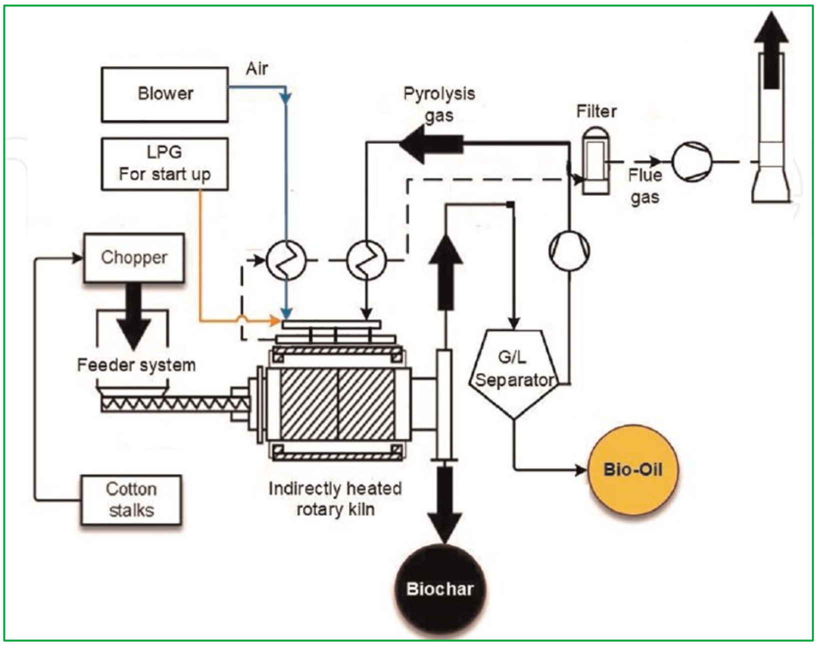

Figure 24: Pyrolysis process for cotton stalks

Other studies have concluded that the integrated processes of anaerobic digestion and pyrolysis, as shown in Figure 25, could be technically and economically feasible.

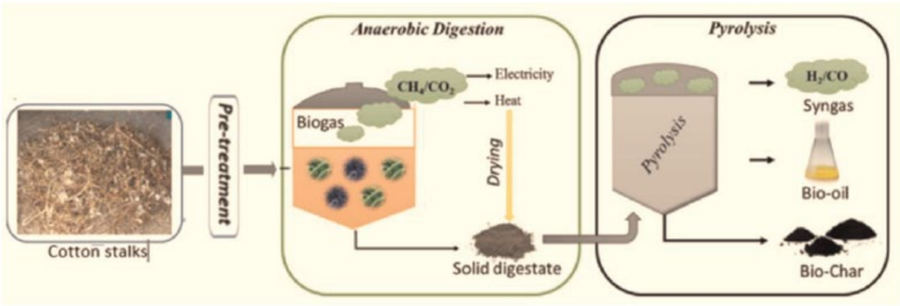

Figure 25: Integrated anaerobic and pyrolysis processing of cotton stalks

It is anticipated that various agricultural sources could be converted into pellets for use in combustion processes in bio-energy plants. Such sources of agricultural waste may include those as shown in Figure 26.

Figure 26: Examples of agricultural waste which can be pelletised

Pyrolysis of cotton stalks has been investigated to produce biochar and bio-oil products. Successful development of a cotton stalk-based bioenergy plant requires a comprehensive assessment of cotton stalk availability and a low-cost supply logistics system to estimate the delivered cost from waste sources.

Figure 27: Cotton Stalk Pellets

Studies[24] have suggested that the availability of cotton stalks can be estimated from the cotton lint yield and the residue-to-crop ratio (RCR) or experimental cotton stalks yield data. For cotton, the RCR value varied from 1.6 to 5.0 with a median value of 4.0 – this suggests that for every tonne of cotton lint produced, there could be the potential of 4 tonnes of cotton stalks.

Other studies[25] experimentally determined that the cotton stalks yield ranged from **2.2 to 2.7 dry tonnes per hectare**. Other relevant data suggests lint yield per hectare of 0.75 to 2 bales/hectare (dryland) and 10 to 12 bales/hectare (irrigated)[26].

Based on the figure of 93,000 hectares of dryland cotton being planted in the 2019 season[27] in the Moree region, the above ratios suggests that the potential volume of cotton stalks could be as much as 251,100 dry tonnes per annum. We note that there is significant volatility in the annual yield of cotton as this is grown without irrigation, and in dry years has very low yield with the future risk of climate change exacerbating this.

On the basis of cotton stalks having the highest burning efficiency and longest burn time compared to corn stover and soybean residues, with dry cotton stalks having a Low Heating Value (LHV) of 17.1 MJ/kg, assuming an overall energy conversion efficiency of 20 per cent, **this suggests a maximum potential renewable energy generation of 236 GWhr per annum from cotton stalks, if all the available cotton stalks from cotton farmers were harvested and used.**

Note: the effect of pesticide residue on feedstock and the impact this may have on any emissions or outputs has not been considered in this report and may be addressed in the air, noise and odour report instead.

6.3.3 Renewable energy in intensive horticulture

A successful hydroponics operation for tomato production in Port Augusta, in South Australia utilises Concentrated Solar Thermal (CST) to direct the sun's rays to a tower to be used for heating of water and production of steam, and used to desalinate saltwater (from the sea) to be used for the tomato plantation in a glasshouse hydroponics set up.

The $200 million plant operated by Sundrop Tomato, has generated jobs for around 175 people. It is the first commercial scale facility of its calibre in the world, using

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[24] Akdeniz et al., 2004; Holt et al., 2004; Milbrandt, 2005; Wanjura et al., 2014

[25] Sumner et al., 1984; Sumner, 1983

[26] https://www.cottonaustralia.com.au/assets/general/Publications/Annual-Reports/2019-20-Cotton-Australia-Annual-Report-web.pdf

https://www.gvia.org.au/the-gwydir-valley/industry-profiles/cotton/

[27] https://www.moreechampion.com.au/story/5869119/2019-dryland-crop-the-second-biggest-since-commercial-production-began/

sunlight and seawater to grow 15 million kg of truss tomatoes a year that will be sold exclusively through Coles supermarkets via a 10-year offtake agreement.

Figure 28: Hydroponics Tomato Plantation using Solar Thermal

The greenhouses will also produce more than 450,000 m^3 of freshwater per year, equivalent to 180 Olympic size swimming pools, and displace the use of more than 2 million litres of diesel per year.

The technology was developed by Danish renewables company (Aalborg), and includes a 137-metre high concentrated solar power tower system, and a 51,500 m^2 solar field consisting of more than 23,000 heliostats.

A similar application could be considered for Moree if the available water quality from the GAB is unsuitable for direct use in irrigation (especially in the mineral content, management of the discharge of it and the need to keep it separated from the other water sources), or if water supply is limited in quantity to support a similar industry in the Moree SAP.

CIE mentions the likely requirement for treatment of water from the GAB using Reverse Osmosis (RO) plants. These may typically require about 2 kWhr/litre of water to be treated. Thermal solar could provide an alternative to this, in addition to being used as a hybrid plant with conventional solar PV generation to produce the electrical energy needs for the facility.

Placements for any thermal solar facility must be carefully considered in the Moree SAP, including but not limited to:

- **Avoiding locations adjacent to any prevalent flight paths/airport due to potential glare from the heliostat mirrors, and height of the tower unit,**
- **Accounting for larger land areas due to the placement and installation requirements for the heliostat mirrors.**
- **Proximity to water source to be treated, and discharged (to minimise storage, pumping and piping requirements).**

6.4 Opportunities for hydrogen production in Moree SAP

6.4.1 General

The use of hydrogen will undoubtedly become part of the sustainable future and its role in the energy transition is widely recognised as providing new opportunities for local industry in Australia to capitalise on this.

There has been a considerable amount of work undertaken (both globally and domestically) seeking to quantify the economic opportunities associated with hydrogen. The *Australian National Hydrogen Roadmap*[28] takes that analysis a step further by focusing on how those opportunities can be realised and provides a blueprint for the development of a hydrogen industry in Australia in general.

With a number of activities already underway, it is designed to help inform the next series of investment amongst various stakeholder groups (e.g. industry, government and research) so that the industry can continue to scale in a coordinated manner.

The low emissions hydrogen value chain consists of a series of mature technologies. While there is considerable scope for further research and development, this level of maturity has meant that the narrative has shifted from one of technology development to market activation.

Barriers to market activation stem from a lack of supporting infrastructure and/or the cost of hydrogen supply. However, both barriers can be overcome via a series of strategic investments along the value chain from both the private and public sector.

The *National Hydrogen Roadmap* [28] shows that while government assistance is needed to kick-start the industry, it can become economically sustainable thereafter. This is demonstrated by first assessing the target price of hydrogen needed for it be competitive with other energy carriers and feedstocks. Second, the assessment considers the current state of the industry, namely the cost and maturity of the underpinning technologies and infrastructure. It then identifies the material cost drivers and consequently, the key priorities and areas for investment needed to make hydrogen competitive in each of the identified markets.

6.4.2 Applications for hydrogen

The opportunity for hydrogen to compete favourably on a cost basis in local applications such as transport and remote area power systems is within reach based on potential cost reductions to 2025. Further, the development of a hydrogen export industry represents a significant opportunity for Australia and a potential 'game changer' for the local industry and the broader energy sector due to associated increases in scale.

Hydrogen gas ('hydrogen') is a versatile energy carrier and feedstock, derived primarily by splitting water or by reacting fossil fuels with steam or controlled amounts of oxygen. While hydrogen has served mostly as an input into a range of industrial processes, it has the potential to be used across a number of applications, including:

- As an **energy source** for:
  - Electricity generation
  - Heating
  - Low emissions transport solutions
- As a **feedstock** for:
  - Ammonia production
  - Chemicals and petrochemicals industry
  - Glass manufacturing
  - Metals processing
  - Synthetic fuels
  - Food industry.

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[28] https://www.csiro.au/en/Do-business/Futures/Reports/Energy-and-Resources/Hydrogen-Roadmap

Further, if produced using low or zero emissions sources, ('clean') hydrogen can enable deep decarbonisation across the energy and industrial sectors.

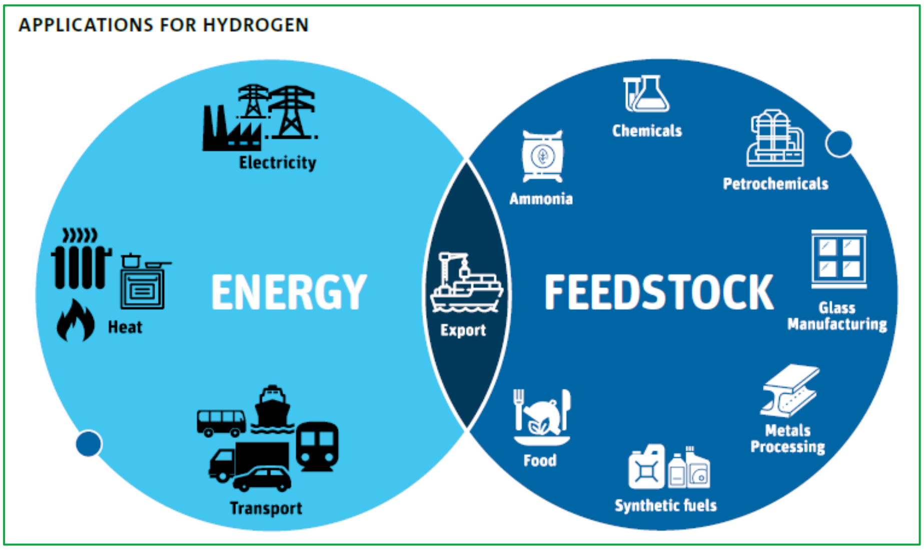


Figure 29: Potential applications for hydrogen [28]

The *National Hydrogen Roadmap* [28] recognises there are a number of domestic trends and characteristics that favour its widespread use, and has particular relevance also to the Moree SAP. These include:

- **Natural gas supply**: On the east coast of Australia, gas prices currently remain high ($8-10/GJ) compared to some overseas markets, with some uncertainty regarding future cost trajectories. Hydrogen could replace natural gas as a low emissions source of heat as well as a potentially cost competitive low emissions feedstock for a number of industrial processes, in the future when hydrogen production costs are lowered.
- **Changing electricity sector**: Hydrogen can help manage the transition to a higher proportion of Variable Renewable Electricity (VRE) in the electricity network by overcoming challenges associated with energy intermittency. Hydrogen offers an opportunity for optimisation of renewable energy use between the electricity, gas and transport sectors (i.e. 'sector coupling').
- **Liquid fuels security**: Australia has long been dependent on imported liquid fuels and at present, is not meeting domestic fuel reserve targets. Hydrogen can play a key role in protecting Australia from supply shocks by localising liquid fuel supplies (e.g. by producing synthetic fuels) or by displacing their use in both stationary and transport applications.

6.4.3 Potential for hydrogen use in Moree

Moree's high solar irradiation levels (the highest in NSW[21]), the proximity of the Moree Solar Farm to the SAP, access to water supplies from deep aquifers and as well as available land lends favourably to the potential of establishing a hydrogen production facility at Moree to support local industry for:

- **Clean transportation solutions** (for use in hydrogen fuelled buses, locomotives and long distance heavy haulage trucks in-lieu of diesel fuels, in the future)
- **Agriculture and farming** (as a fuel substitute to diesel, when machinery and equipment are developed to operate on Hydrogen in the future)
- **Power generation solutions** (when coupled with hydrogen fuelled turbines or fuel cells)

- **Home and commercial/ industrial application** (as a substitute for natural gas as a fuel / process-gas for heating)
- **Industrial applications** (as a raw material/ feed-stock to support value-add industries, such as ammonia, methanol and fertilizer production)
- **Energy buffer** (for 'storage' of energy from surplus levels of generation at times of low load or when export levels from large grid-scale renewable operations are curtailed or restricted).

6.4.4 Hydrogen production and efficiencies

The production of hydrogen may be from two methods:

- **Thermochemical** - using a fossil fuel feedstock e.g. Natural Gas (through incineration, and paired with Carbon Capture and Storage or CCS, of which there is none in the Moree SAP, but possibly in the Narrabri gas region in the future); or
- **Electrochemical** - using Water (for which there is a reasonable supply of it in the Moree SAP, particular when coupled with renewable solar energy generation).

Thermochemical production of 'Grey Hydrogen' using methane or coal with CCS is less challenging than the production of 'Green Hydrogen' using electrolysers, especially at 'scale'.

For Grey Hydrogen, the necessary inputs (i.e. coal, methane, pore space for CO_2 storage) are required to be relatively plentiful at the production facility, e.g. at coal mines. The technology is also more mature and proven at large scales to currently be the lowest cost source for the production of hydrogen. There are many facilities in operation globally which produce hydrogen from fossil fuels with CCS at large scale (ranging from 200 to 1,300 tonnes of hydrogen/day).

The **thermochemical process** of Hydrogen production using coal gasification, is briefly described below:

- Chemically, coal is a complex and highly variable substance that can be converted into a variety of products. The gasification of coal is one method that can produce power, liquid fuels, chemicals, and hydrogen.

  Specifically, hydrogen is produced by first reacting coal with oxygen and steam under high pressures and temperatures to form 'synthesis gas', a mixture consisting primarily of carbon monoxide (CO) and hydrogen (H_2).
- Coal gasification reaction (summarised):

  $$\mathbf{CH_{0.8} + O_2 + H_2O \rightarrow CO + CO_2 + H_2 + \text{other impurities}}$$

- After the impurities (e.g. H_2S, Sulphur) are removed from the 'synthesis gas', the carbon monoxide (CO) in the gas mixture is reacted with steam (H_2O) through the water-gas shift reaction to produce additional hydrogen and carbon dioxide:

  $$\mathbf{CO + H_2O \rightarrow H_2 + CO_2}$$
- Hydrogen (H_2) is removed by a separation system, and the highly concentrated carbon dioxide (CO_2) stream can be subsequently fed into Carbon Capture and Storage systems (CCS).
- The Hydrogen and carbon monoxide produced, and also when added with Nitrogen, can be used for a variety of purposes, as shown in Figure 30.

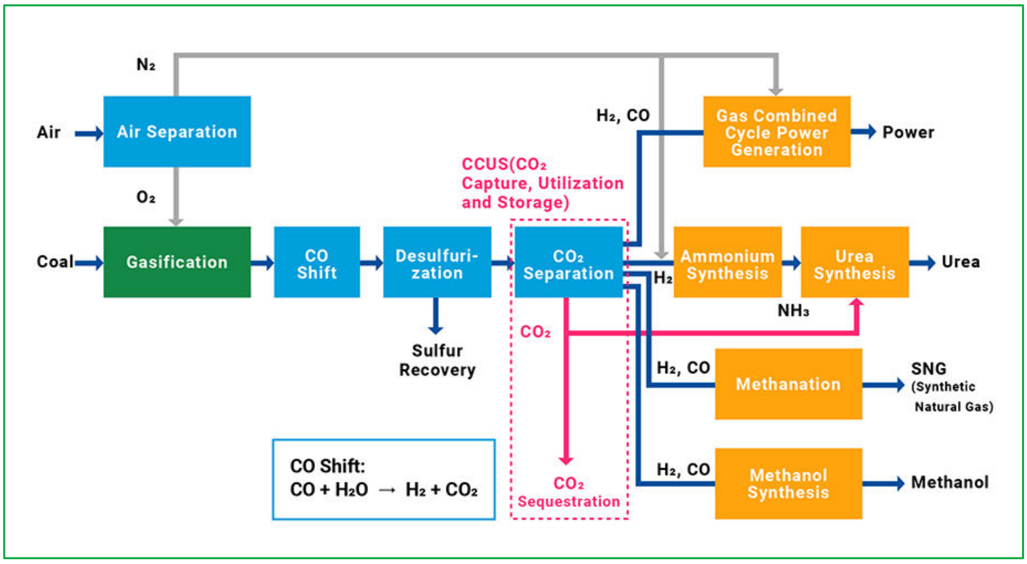


Figure 30: Thermochemical production of hydrogen

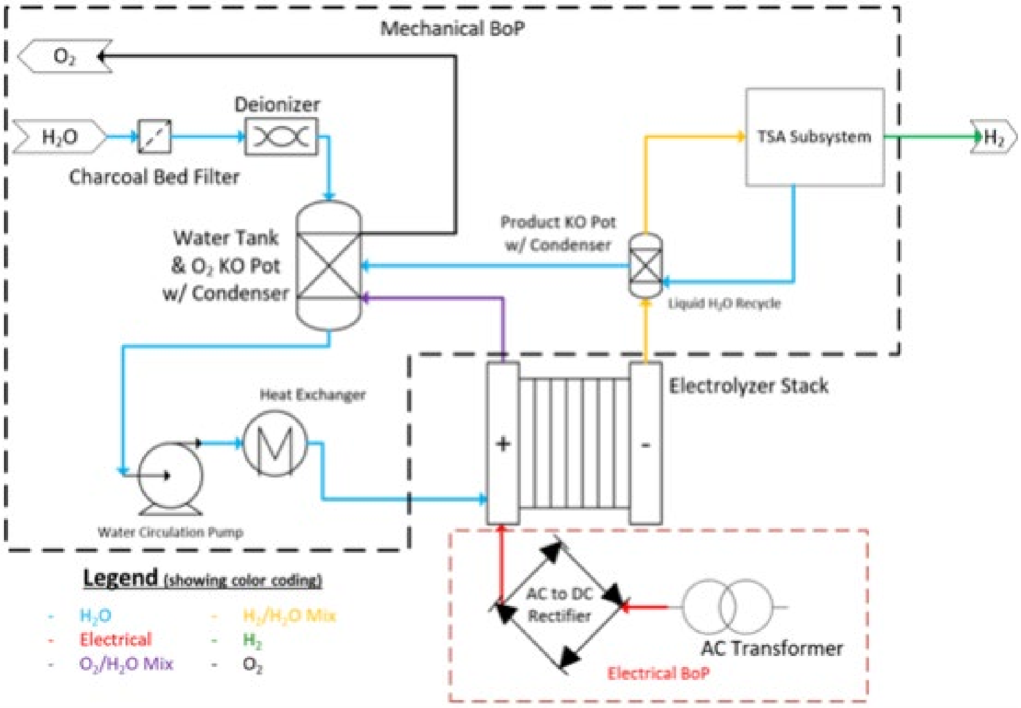
The **electrochemical conversion** of water to hydrogen takes place via electrolysis, where the water molecule is split into hydrogen and oxygen using electricity. The electrolysers split the water molecules into hydrogen and oxygen:

$2\ H_2O \rightarrow 2\ H_2 + O_2$

Typical conversion efficiencies of industrial scale polymer electrolyte membrane (or PEM) electrolyser and alkaline electrolysis (AE) is about 75 per cent. The conversion process 'consumes' the water and results in the production of hydrogen and oxygen gases, which can be stored and used as previously outlined.

Typical statistics for plant and equipment used in the hydrogen space, are as below:

- Industrial electrolysers have a typical conversion efficiency of about 75 per cent.
- Electrolysers typically consume ~ 10 to 16 litres of de-ionised (DI) water per kilogram of hydrogen produced depending on the electrolyser technology adopted. It is important to note that this necessitates the conditioning and treatment or raw water supplies to a required level of purity before the water can be introduced into the electrolysers.
- Electrolysers also consume about 52 to 60 kWhr of electrical energy per kilogram of hydrogen produced.
- Fuel cells have a conversion efficiency of about 50 to 60per cent.
- Fuel cells can generate about 17 to 20 kWhr per kilogram of hydrogen.



Source: NEL

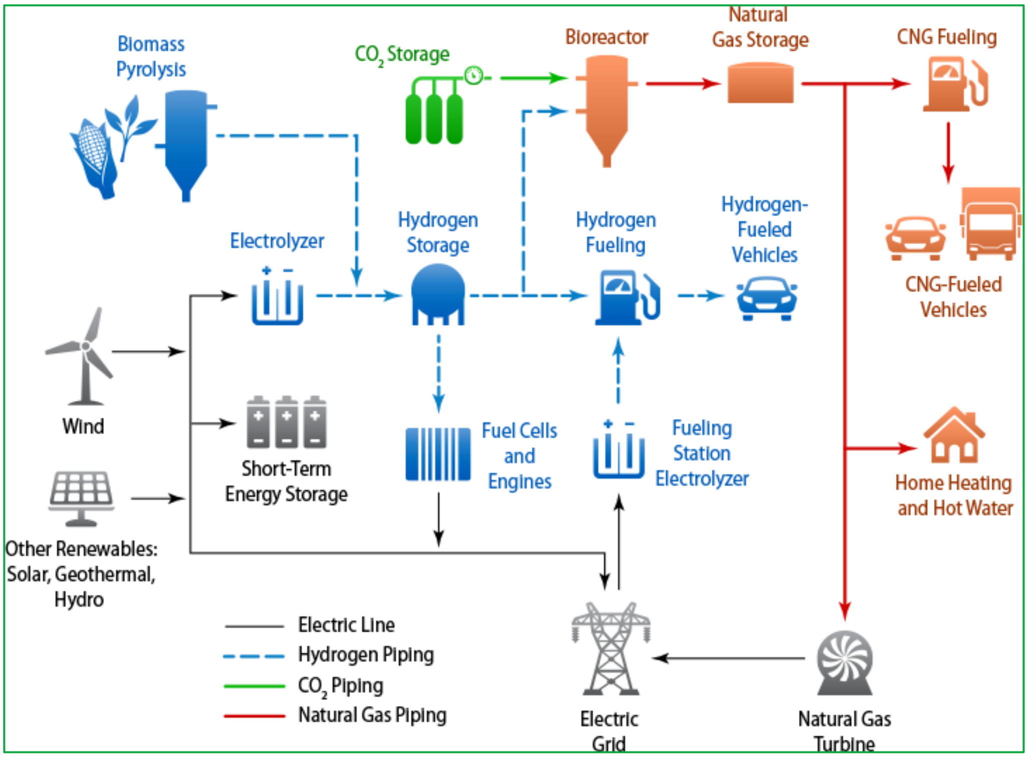
Figure 31: Typical electrolyser process flow diagram

If the electricity source to the electrolysers is sustainable (e.g. from renewable energy sources such as solar PV or bio-energy), then the hydrogen produced is commonly referred to as “green hydrogen”.

Electrolysis provides a more modular, distributed option that can be scaled up according to future demand. It is therefore more likely to meet the majority of hydrogen demand prior to 2030 and the expected cost curve is reflected in the hydrogen competitiveness figure shown later in this section of the report.

AE is currently the more established and cheaper technology (about \$5.50/kg H_2) and will therefore continue to play an important role in the development of the industry. Despite its level of maturity, incremental improvements in AE can still be achieved through subtle gains in efficiency.

Although currently more expensive, PEM electrolysis is fast becoming a more competitive form of hydrogen production. It also offers a number of other advantages over AE including faster response times (which makes it more suitable for coupling with VRE) and a smaller footprint for scenarios in which there are limitations on space (e.g. hydrogen refuelling stations). RD&D is expected to lead to improvements in PEM plant design and efficiencies. Increases in production economies of scale are also likely to reduce technology capital costs.



Source: NREL

Figure 32: Scenarios for hydrogen production and usage[29]

6.4.5 Comparison between green and grey hydrogen production

Table 13 provides some stark comparisons between the two, namely in the amount of energy needed to produce the same amounts of hydrogen.

Table 13: Electricity Requirements per 100 tonnes per day H_2 produced[30]

	Specific Electricity Consumption (kWh/kg of H_2)	**Approximate Continuous Power Requirement (MW)**	**Required Renewable Electricity Installed Capacity Assuming a Capacity Factor of 0.3**
Electrolysis (PEM)	54.6	227	757MW
Steam Methane Reformation with CCS	2	9	30MW
Coal Gasification with CCS	4	18	60MW

Production of Green Hydrogen (using electrolysis) uses **25 times more energy** than production of Grey Hydrogen (using steam methane reforming with CCS) and **12 times more energy** than production using coal gasification with CCS.

As such, the ultimate scale of potential Green Hydrogen production in the Moree SAP is constrained by the amount of renewable electricity and water that is available in the area (or alternatively imported into the area). It is worth noting also that water quality

29 https://www.nrel.gov/hydrogen/renewable-electrolysis.html
30 Global CCS Institute

for use in Hydrogen production using electrolysers, requires pre-treatment typically using Reverse Osmosis plant, and as such recycled town water or water from WWTP would be unsuitable for use without undergoing pre-treatment.

The above suggests that a plant producing 10 tonnes per day of clean hydrogen via electrolysis would require 75 MW of installed renewable electricity capacity to power it, which is ~ the current size of Moree Solar Farm (70 MWdc).

However, the consumption of water for that level of hydrogen production, would be approximately 240,000 litres per day (or 87.6 gigalitres per year) and may exceed the allocations of water available to the Moree SAP.

6.4.6 Cost of hydrogen production

The cost of hydrogen from both types of electrolysis can be significantly reduced via the scaling of plant capacities (e.g. from 1 MW to 10 MW to 100 MW), greater utilisation and favourable contracts for low emissions electricity (e.g. 4 to 6 c/kWh). With a number of demonstration projects likely over the next three to four years needed to de-risk these assets at scale, it is expected that costs could reach approximately \$2.29-2.79/kgH_2 by 2025.

Due to the losses in the conversion/electrolysis process (of hydrogen production), and then further inherent losses in the downstream usage processes (such as in industrial heaters, boilers, furnaces or in power production applications), the route to hydrogen application in heating, power generation or as an energy buffer does not make sense, and overall process efficiencies favours instead routes for local use of hydrogen within the Moree precinct, e.g. for transport applications, or as a raw material for industrial applications (ammonia/ fertiliser production).

If hydrogen produced is to be stored, then shipped or transported for use outside of the Moree precinct, the further efficiency losses would arise from the storage, compression/liquefaction, distribution/transportation, etc. of the supply chain. Furthermore, the necessary supporting infrastructure to enable the usage of hydrogen outside of the Moree SAP will necessitate further investments which relies on 'scale' to ensure returns on the capital investments to be made.

6.4.7 Hydrogen competitiveness

Compression of gaseous hydrogen generally represents the most attractive option for stationary storage given the comparatively lower cost and greater availability of space. With likely improvements in compression efficiencies, storage of hydrogen is expected to add ˜\$0.3/kgH_2 to the cost of hydrogen produced by 2025 (as reflected in the hydrogen competitiveness curve as shown in Figure 33).

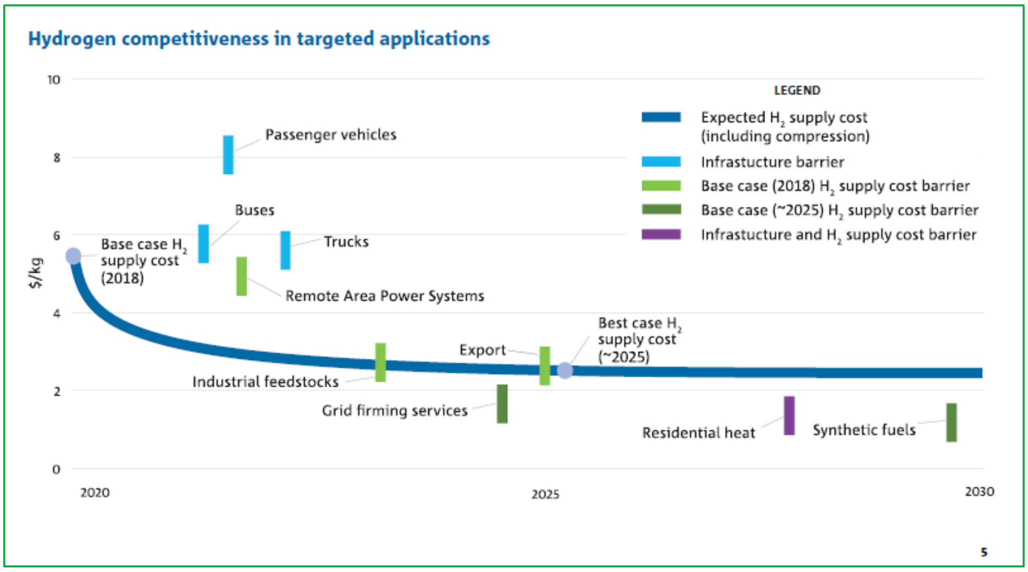


Figure 33: Hydrogen Competitiveness Curve (CSIRO)

Indeed, the hydrogen competitiveness curve highlights the potential expected reductions in the cost of hydrogen supply and the progression of target markets based on when hydrogen could be commercially competitive with alternative technologies. It also identifies where the barrier to market is infrastructure (i.e. above the 'hydrogen cost curve') and/or the cost of hydrogen supply (i.e. below the 'hydrogen cost curve').

The competitiveness of hydrogen against other technologies is likely to then improve when considering factors such as localisation and automation of supply chains, energy supply and carbon risk. Further, while each application has been assessed individually, a unique advantage of hydrogen is that it can simultaneously service multiple sources of demand. Thus, in practice, a single suitably scaled hydrogen production plant could secure offtake agreements in a number of applications depending on available infrastructure, policy and demand profiles, from both local and external usage.

Hydrogen systems consisting of storage and fuel cells are unlikely to be constructed for the sole purpose of grid stability, due to the need for a hydrogen price of less than $2/kg to compete with batteries, pumped hydro and gas turbines.

Direct combustion of hydrogen for the purpose of generating heat is unlikely to compete with natural gas on a commercial basis before 2030.

6.4.8 Potential hydrogen projects in Moree SAP

It is understood during the site visit, that there is a proposal to develop a small scale 300 kW hydrogen facility which utilises the renewable energy generated from the Moree Solar Farm and disposed aquifer water from the nearby ski-park ponds (Moree Water Park), to produce about 80 kg of hydrogen per day. The hydrogen produced is planned to be used as a fuel source for a zero-emissions bus trial project. The project has interested parties which include suppliers of electrolysers, water treatment (reverse osmosis) equipment, gas compressors, hydrogen storage and refuelling equipment, as well as manufacturers of fuel-cell buses and even locomotives from the USA. It is uncertain if the project has achieved financial close at the time of preparing this report.

The proposed plant is aimed to be modular, and as such, the operation could potentially be scaled up to produce hydrogen for use as a feedstock for local industrial applications including ammonia and fertiliser manufacturing, or for use in industrial facilities as a substitute for natural gas (e.g. in value-add agribusinesses).

Large scale electrolysis facilities currently utilise modular solutions that can be scaled up according to future demand. The largest PEM electrolyser (currently built by Siemens, the SILYZER 300 – Figure 34) is a modular design that makes unique use of scaling effects to minimize investment costs for large-scale industrial electrolysis plants. With each SILYZER 300 module capable of producing 100 kg of Hydrogen per hour, stacking multiple PEM modules to produce up to 2,000 kg/hr (or 48 tonnes per day, assuming continuous electrolyser operation) is the approach adopted by Siemens – e.g. for a 17 MW plant (double digit class), utilising an array of 24 x electrolyser modules, producing 340 kg/hr. Single large electrolysers in excess of 100 MW (triple digit class) are currently not yet available and are only in early development phase, however, Siemens expects that their SILYSER portfolio would scale up by a factor of 10 every 4 to 5 years driven by market demand and as more hydrogen projects are co-developed with their clients globally.

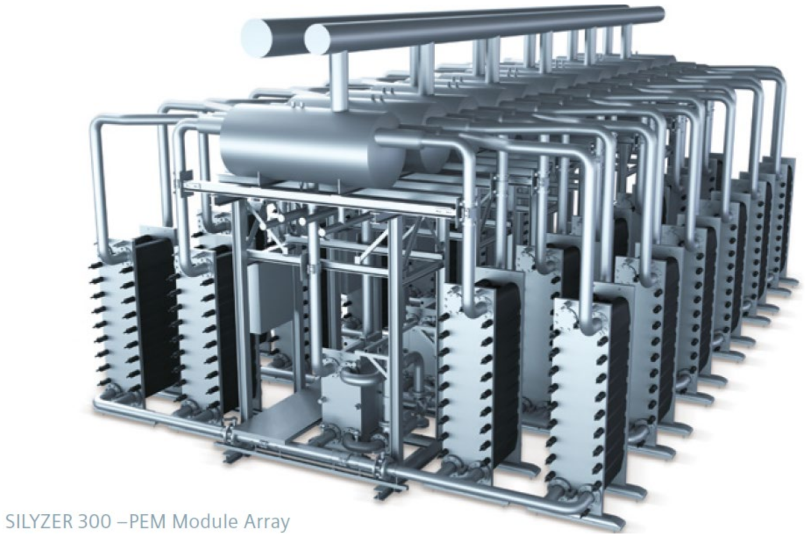


Figure 34: PEM Module Array (Source: Siemens)

Arcadis' analysis suggests that there is an opportunity to potentially produce about 5 tonnes of green hydrogen per day utilising renewable energy from new solar farms which could be developed in the SAP in future, in addition to supplying the load and electrical energy requirements of new businesses in the SAP.

Examples of similarly sized plants have been announced in other parts of the world, including:

- Japan announced the completion of the Fukushima Hydrogen Plant (Figure 35), by the Fukushima Hydrogen Energy Research Field (FH2R), which was the world's largest facility for green hydrogen production from renewables. The plant uses a 20 MW solar array, backed up by renewable power from the grid, to run a 10 MW electrolyser at the site which can produce up to 100 kg of hydrogen an hour, with initial output directed to fuel hydrogen cars and buses in Japan, including some to be used at the Tokyo Olympics.

Figure 35: Fukushima Green Hydrogen Plant

- AkzoNobel (the global paints, coating and specialty chemicals firm), has unveiled plans to build Europe's largest green hydrogen production plant in a bid to cut global CO_2 emissions. The facility, to be built in the Netherlands in collaboration with gas network operator Gasunie, would use a 20 MW water electrolysis unit to convert sustainable electricity into hydrogen. The planned installation would produce around 3,000 tonnes of green hydrogen each year, which can either be used by AkzoNobel's chemicals division or be sold to third parties, such as public transport companies using hydrogen buses. The eventual aim is to convert and store sustainable energy in the form of hydrogen on a much larger scale, with plants of at least 100 MW.

6.5 Virtual Power Plants (VPP)

A Virtual Power Plant (VPP) is an interconnection of a combination of various Distributed Energy Resources (DERs) including roof top solar PVs, solar farms, bio-energy power plants, Energy-from-Waste plants, etc., and may also include large consumers of loads (e.g. industrial plants or hydrogen production plants), as well as distributed or centralised energy storage systems – all controlled and managed centrally.

The operation and ownership of respective energy generation plants, storage systems and plants that consume load/energy may be completely independent of the operator and owner of the VPP, however the inclusion of the respective plants to be integrated and controlled by the central VPP operations is critical.

The objective of a VPP is to relieve the load on the grid by smartly dispatching and distributing the power generated by the individual units during periods of peak load. Additionally, the combined power generation and power consumption of the networked units in the VPP is traded on an energy exchange basis.

The participants of the VPP are connected to the VPP's central control system via a remote control unit to allow all assets to be efficiently monitored, coordinated and controlled by the VPP central control system. Control commands and data are transmitted via secured data connections which are shielded from other data traffic due to encryption protocols.

In addition to operating every individual asset in the VPP along an optimized schedule, the central control system uses a special algorithm to adjust to commands from the transmission network operator, market pricing signals, energy demand and generation levels, etc. just as larger conventional power plants that participate in the wholesale electricity market do.

The bidirectional data exchange between the individual plants and the VPP not only enables the transmission of control commands. It also provides real-time data on the capacity utilization of the networked units. For example, the feed-in of solar plants, as well as consumption data and BESS charge levels, can be used to generate precise forecasts for electricity trading and scheduling of the controllable power plants.

The establishment of a VPP for the Moree SAP offers exciting opportunities to enable the effective control of all available energy generation sources within the SAP, control of energy consumption by loads, and the maximisation of the sustainability position of the Moree SAP.

6.6 Micro-grid / embedded network

The challenges of connecting large solar-farms in the electricity grid at Moree was highlighted in the earlier sections of this report – namely with the likely challenge that is expected to be faced by the proponents intending to connect large grid-scale solar-farms in the Moree SAP given the large number of projects already proposed to be connected and the limitation in transmission system capacity to ensure un-curtailed exports.

This suggests a potential benefit of establishing a privately owned, embedded network that is effectively a "micro-grid" which may allow the development of suitably sized large solar farms and other generation sources, to effectively supply the new industries and businesses/precincts in the SAP directly by the new generation sources, controlled and managed centrally as a VPP, and effectively arranging the new generation sources "behind the meter"/"behind the point of connection" to the grid.

Such a concept may allow energy to be bought on-bulk with PPAs between energy generators, and sold/ distributed in normal retail fashion to industries/ businesses/ consumers within the SAP.

A micro-grid is effectively a private electricity network that uses local energy generation sources connected to it, to supply all loads within that network. It may be capable of operating with or without support from the main power grid.

To monetise the benefits of a micro-grid, an embedded network must be in place to on-sell energy to consumers.

Private consortia would need to, and may be interested in investing in such systems, as is understood to be expressed at the Wagga Wagga SAP with the Economic Development Corporation (EDC) and local shire.

The intricacies of establishing a micro-grid arrangement for Moree has not been examined in detail in this report, but the high level considerations of such an arrangement will entail resolution of the following, which include economic, regulatory and technical matters:

- Establishment of the special purpose vehicle (SPV) to include the relevant bodies needed to underpin the investment in the privately owned electricity/energy network within the SAP
- Likely duplication of assets and infrastructure (including substations, powerlines, etc.); and transfer of assets from Essential Energy/ TransGrid as may be required
- Ownership of assets within the same geographic area
- On-going operation and management of the network
- Determination of point of connection to the grid
- Construction of new physical assets, easements, etc.
- Economic benefits and business model
- Regulatory issues – supply quality, reliability, protection of consumers, supply restoration, etc.

- Technical issues - ability to adequately detect and clear faults on the network principally supplied from distributed asynchronous generation sources coupled using inverter technology, voltage and frequency control, etc.

Other factors include those as shown in Figure 36, as an example of the suite of considerations that need to be carefully examined and resolved as part of the establishment of an embedded network[31]:

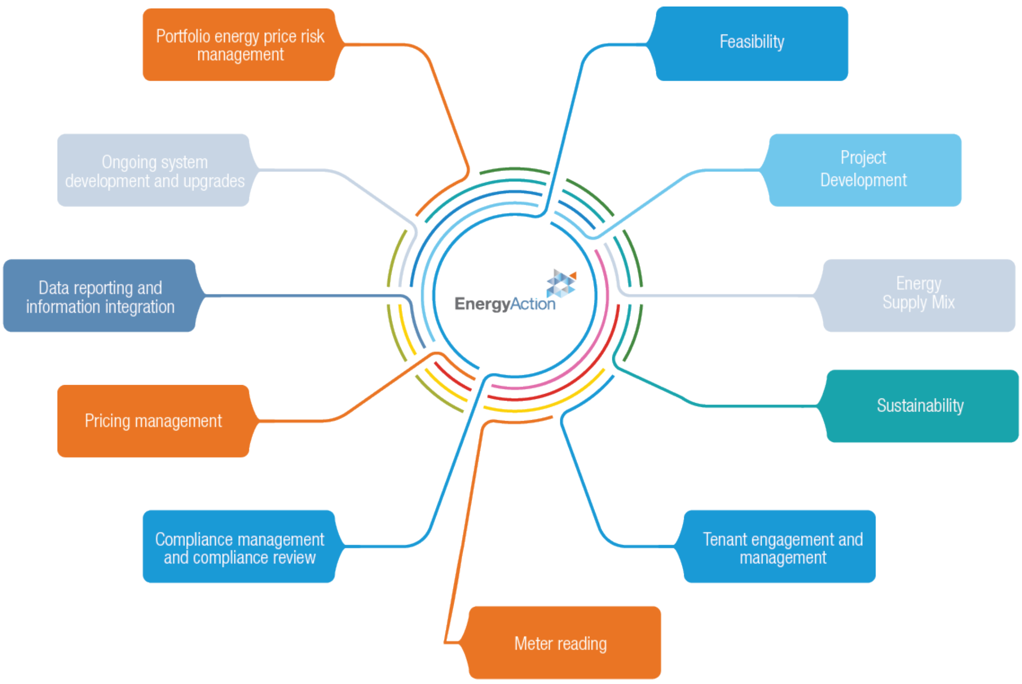


Figure 36: Embedded networks and micro-grid

6.7 Summary of opportunities identified

Table 14 summarises the key opportunities for renewable energy identified and recommended to be pursued for the Moree SAP.

Table 14: Summary of opportunities for renewable energy to be pursued

Category	Description	Priority	Comments
New large-scale solar farms	New or additional solar farms would certainly be a key opportunity that must be pursued for the Moree SAP, to offset (meet or exceed) the energy demand from the new businesses and industries, and to achieve a net zero target	High	It is critical to ensure that sufficient land-area is allocated for this purpose in the Structure Plan.

31 https://www.energyaction.com.au/renewable-energy/microgrids-embedded-networks

Category	Description	Priority	Comments
Roof Top Solar PV	Roof-top solar installations on large warehouses to reduce the energy consumed by each facility through the installation of 'inside the fence' renewable energy generation sources.	High	There is an opportunity to incorporate the stipulation for the installation of roof-top solar PV on new facilities and premises in the SAP in future, as a planning or development approval/sustainability requirement.
Bio-Energy Plant	Processing of Agriculture Waste – including: composting, gasification, pyrolysis, fermentation (ethanol), anaerobic digestion and direct incineration to produce bio-fuels or heat and/or electricity.	High	Cotton biomass waste is understood to be relatively abundant from current agricultural production in the Moree region. CS, wheat straw, and woody plants have high carbon and oxygen contents, they are suitable for pelletizing, and as feed-stock for energy production.
Renewable Energy in Intensive horticulture	Use of Solar Thermal solutions to be integrated with glass-house facilities, to provided treated water for hydroponic based horticulture facilities – including medicinal cannabis, vegetables, etc. Renewable energy from new solar farms could provide energy for the cooling systems to manage the heat in Moree's hot environment.	Medium-High	Model plant in commercial operation in Port Augusta, South Australia – SunGrow Tomatoes. The additional energy requirements (and the expense) for maintaining suitable climatic conditions will likely present an additional cost for prospective horticulture businesses.
Green Hydrogen Production	Use of renewable energy sources to electrolyse treated/demineralised water, to produce hydrogen (and oxygen), than may be used for various purposes including: Feedstock for industry, (e.g. fertilizer production) process gas for heating, clean alternative fuel for transportation, power generation and energy storage	Medium (to Low)	Price competitiveness is currently not attractive across all targeted use area – but will reduce in future over time, as demand, scale and technology continues to improve.

Category	Description	Priority	Comments
Virtual Power Plant (VPP)	Aggregation and control of renewable energy generation sources from various distributed energy facilities including roof-top solar PV installations in the precinct.	Medium	The establishment of a VPP for the SAP offers exciting opportunities to enable the effective control of all available energy generation sources within the SAP, control of energy consumption by loads, and the maximisation of the sustainability position of the Moree SAP.
Micro-Grid/ Embedded Networks	Connections of large generators is likely to be challenging due to already large number of projects proposed to be connected in the NW area, and the limitation in available transmission system capacity to ensure un-curtailed exports (until major upgrade works are undertaken and completed)	Medium	May allow the development of suitably sized large solar farms and other generation sources, to effectively supply the new industries and businesses in the SAP directly by the new generation sources, controlled and managed centrally as a VPP, and effectively arranging the new generation sources "behind the meter"/ "behind the point of connection" to the grid.

7 STRUCTURE PLAN ASSESSMENT

7.1 Final Master Plan

Following the scenario assessment phase and reporting, a FEbD Workshop was held in Moree at the MPSC premises between 17 and 20 November 2020 to develop the Master Plan for the investigation area. The workshop enabled an atmosphere of interdisciplinary collaboration to understand the environmental, infrastructure, and social constraints and develop the proposed final Master Plan.

During that workshop, it was determined that the initial scenarios assessed did not fully meet the vision and aspirations of the Moree SAP and a reconfiguration of the proposed land-usages and land-areas, taking into account inputs from various stakeholders was undertaken. Vital information from the market-sounding exercise which gauged the level of interest and expected take-up of land-parcels from new businesses and also an analysis of the types of new businesses to be serviced, was a key consideration from a renewable energy perspective as this directly affected the estimated energy demands of the new businesses and the size/scale of the new renewable energy opportunities which would be needed in order to achieve the net zero target.

The location of the new businesses also informed the suggested siting of new renewable energy generation (namely the new large scale solar farms) in the Structure Plan. The proposed final structure plan that is assessed in this report, is as shown in Figure 37.

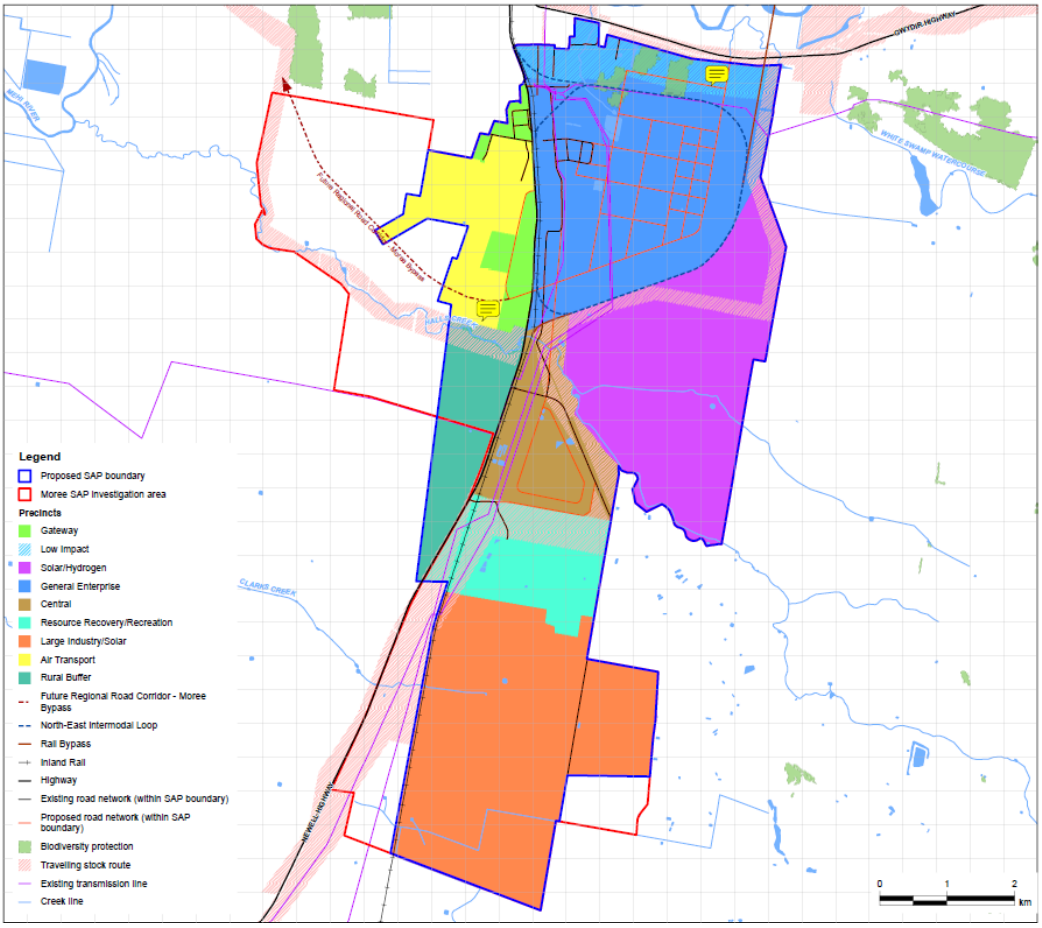


Figure 37: Final proposed Structure Plan assessed

7.2 Land use type, area, estimated energy demand and supply analysis

As per the CIE Economic Study, the proposed SAP land uses, the percentage of land allocated to infrastructure, and net developed area for 40 years are summarised in Table 15.

Table 15: Proposed land use areas and estimated energy demand/ generation

Land use type	Net developable area (Hectares)	Estimated energy demand (GWhr/yr)	Estimated energy generation (GWhr/yr)
Intermodal	30	55.4	-
Freight and logistics	20	22.1	9.6
Intensive horticulture/ native horticulture	520	119.9	-
Resource recovery	60	3.7	7.3
Value add agriculture	80	90.3	-
Bioenergy/ high impact industrial	30	97.4	47.7
Potentially hazardous	25	30.7	-
Enterprise/ hub	10	15.1	1.4
Energy/ solar (including hydrogen) **	714	79.6	453.3
Total	**1,475**	**514.1**	**519.3**

** The analysis is based on the allocation of the land area in the final Structure Plan of 714 hectares (combined total, for the central and south solar farms, shown as Purple and Orange in Figure 37). This should be the minimum land area for solar farms. Based on this, Arcadis' analysis suggests that the estimated energy generated would be sufficient (albeit marginally) to meet the estimated energy demands including green hydrogen production (of up to 5 tonnes/day in the future) and satisfy the net zero target vision and aspirations for the Moree SAP.

The basis of the estimates for the energy demand and generation figures using the CIE recommended land-use areas, are explained in the following sections of the report.

8 RENEWABLE ENERGY ASSESSMENT

The basis of estimates for the energy demand and energy generation figures are set out in this section of the report.

8.1 Energy demand estimates

The methodology and assumptions described in this section were used to determine the estimates for the energy demands and potential energy generation for the various land use areas:

- Arcadis reviewed the market sounding exercise (by CIE) which described the most likely investments to be attracted to the Moree SAP and suitable industries to be considered, based on the level of interest shown from the wide mix of businesses who were consulted
- Arcadis reviewed work recently undertaken and completed for the Wagga Wagga SAP and the estimates of energy demand and/or production in those studies for similar land-uses/ businesses/ industries that were considered
- Arcadis considered the typical energy demands of businesses or facilities which were identified in the market sounding exercise
- Arcadis determined the estimates of energy demand, based on:
  - The anticipated number of businesses, and size of the allotted land use areas
  - Consideration of the development footprint (as a percentage of the allotted land) within which facilities or premises could be established
  - Assumptions of typical electricity ‘demand density’ figures, for the respective development types using the approach as typically adopted by electrical utilities (when undertaking their network planning studies), as well as relevant guidance from Australian Standards and other international guidelines on load estimation, as well as databases of typical load and energy demands from various business and industry types in the public domain (e.g. from the Energy Information Administration or EIA database).
  - Arcadis’ internal project knowledge of similar land use – e.g. for intermodal facilities, warehousing and logistics hubs, etc. for which detailed load demand and energy estimates were previously prepared for similar projects by Arcadis.
  - Assumptions of likely supply transformer ratings, hours of operation of the businesses, load factor, etc.
- Arcadis determined the estimates of energy generation, based on:
  - Assumptions of fuel stocks volumes from various waste-streams to produce bio-energy (e.g. cotton stalk yield from cotton growers in the Moree region)
  - Assumptions of new roof-top solar PV installed on Warehouses, buildings, offices, etc.
  - Assumptions of ground-mount solar PV installations in new solar-farm precincts, based on the density and energy yield of the existing Moree Solar Farm and assuming the use of single-axis trackers as per the existing MSF.
  - Assumptions of typical output levels from a solar farm sized to fully take up the allotted land area for energy/ solar farm, for both the north/ central and south locations.
- Assumptions of green hydrogen production volumes collocated in the Energy/Solar Farm land-use areas.
- Arcadis had not considered any other non-electrical energy demand or energy production (e.g. bio-fuels, syn-gas, etc.) for the Moree SAP.

The assumptions used by Arcadis are as shown in Table 16.

Table 16: List of assumptions used

Land use type (and area)	Assumptions
Intermodal **(30 ha)**	Load demand is based on the Moorebank Intermodal Facility, comprising Rail sidings, marshalling yards; storage areas for goods (covered and uncovered); transfer facilities (gantrys, conveyors, etc); hard stand areas for the assembly and parking of vehicles; buildings for administration purposes; ancillary activities (fuel storage, repairs, driver facilities, etc). Load demand estimate of 7.9MVA, 24/7 operation with a high load factor of 0.8 providing an estimated energy demand of 55.4 GWh/yr No significant renewable energy generation assumed in this precinct. Small scale renewable energy generation may still occur.
Freight and logistics **(20 ha)**	Based on the area comprising Warehouses; storage areas for goods (covered or uncovered); transfer facilities; hard stand areas for parking and assembly; buildings for offices and administration purposes; ancillary activities (fuel storage, repairs, driver facilities, etc). Average warehouse lot of 40,000 m^2 (or 13.5 ha per lot). Average covered area per warehouse lot of 70% (with the remainder being for open car-park or open-storage use). Average load demand of 20 $W/m^{2.}$ providing an estimated energy demand of 22.08 GWh/yr. Rooftop solar PV assumed to be installed on every warehouses (on basis that this may be a stipulation on the development approval and sustainability requirements for the precinct) with a further assumption of 50% of suitable roof-space areas compared to covered floor area. Average solar PV installation on warehouse roof-spaces of 0.08 kW/m^2 and solar energy yield of 1,716 kWhr/kWdc/yr, providing an estimated energy generation of 9.6 GWh/yr
Horticulture and intensive agriculture **(90% of 520 ha)**	Landarea assumed to be used for intensive or enclosed cropping facilities (e.g. for Medical cannabis, mushrooms and hydroponics like tomatoes, vegetables, etc.) in large scale glass-houses or poly-tunnels. The CIE report mentions that the hot weather experienced in Moree can be a barrier to some forms of agriculture. Controlled horticulture in hot environments may require cooling systems to reduce the heat. Preliminary investigation suggests that controlled horticulture in Moree may be possible, however the additional energy requirements (and the expense) for maintaining suitable climatic conditions will present an additional cost for prospective businesses. Facility size dependent on specific activity – ranging between 5 to 30 ha per facility. Average energy demand levels of 11.85 MJ/m^2 assumed, with a 30% additional factor for Moree's hot climate which places additional energy demand for cooling.Electrical energy demand was not offset by use of any Solar Thermal solutions as deployed for the example hydroponics facility in SA, for tomato growing mentioned previously in the report. Aquaculture (i.e. breeding, rearing, and harvesting of fish / shellfish), land-area assumed to be largely taken up by ponds. Relatively small allotment needed, approx. 5 ha. On site facilities comprising pumps, blowers/aerators, buildings. (Harvested stock is assumed to be sent away to processing facilities located outside of the landuse area. Low energy demand assumed). Combined average energy density of 0.252 GWh/ha-yr, providing an estimated energy demand of 49.8 GWh/yr. No significant renewable energy generation assumed in this precinct. Small scale renewable energy generation may still occur.

Land use type (and area)	Assumptions
Traditional native horticulture **(10% of 520 ha)**	Land area assumed to be used to cultivate and harvest Indigenous plants (e.g. Native Mints, Murnong, Fingerlimes, Myrtles, Native Thyme, Black Apple, Dorrigo Plum, Riberry, Native Currants, Salt Bush, Native Plums, Native Ginger, etc.) in non-enclosed cropping facilities. Small facility for production of native products – e.g. crushing, grinding, packaging, supplied from a 1000kVA transformer, operating at a low load factor of 0.4 for 5 days/week. Very low estimated energy demand of ~ 1GWh/yr, of around 2% of that consumed in enclosed cropping / intensive horticulture facilities. No renewable energy generation assumed in this precinct.
Resource recovery **(60 ha)**	Waste recovery facilities; comprising transfer stations; storage area; waste processing; recycling. Power and energy demand estimate based on assumptions for the existing Moree Waste Management facility, and scaled to the allotted landarea, providing an energy demand estimate of 5.6 GWh/yr Excludes any on-site 'Energy from Waste' facility due to the insufficiency of volumes of municipal waste to support a large scale Energy-from-Waste plant in the SAP. It is furthermore assumed that there is limited interest in the importation of municipal waste on bulk from populous locations outside of Moree. In addition, energy production from pyrolysis of rubber tyres → syn-gas → electrical power, based on data from a DA submitted in 2015, was estimated to be ~ 2MW/hr; and assuming an operation of 10 hrs/day and 7 days/wk, this equated to an energy production of 7.3GWh/yr. Demands from Reverse Osmosis (RO) water treatment plants, or pretreatment plants to process lower quality water sourced from the GAB have not been considered due to uncertainty in the volumes that may need to be processed. Typical energy consumption is around 2 kWhr per cubic meter of water processed.No significant renewable energy generation assumed in this precinct. Small scale renewable energy generation may still occur.
Value add agriculture **(80 ha)**	Several facilities considered include flour milling (semolina), chickpea canning or oil crushing plants, as well as grain storage, sorting and handling. Also, early food processing facility including cold storage facilities. Energy consumption data from EIA database was used, for various industrial processing plant types, ranging from Grain and Oilseed Milling, Wet Corn or Wheat Milling, Sugar Manufacturing, Fruit / Vegetable Processing, etc. to provide an energy demand estimate of 90.3 GWh/yr
Bio-energy generation (30 ha) - **Including high impact industrial facilities related to bio-energy production**	Facilities to processing organic waste from the agri-sector (e.g. pelletising plants for processing of Cotton Stalks or CS) with an energy demand of 32.4 GWh/yr, an alcohol plant with an energy demand of 64.9 GWhr (based on EIA database). Energy generation facility to produce electrical energy from direct incineration of CS pellets to provide an estimate of 47.7 GWhr/yr (based on dry CS having a Low Heating Value LHV of 17.1 MJ/kg, and assuming an overall energy conversion efficiency of 20%, and processing of only 20% of the available 251,000 tonnes p.a. of CS estimated to be available in the region). In addition to waste from the cotton industry, other potential sources could include combustible waste streams from wheat, chickpeas, pecans and barley crops which are also prevalent in the Moree Plains LGA. The CIE report highlights significant annual variability in broadacre yields. Other bio-energy plants involving processes such as composting, gasification, pyrolysis for syn-gas, fermentation (ethanol), and anaerobic digestion were not specifically considered.

Land use type (and area)	Assumptions
	Bio-gas production has not been assessed - there are currently no biogas facilities operational in Australia other than those based on landfill sites and sewerage treatment plants. Bio-gas will be in direct competition with gas from the adjacent Narrabri region which may be accessed via the Hunter Gas Pipeline (HGP) that is proposed to traverse the East of the SAP. High volume users of gas in the SAP (e.g. large industrial plants or glasshouses) would favour access to a mains-gas solution compared to uncertainty in bio-gas production volumes or economics. A longer term plan could still be to develop bio-gas production within the SAP and transition away from gas from the Narrabri region, if it can be proven to be economically viable and sustainable. Bio-fuel production has also not been assessed due to indicated low likelihood / probability of interest from new businesses, per the CIE report. Livestock intensity is significantly reduced in Moree Plains compared to the New England tablelands. Abattoir operations or poultry facilities were not considered. These facilities require large amounts of energy and typically rely partly on gas or coal. Furthermore, a lot of land is needed, estimated to be 140 ha based on the Bindaree Beef facility, and water use is very high, and needs to be grade A. Approx. 2ML of water is used per day to slaughter 1 000 cattle. As such, it was assumed there is a very low likelihood of abattoirs or poultry facilities establishing in the Moree SAP. No livestock waste utilizing anaerobic bio-digestion technology was therefore considered.
Potentially hazardous industry (25 ha)	Production facilities for nitrogen products (e.g. fertilisers, ammonia) and proximity to green hydrogen production facility is advantageous. Facility size between 2 to 4 ha is assumed, however, a large buffer zone is assumed to surround the facility. Energy consumption data from EIA was used, to provide an estimated energy demand of 30.7 GWh/yr. No significant renewable energy generation assumed in this precinct. Small scale renewable energy generation may still occur.
Energy generation: solar, green hydrogen **(total land area of 714 ha:** **375 ha for north/ central; and 338 ha for south)**	Assumptions: - solar farms sized to take up the allotted land areas, based on similar density as the existing Moree Solar Farm - approx., 112MW solar farm in the North/Central location - approx. 100MW solar farm in the South location - single axis tracking system assumed - estimated total energy generation of 453.3 GWh/yr from the new solar farms - output of the existing Moree Solar Farm was not considered as it is 100% contracted through a long term PPA with Origin - Green Hydrogen production (using electrolysis and renewable energy from the new solar farms) and collocated on-site adjacent to the new solar farms. - Hydrogen volumes of 5 tonnes per day, resulting in an energy demand of 79.6 GWh/yr
Enterprise/ hub **(10 ha)**	Offices; showrooms; service centres; sheds; bulky goods retailing; activity centres; recreation facilities; light industry; industrial retail outlets; rural supplies; vehicle and body repairs; etc. with average energy density of 20 kWhr/sq.ft/yr (based on EIA data). Single storey facility comprising offices, classrooms for training and education or community use; food and beverage; retail; visitors centre, etc. Total Gross Floor Area of 20,000 m2 assumed. Estimated energy demand of 15.1 GWh/yr and estimated energy generated from roof-top PV of 1.4 GWh/yr.

The estimated energy demands and energy generation was presented earlier in Table 15.

8.2 Land area recommended for solar farms

Comparison of the estimated annual electrical energy demands from the various land use areas, with the estimated renewable energy generation within the Moree SAP concluded that it is essential that as a minimum, the full 714 hectares of land area needs to be allocated for potential new solar farms (at the "north/ central" and "south" locations) in the final Structure Plan in order to satisfy the net zero target vision and aspirations for the Moree SAP.

8.3 Likelihood of connection of large renewable energy generators in Moree SAP

The new solar farms in the Moree SAP may be assumed able to be established and permitted, from a land-use perspective.

However the technical matters associated with the grid/transmission system, and interconnection challenges to permit the connections of new solar farms (nominally ~ 220 MW in total, in addition to the existing 56 MW Moree Solar Farm) is likely to be challenging under the current circumstances due to transmission network constraints outlined earlier in the report, as informed by the AEMO Integrated System Plan (ISP) and in TransGrid's Transmission Annual Planning Report (TAPR) which noted the following:

- "While NSW has a pipeline of some 116 large-scale renewable energy proposals for more than 18,000MW of capacity, fewer than one in 20 are currently able to connect to the network due to transmission network constraints and other system stability issues which are outlined in AEMO's 2020 Integrated System Plan (ISP)"
- "TransGrid has received significant ongoing interest from renewable energy proponents seeking to connect to the network in this area (Northern NSW)" … "there is approximately 520 MW of renewable generation connected in the area. A further 115 MW is committed to connect and more than 1,180 MW is at an advanced stage in the connection process. However, the limited capacity of the current 330 kV and 132 kV networks will result in output limitation of connecting generators as the pool of generators in the area increases. This will inhibit the connection of additional generation in the area".
- "thermal and voltage constraints may arise in the Gunnedah area (to the South of the Moree region) leading to an emerging risk to reliability if large increases in loads (e.g. from mining or gas developments) [and possibly from increases in load in the Moree SAP] were to proceed in the area".
- "Wind, solar and other inverter-based generators require adequate levels of system strength to operate correctly. As the penetration of inverter-based generators increases, there will be a need to install network assets such as synchronous condensers or SVCs to provide additional system strength"
- [although none have been flagged as being needed in the Northern Region including the Moree area]".

No connection application/ enquiry has been made, or detailed power system studies conducted, to confirm the viability of connecting the proposed new solar farms in the Moree SAP.

This report makes the fundamental assumption that this is possible (or will be possible in the future) when the various transmission upgrade works as outlined in the AEMO ISP is completed to support increases in renewable energy generation in the REZs and at Moree.

Arcadis further notes and recommends that connection enquiries/applications and the necessary detailed power systems studies should be conducted for the proposed renewable energy generators for connection to the grid at Moree,

either by proponents of new solar farms (or on behalf of them by the RGDC, and possibly funded also by the RGDC) during the concept design and development stage of the strategic business case for the project.

The merits of establishing a 'micro-grid'/'privately owned embedded network' to allow the aggregation of the renewable energy generation sources in bulk, and to supply the new land-use areas, is recommended as a possible mitigation strategy, for further consideration, to possibly support the early development of suitably sized large solar farms (in a staged manner) before the upstream transmission network augmentation works as outlined in the AEMO ISP is completed.

This would effectively provide a means for new solar farms to supply the new industries and businesses in the SAP directly, and be controlled and managed centrally as a VPP, and effectively arranging the new generation sources "behind the meter"/"behind the point of connection" to the grid.

8.4 Impact on infrastructure

Arcadis also assessed the infrastructure and its capacity within and outside of the Moree SAP at a desk-top level, to identify any potential augmentation works that would be required purely from a capacity adequacy basis, to support the additional load demands of the SAP and connections of new generation sources. However, no detailed power system studies and load flow simulations have been undertaken to confirm the load flows and impact on transmission asset capacities under contingency conditions.

The assessment is summarised as below:

- Arcadis calculated the estimated ultimate total load demand for the Moree SAP from new businesses and including existing loads, to be approximately 89.9MVA
- Despite having two transformers installed, the 'firm capacity' (with one transformer being out of service) of the existing Moree 66/22 kV Zone Substation is only 33 MVA.
- Identified upgrade works to service the 89.9 MVA of load include:
  - Addition of a third 66/22 kV transformer and new 22 kV bus at the Moree Zone Substation
  - Establishment of a new 66/22 kV 'SAP' Zone Substation, to be located further South of the existing Moree Zone Substation and sited at the relative 'centre of gravity' of the new load precincts. This substation will need to have two 66/22 kV 33 MVA transformers.
  - Two 66 kV lines or underground cables, from the TransGrid bulk supply 132/66 kV substation to the new 'SAP' Zone Substation, to match the rating of the 66 kV lines supplying the existing Moree zone substation.
- New feeder bays in the TransGrid 132/66 kV Bulk Supply substation to permit:
  - The connection of the 112MW North/Central solar farm at 132 kV
  - The connection of the 100MW South solar farm at 132 kV
  - The connection of the new 'SAP' Zone Substation at 66 kV
- The total estimated ultimate load demand for the Moree region will be approximately 92.5 MVA. The total load demand will present itself to the TransGrid bulk supply point substation and to the transmission network upstream of Moree, but will in effect be reduced by any renewable energy generation sources within the SAP. Even for the worst case scenario of no offsets from local renewable energy generation, no augmentation works were identified by Arcadis from a transmission line capacity adequacy basis since the 132 kV transmission lines upstream of Moree are rated for about 100 MVA or slightly higher.

- However, as there are only two 100 MVA 132/66 kV transformers in the TransGrid substation, the addition of a 3rd transformer is likely to be needed.
- New 22 kV distribution feeders from the Zone Substations to service the loads in the SAP, and connection of the Bio-Energy Plant and Hydrogen Production Plant.

The upgrade works are illustrated in red, in Figure 38.

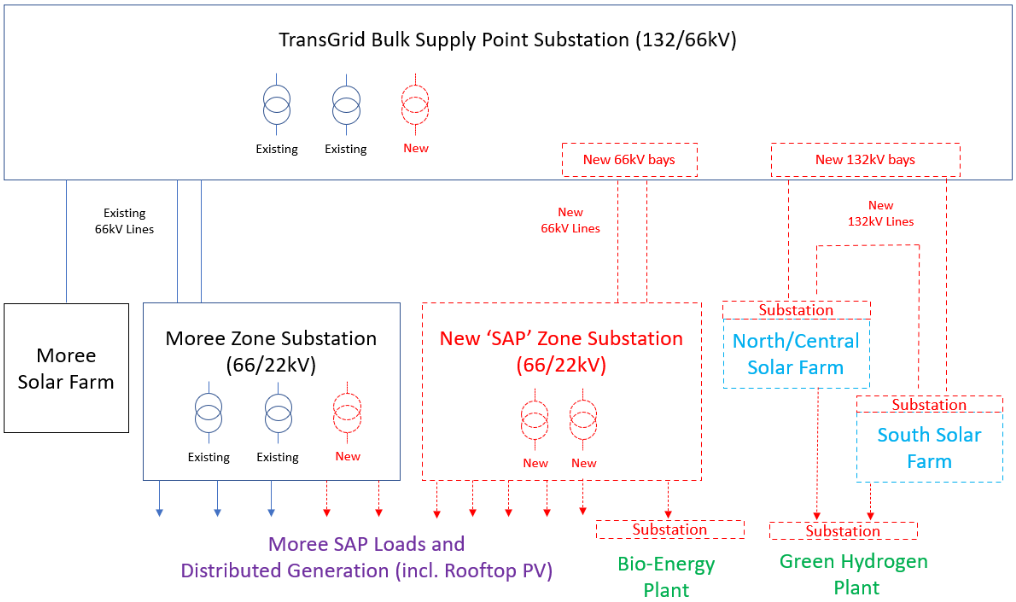


Figure 38: Transmission and distribution system upgrade (concept only)

9 DELIVERY PLAN AND STAGING

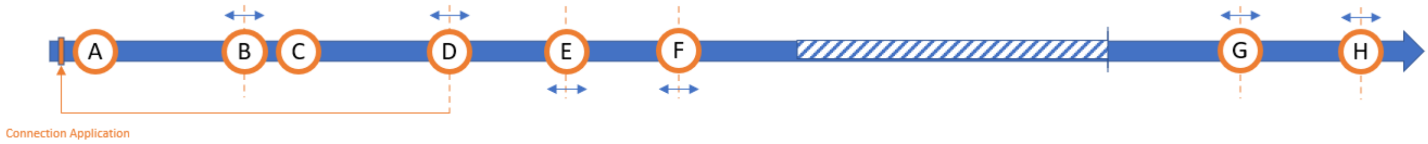
9.1 Design and costs

The infrastructure upgrade works identified in the previous section would be required to be designed and costed as part of the development of the Final Business Case and Delivery Phase.

This information is not provided in this report.

9.2 Proposed staging of works

The following discusses the potential staging of the works:



Solar farm connection applications and detailed studies need to occur as early as possible at start of the delivery plan (due to long time delays and need to confirm viability of connections).

Also, mechanism to secure energy produced from new generation facilities, and to directly supply the businesses in the SAP – e.g. formation of a SPV which could include the RGDC, MPSC and/or a Retailer, and PPAs needs to be determined.

Decision to establish 'embedded network' is subject to the resolution of all of issues mentioned in the report, and dependent on outcome of connection of new solar farms.

Establishment of a VPP for the SAP will require further consultation with suitable technology providers to conduct investigative studies to confirm the net benefits and viability for the SAP.

A. New 22kV distribution feeders from the existing Moree 66/22kV zone substation, to pre-service the land areas to the north of the SAP.

B. As the SAP is progressively developed, spare capacity from the Moree Zone Substation (MZS) will eventually be depleted, requiring the addition of a 3rd 66/22kV transformer and new 22kV bus.

C. A new 'SAP' 66/22kV Zone Substation (SZS) will also be needed, incl. new 66kV lines (or U/G cables) and new 66kV feeder bays in the TransGrid BSP. This may also be strategically developed ahead of time (or defer capital spending until it is required).

   New 22kV distribution feeders form the new SZS will be required to preservice the land areas further to the south of the SAP.

D. When the new Solar Farms are approved to be connected, new 132kV lines to TransGrid BSP will be needed, incl. new 132kV feeder bays. SOW will be dependent on the outcomes of the interconnection studies. New solar farms could be staged in smaller portions.

E. Bio-Energy plant will be dependent on the ability to secure sufficient volumes of waste from the argi-sector and the confirmation of the economic viability of the operations, and demand from new businesses.

F. Green Hydrogen plant is contingent on availability of surplus renewable energy to supply the electrolysers, and confirmation of the economic viability and local demand.

G. Depending on the ultimate future load demand of the SAP, and in combination with the connections of the new renewable energy generation, the addition of the 3rd 132/66kV transformer in the TransGrid BSP may be required at some point in the future.

H. Hydrogen production within Moree may allow for the ‘phasing out’ or transition away from the supply of gas from the Narrabri gas fields, in the future, depending on production volumes, economic viability and demand levels.

10 CONCLUSIONS

The assessment of the Structure Plan by Arcadis from a renewable energy perspective confirms the following:

Table 17: Alignment of Structure Plan with various requirements

Category	Aligned
Vision and Aspirations of the Moree SAP	✓
United Nations Sustainability Goals (including net zero carbon)	✓
State Environmental Planning Policy (Activation Precincts) 2020 (SEPP)	✓
NSW Renewable Action Plan	✓
NSW Climate Change Policy Framework	✓
NSW Infrastructure Strategy 2018-2038	✓
NSW Electricity Strategy	✓
NSW Government's Net Zero Plan Stage 1: 2020-2030	✓
NSW Clean Energy Strategy Guide for Businesses	✓
NSW Guide to Corporate Power Purchase Agreement (2018)	✓
Capitalises on Moree's high solar irradiance levels	✓
Use of waste from the agriculture sector for the purposes of energy generation	✓
Embraces new technologies, innovative and sustainable energy solutions: - Solar PV - Bio Energy - Bio Gas - Virtual Power Plant - Micro-Grid / Embedded Networks	✓
Attracts renewable energy investment, promotes and facilitates opportunities	✓
Strategic and integrated approach to assessment of renewable energy projects	✓
Opportunities for renewable energy to provide direct benefits to the SAP	✓
Aligned with broader sustainability aspirations and outcomes for the SAP	✓
Achieves a Net Zero emissions target	✓
Aligned with the Circular Economy aspirations and outcomes for the SAP	✓
Incorporates Green Hydrogen production to provide alternative fuel for local industries	✓
Able to be staged to suit the development of the SAP over a 40 year horizon	✓
Integrates into the overall Renewable Energy Zone development plans in the ISP	✓

11 LIST OF ABBREVIATIONS

AC	Alternating current
AE	Alkaline Electrolyser
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AFE	Automated Fracture Extraction
AREMI	Australian Renewable Energy Mapping Infrastructure
ARENA	Australian Renewable Energy Agency
BESS	Battery Energy Storage System
^{o}C	Degrees Celsius
CEC	Clean Energy Council
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CS	Cotton Stalk
CSG	Coal Seam Gas
CST	Concentrated Solar Thermal
DAPR	Distribution Annual Planning Report
DC	Direct Current
DPIE	NSW Department of Planning, Industry and Environment
EE	Essential Energy
EOI	Expression Of Interest
EPA	Environmental Protection Authority
FRV	Fotowatio Renewable Ventures
GAB	Great Artesian Basin
GIS	Geographic Information System
GJ	Giga Joules
GW	Giga Watt
GWh	Giga watt hour
H_2	Hydrogen
H_20	Water
ha	hectares
HV	High voltage
ISP	Integrated System Plan
kg	kilogram
km	Kilometer
kV	Kilovolt
kVA	Kilovolt-ampere

kW	Kilowatt
LGA	Local Government Area
LGC	Large-Scale Generation Certificates
LV	Low voltage
m	Metre
m/s	Metre per second
MPSC	Moree Plains Shire Council
MSF	Moree Solar Farm
MSW	Municipal Solid Waste
MV	Medium voltage
MVA	Mega volt amperes
MW	Megawatt
MWh	Megawatt-hour
MWp	Megawatt-Peak
NA	Not Available
NEM	National Electricity Market
NER	National Electricity Rules
NSP	Network Service Provider
NSW	New South Wales
p.a	per annum
PEM	Photon Exchange Membrane
PPA	Power Purchase Agreement
PV	Photovoltaic
QRET	Queensland Renewable Energy Target
R&D	Research
RE	Renewable Energy
RET	Renewable Energy Target
REZ	Renewable Energy Zone
RGDC	Regional Growth NSW Development Corporation
SAP	Special Activation Precinct
SCR	Short circuit ratio
SDG	Sustainable Development Goals
SEPP	State Environmental Planning Policy (Activation Precincts) 2020
SSORC	NSW Southern Sydney Regional Organisation of Councils
TAPR	Transmission Annual Planning Report
TBA	To be advised (later)
TNSPs	Transmission Network Service Providers
V	Volt
VRET	Victorian Renewable Energy Target

W	Watt
Wp	Watt peak
WRPF	Waste Receiving and Processing Facility
WtE	Waste to Energy
WTG	Wind Turbine Generators