Williamtown SAP

Renewable Energy Revised Final Report

Department of Planning, Industry and Environment

Reference: 510674

Revision: 6

2022-03-18

aurecon

Bringing ideas to life

Document control record

Document prepared by:

Aurecon Australasia Pty Ltd
ABN 54 005 139 873
23 Warabrook Boulevard
Warabrook NSW 2304
Australia

T +61 2 4941 5415
E newcastle@aurecongroup.com
W aurecongroup.com

Document control						
Report title		Renewable Energy Revised Final Report				
Document code		B3.2J	**Project number**		510674	
File path		Https://aurecongroup.sharepoint.com/sites/510674/5 Deliver Design/501 Engineering/Renewable/Stage 3/B3.2J Renewable Energy Report_V6.0.docx				
Client		Department of Planning, Industry and Environment				
Client contact		Caitlin Elliott	**Client reference**			
Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Verifier** (if required)	**Approver**
0	2020-11-23	Baseline Analysis Draft for comment	JL, AH	CA	TK	GL
1	2021-03-12	Baseline Analysis Final Report	JL, AH	CA	TK	GL
2	2021-03-12	Energy Strategy Testing First Draft for Review and QS	JL, RS, CG	BM	TK	GL
3	2021-04-01	Energy Strategy Testing Final Report	JL, RS, CG	BM	TK	GL
4	2021-05-24	Draft Structure Plan First Draft for Review and QS	JL, AJ, EC, JO	CA	TK	SD
4.2	2021-11-26	Updated Final Draft Structure Plan	CG	CA		
5	2022-02-09	Updated for Agency Comments	AB, MM	CG		
6	2022-03-18	Updated for Change in Project Area Scope	MM	AL		
Current revision		**6**				

Approval			
Author signature		Approver signature	
Name	Charlotte Guthleben	Name	Greg Lee
Title	Consultant, Future Energy	Title	Manager, Infrastructure Advisory

Contents

Abbreviations **7**
1 Executive Summary **1**
2 Introduction **5**
2.1 Purpose 5
2.2 Background Context 6
2.2.1 Williamtown SAP Background 6
2.2.2 Williamtown SAP Location 7
2.2.3 Williamtown Renewable Energy Context 9
2.3 Key Strategy Inputs 10
2.3.1 Targets for the Precinct 11
2.3.2 Strategic Plans and Policies 12
2.3.3 Site Constraints 17
2.3.4 Enabling Infrastructure 19
3 Structure Plan **22**
3.1 Methodology and Approach 22
3.2 Proposed Structure Plan 22
3.2.1 Renewable Energy Vision 23
3.2.2 Constraints and Opportunities 24
3.3 Energy Strategy 27
3.3.1 Overview 27
3.3.2 Technology Mix 27
3.3.3 Grid Connection Arrangements 29
3.3.4 Estimated Energy Demand and Supply Analysis 29
3.3.5 Operating Model 31
3.3.6 Regulatory Framework 37
3.3.7 Commercial Arrangement 38
3.4 Delivery Plan and Staging 48
3.4.1 Design and Costs 48
3.4.2 Impacts Assessment 49
3.4.3 Proposed Staging Works & Recommendations 49
4 Conclusion **53**
Appendix A Baseline Assessment **54**
A.1 Electricity Generation Technologies 58
A.1.1 Large-scale Solar PV 58
A.1.2 Small-scale Solar PV 61
A.1.3 Large-scale Wind 63
A.1.4 Small-scale Wind 64
A.1.5 Bioenergy 65
A.1.6 Waste to Energy 67
A.1.7 Large-scale Solar Thermal 69
A.1.8 Geothermal 70
A.2 Electricity Aggregation Technologies 72
A.2.1 Microgrid 72
A.2.2 Virtual Power Plant 74
A.3 Commercial Electricity Supply Arrangements 75
A.3.1 Corporate PPA 75

A.4 Other Energy Production Technologies 77
A.4.1 Hydrogen Production 77
A.4.2 Biofuels 79
A.4.3 Small-scale Solar Thermal 81
A.4.4 Process Heat and District Heating 81
A.5 Baseline Assessment Conclusions 83

Appendix B Energy Strategy Testing 84
B.1 Land Use Scenarios 84
B.1.1 Proposed Renewable Energy Strategies 84
B.2 Energy Strategy Formulation 85
B.2.1 Opportunities and Constraints 85
B.2.1 Conclusions and Approach 86
B.2.2 Gas demand alternatives 86
B.3 Energy Strategies 88
B.3.1 Overview 88
B.3.2 Base technology mix 88
B.3.3 Option 1 90
B.3.4 Option 2 92
B.3.5 Option 3 94
B.4 Summary of Strategy Testing 96
B.4.1 Potential Infrastructure Summary 97
B.5 Further considerations 98

Appendix C Demand and Generation Estimation Methodology and Assumptions 99

Figures

Figure 1-1 Overview of Energy Strategy Definition
Figure 1-2 Overview of Energy Strategy Definition for Scenario Plan
Figure 2-1 Williamtown SAP Visions
Figure 2-2 Williamtown SAP Study Area
Figure 2-3 The Modern Energy Trilemma
Figure 2-4 NEM Volume Weighted Average Wholesale Electricity Prices
Figure 2-5 The Energy Hierarchy
Figure 2-6 Williamtown SAP Renewable Energy Aspirations
Figure 2-7 The Waste Hierarchy
Figure 2-8 Energy resources in the Hunter region, Hunter Regional Plan 2036
Figure 2-9 Williamtown SAP Structure Plan Boundary Land Zoning
Figure 2-10 RAAF Williamtown obstacle limitations, Port Stephens Development Control Plan 2014
Figure 2-11 Indicative Constraint Levels across Structure Plan boundary
Figure 2-12 Port Stephens Load Area network layout, Ausgrid DAPR 2019, with site boundary overlay
Figure 3-1 The 7 SAP Principles which governed the masterplan
Figure 3-2 Williamtown SAP Structure Plan
Figure 3-3 The Modern Energy Trilemma
Figure 3-4 NEM Volume Weighted Average Wholesale Electricity Prices
Figure 3-5 Design principles and key planning factors for renewable energy strategy
Figure 3-6 Ausgrid Grid level Battery commissioned in February 2021 at Beacon Hill, NSW
Figure 3-7 Structure plan design principles and technology summary
Figure 3-8 Structure plan technology mix
Figure 3-9 Comparison of indicative total annual SAP demand and generation
Figure 3-10 Average roof-top solar generation in the SAP

Figure 3-11 Comparison of annual average estimated supply and demand profiles
Figure 3-12 Simple block diagram of the microgrid operating model
Figure 3-13 Simple block diagram of the VPP operating model
Figure 3-14 Simple block diagram of the peer-to-peer operating model
Figure 3-15 Small Business User Bundled Variable Tariffs | c/kWh
Figure 3-16 Ausgrid Business Consumer Usage Tariffs | c/kWh
Figure 3-17 Rooftop PV Upfront Capital Cost | AUD
Figure 3-18 Rooftop PV Upfront Capital Cost | AUD/kW[15]
Figure 3-19 NPV after 10 years per kW of installed solar; payback period (years)
Figure 3-20 Green Power Purchasing Surcharges from 4 major retailers | c/kWh as a function of green power percentage
Figure 3-21 Structure plan and staging
Figure 3-22 Transmission and distribution staging works
Figure A-1 NEM Transmission and Generation Map, AEMO 2021
Figure A-2 Regional solar resource levels, AREMI
Figure A-3 Regional wind resource, AREMI
Figure A-4 NSW sawmill residues (dry tonnes), AREMI
Figure A-5 NSW organic waste production, AREMI
Figure A-6 Geothermal temperature at 2km below surface, AREMI
Figure B-1 Design principles and key planning factors for renewable energy strategy
Figure B-2 Overview of Energy Strategies
Figure B-3 Baseline technology mix
Figure B-4 Scenario 1 Design Principles and Technology Summary
Figure B-5 Option 2 Design Principles and Technology Summary
Figure B-6 Option 3 Design Principles and Technology Summary

Tables

Table 1-1 Design philosophies for each scenario
Table 2-1 Summary of policies and plans
Table 3-1 SWOT assessment of base technology mix
Table 3-2 Demand values and assumptions
Table 3-3 Upper Limit of Technology Mix Sizing
Table 3-4 Description of the proposed operating models available to Williamtown SAP
Table 3-5 Components of the microgrid operating model
Table 3-6 Benefits of the microgrid operating model to the stakeholder
Table 3-7 Components of a VPP operating model
Table 3-8 Benefits of the VPP operating model to the stakeholder
Table 3-9 Comparison of the proposed operating models for Williamtown SAP
Table 3-10 Key considerations for energy resilient SAP
Table 3-11 Key considerations for cost effective SAP
Table 3-12 Relative tariff comparison
Table 3-13 Comparison of commercial models – arrows indicating improvement relative to no Microgrid arrangement
Table 3-14 Funding & Commercial incentives
Table 3-15 Key Risks and Unknows
Table 3-16 Infrastructure Requirements
Table 3-17 Impact assessment of implementing the energy strategy on infrastructural, social and environmental elements
Table 3-18 Demand and generation breakdown by stage
Table 4-1 Summary Assessment of Renewable Structure Plan
Table A-1 Renewable Generation Technologies Assessment Summary
Table B-1 Design philosophies for each strategy
Table B-2 Indicative Energy User Requirements within Williamtown SAP
Table B-3 Options for gas demand alternatives

Table B-4 SWOT analysis of the base technology mix
Table B-5 SWOT assessment of Option 1
Table B-6 SWOT assessment of Option 2
Table B-7 SWOT assessment of Option 3
Table B-8 Comparison of Energy Strategy Options
Table B-9 Potential Infrastructure Summary

Abbreviations

Abbreviation	Definition
AC	Alternating Current
AEMO	Australian Energy Market Operators
AREMI	Australian Renewable Energy Mapping Infrastructure Project
ARENA	Australian Renewable Energy Agency
BESS	Battery Energy Storage Systems
BSP	Bulk Supply Point
CEFC	Clean Energy Finance Corporation
CfD	Contract for Difference
CHP	Combined Heat and Power
COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSP	Community Strategic Plan
CST	Concentrated Solar Thermal
CWMAP	Carbon and Water Management Action Plan
DAREZ	Defence and Aerospace Relation Employment Zone
DBYD	Dial Before You Dig
DC	Direct Current
DER	Distributed Energy Resource
DNSP	Distribution Network Service Provider
DPE	Department of Planning and Environment
DR	Demand Response
DTAPR	Distribution and Transmission Annual planning Report
EBD	Enquire By Design
ESB	Energy Security Board
FAA	Federal Aviation Administration
FCAS	Frequency Control Ancillary Services
FCEV	Fuel-cell Electric Vehicle
FIT	Feed In Tariff
GHG	Greenhouse Gas
Gwh	Giga-Watt Hours
HV	High voltage
HVO	Hydrogenated Vegetable Oil
ICT	Information and Communications Technology
IEA	International Energy Agency
ISP	Integrated System Plan
JSF	Joint Strike Fighter
kV	Kilovolt
LCOE	Levelised Cost Of Energy
LGC	Large-scale Generation Certificate
LRET	Large-scale Renewable Energy Target
LTESA	Long Term Energy Service Agreement
LUoS	Local Use of System

Abbreviation	Definition
LV	Low Voltage
MSW	Municipal Solid Waste
MVA	Mega Volt Amps
MWh	Mega-Watt Hours
NEM	National Energy Market
NIMBY	Not In My Back Yard
NUoS	National Use of System
OLS	Obstacle Limitation Services
PFAS	Polyfluoroalkyl Substances
PPA	Power Purchasing Agreement
PV	Photovoltaic
RAAF	Royal Australian Air Force
RET	Renewable Energy Target
REZ	Renewable Energy Zone
SAP	Special Activation Precinct
SRES	Small-scale Renewable Energy Scheme
STATCOMS	Static Synchronous Compensator
STC	Small-scale Technology Certificates
STS	Static Transfer Switch
SWOT	Strengths, Weaknesses, Opportunities and Threats
TAPR	Transmission Annual Planning Report
VNI	Victoria-New South Wales Interconnector
VPP	Virtual Power Plant
VRE	Variable Renewable Energy
WAP	Williamtown Aerospace Precinct
WSGG	Western Sydney Green Gas
WtE	Waste to Energy
WTG	Wind Turbine Generator
ZS	Zone Substation

1 Executive Summary

The Williamtown SAP aims to be a carbon-neutral precinct. To this end, Aurecon has been engaged to develop a renewable energy strategy for the precinct.

Baseline assessment

Local strategic plans and policies, such as state-wide policies for New South Wales, are supportive of the uptake of renewable energy technologies within the state, particularly in the Hunter Region.

A broad range of potential generation technologies for the SAP were assessed against a range of relevant criteria. Technologies that were rated overall as having good on-site potential for Williamtown SAP were:

- Large-scale solar PV
- Small-scale solar PV
- Waste to energy
- Small-scale solar thermal
- Large-scale battery
- Small-scale batteries
- Microgrid
- Virtual Power Plant (VPP)

These technologies have been considered further for application in the Williamtown SAP, alongside the use of Power Purchasing Agreements (PPAs) with off-site renewable energy generators to meet demand. Additionally, bioenergy, hydrogen, and biofuels were selected for further consideration. These technologies tended to be less commercially and technologically mature than others investigated but had the potential for stimulating local economic activity and circular economy opportunities.

To read about the Baseline Assessment, see Appendix A.

Energy strategies for each land use

In line with the development philosophies for each SAP scenario, a guiding vision for renewable energy development was set for each land-use scenario, as laid out in Table A. These visions were used to guide the energy strategy definition for each scenario.

Table 1.1 Design philosophies for each scenario

SAP Scenario	Vision for renewable energy
Option 1	▪ Renewable energy used to offset SAP energy demand and engage SAP community in sustainability initiatives. ▪ Well established technologies used to minimise capital cost and development risks. Strong focus on community support and involvement.
Option 2	▪ Renewable energy used to offset SAP energy demand and stimulate circular economy opportunities. ▪ Combination of mature and emerging technology applied to mitigate risk while stimulating economic growth and local jobs.
Option 3	▪ Renewable energy and future fuels opportunities used to offset energy demand and facilitate innovation in the SAP. ▪ Advanced and innovative technologies such as hydrogen and biofuels manufacturing employed to support the aviation precinct and other regional economic activity.

The main driver for the difference in energy strategy options is the appetite for innovation and economic growth. We therefore suggest a **common baseline technology mix** for each land-use scenario supported by supplementary technologies which will stimulate economic growth and industry activity.

Around this baseline technology mix, **supplementary technologies** including generation and advanced fuels have been suggested in each option to align with the vision for renewable energy and development for the SAP.

- For Option 1, key design principles were a focus on sustainability, community, and low land impact. A community battery and VPP aggregation program have been proposed, as these involve strong community engagement and create value streams for the SAP while involving minimal land development.
- For Option 2, supplementary technologies which stimulate local economic activity and resonate with a 'movement economy' focus have been selected. Hydrogen could be produced for use in a local transport fuel trial, growing

this emerging market in the region and responding to state goals for hydrogen. A bioenergy waste to energy plant could make use of local waste outputs to produce electricity, responding to circular economy principles.

- For Option 3, a focus on innovation and economic activity on a regional and wider scale was taken. Hydrogen production was again considered, but with a look to future expansion and regional markets. A biofuels pilot plant for aviation fuels has been proposed to engage with the local aerospace industry.

The energy strategy for Option 1 makes use of mature technologies but has some risks associated with commercially feasible models and evolving regulation for VPP involvement in the wholesale electricity market. This is a capital-intensive option, with lower operating costs.

Key risks for the strategies for Options 2 and 3 are associated with commercial feasibility. Both hydrogen and biofuels represent emerging markets, so potential local and regional demand for these products will need to be assessed carefully. These technologies have relatively high capital and operating costs, but significant potential for expansion and economic stimulus.

Figure B outlines the progressive development of the energy strategy for each land use option, and summarises the technologies proposed in each case.

To read about the Energy Strategy Testing, see Appendix B.

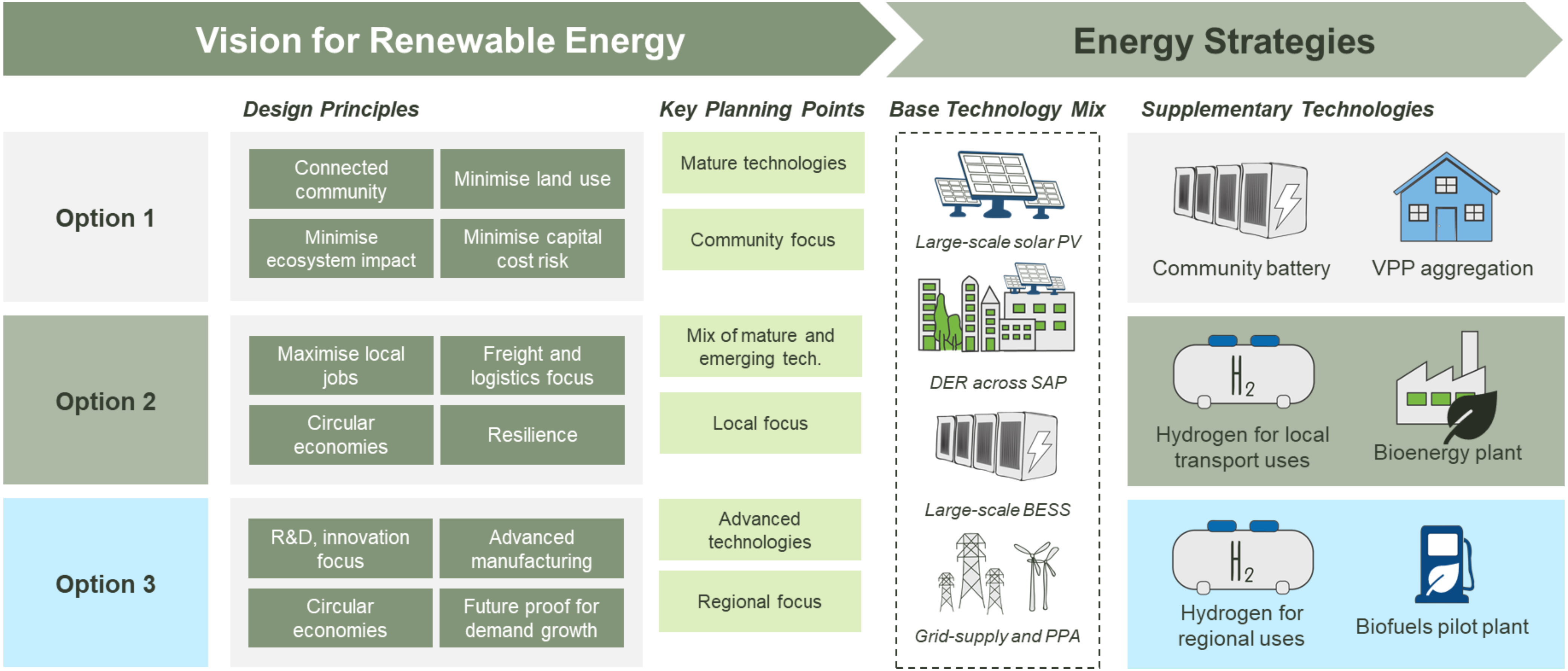


Figure 1.1: Overview of Energy Strategy Definition

Structure Plan

Replicating the approach applied in the scenario testing exercise described above, the following energy strategy was developed for the structures plan.

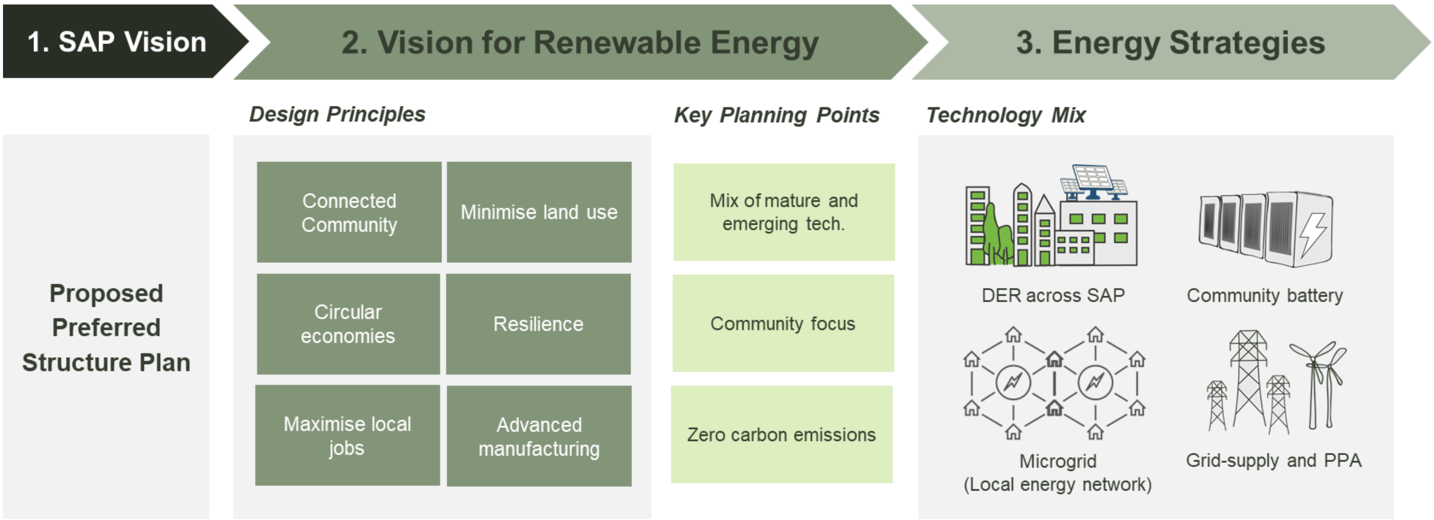


Figure 1.2 Overview of Energy Strategy Definition for Scenario Plan

The final renewables plan for the Williamtown SAP is:

- Installation and management of a control system managed by Ausgrid (or potentially an energy retailer or a third party) to provide control of connected solar and battery resources in the SAP to minimise energy costs to Ausgrid, Retailers and end users. This control system will also be able to function in grid-islanding mode, to balance load and generation for up to 12 hours when there is loss of the main grid supply.
- Require each business that locates into the SAP to either procure a green energy contract directly from an energy retailer or otherwise enter into a buyer's consortium with other SAP businesses to sign a power purchase agreement with a renewable generator.
- Require each business that locates into the SAP to commit to the installation of solar panels on their roof, as feasible.
- In collaboration and agreement with Ausgrid, install at least 250kW sized grid level batteries (and possibly larger as energy densities improve over time) throughout the precinct in the order of one grid connected grid level battery for every 1000kVA 11kV/415kV kiosk installed. These batteries will be owned and managed by Ausgrid. These will be installed as part of Ausgrid's business-as-usual planning function of developing their electricity network as the precinct grows over the next 20 to 30 years.
- Ensure that businesses locating into the SAP are educated about the opportunity to save costs on their electricity bill by first reducing their behind-the-meter consumption with solar on their roof, and secondly, by taking advantage of the grid level battery to store excess energy and to be used to offset their consumption during periods when generation begins to decline.
- If manufacturing businesses locate into the SAP that require gas-derived heat for the business, require them to use heat pumps for low temperature applications and space heating. For high temperature usage (typical high temperature process heat), there is potential to use sustainable biomass or waste-to-energy alternatives. Monitoring of biomethane or hydrogen opportunities should continue though as these fuels are promising options to provide a decarbonised alternative once technology matures. For instance, biomethane trials involving Jemena/Sydney Water could result in green purchasing opportunities for methane.

More detail of each of these items of the plan is given in Section 3.

2 Introduction

The Williamtown SAP will enable the Hunter Region to grow as a national and international Defence hub and centre of excellence for Australia's aeronautics, aerospace, and defence industries. The precinct will have significant energy demands including an estimated 111 MVA of peak demand through the local network.

Investment in renewable energy as part of the Williamtown SAP has the potential to contribute towards environmental and socio-economic development goals both locally and regionally. This can be achieved by attracting innovative industries with an interest in sustainable business practices and technology development. Delivering cost-effective, low-emissions and reliable power will underpin the ability of the precinct to attract these types of businesses.

The Williamtown SAP aims to be a carbon-neutral precinct. To this end, Aurecon has been engaged to develop a renewable energy strategy for the precinct. The strategy will be developed in three stages with 'Enquiry by Design' workshops between each stage which will explore design and development options.

2.1 Purpose

The renewable energy strategy for Williamtown SAP was developed in three stages:

Baseline assessment

The Baseline Assessment (Appendix A) is the first stage of the SAP planning process and will assist the Department of Planning and Environment (DPE) in identifying areas for deeper exploration. Appendix A summarises the current regional renewable energy context and constraints and then identifies high-level opportunities for renewable energy to be integrated into the development.

The objective of this assessment is to provide:

- An understanding of the area's context and relevant strategic energy plans, policies and infrastructure.
- An outline of the existing transmission and distribution network limitations that could affect the development of renewables in the area.
- An outline of the existing and future renewable resources in Williamtown and the surrounding Hunter Region.
- A baseline assessment of different renewable energy sources that could be deployed as part of the Williamtown SAP development.

The Baseline assessment was limited to a desktop study based on readily accessible information.

To read about the Baseline Assessment, see Appendix A.

Energy strategy testing (scenario development)

Following a comprehensive baseline analysis undertaken in Stage 1 of the Master Plan process, a range of scenarios were developed through a Preliminary Enquiry by Design (EBD) Workshop. An overview of scenario testing methodology can be found in Appendix B.

The purpose of the scenario assessment is to test the scenarios and provide an evaluation and comparison of the strengths, weaknesses, opportunities, and threats relating to energy strategy for the development.

The scenarios required careful consideration to maximise and balance the outcomes across all Williamtown SAP technical packages; factors such as the location and capacity of required infrastructure or services were taken into account to improve the success of the SAP. These scenarios have been tested and evaluated to compare the strengths, weaknesses, opportunities, and threats (SWOT) of each. Our scenarios testing and reporting have been informed through the following tasks:

- Review of the key findings from the baseline analysis, particularly the opportunities and constraints
- Comparative analysis that assessed and compared the three scenarios against the testing criteria
- SWOT analysis to evaluate the strengths, weaknesses, opportunities, and threats
- Collaboration with the other Williamtown SAP technical packages

To read about the Energy Strategy Testing, see Appendix B.

Structure plan finalisation

The outcomes of this analysis will inform assessments in the Final EBD workshop and the subsequent preferred structure plan.

2.2 Background Context

Identifying opportunities for the SAP requires an understanding of the site's drivers and constraints. This section outlines the SAP's vision and general aspirations, the geographic location of the SAP and its anticipated energy needs.

2.2.1 Williamtown SAP Background

The Department of Planning and Environment (DPE) and Regional Growth NSW Development Corporation's establishment of Special Activation Precincts (SAPs) is a joint Government Agency and innovative approach to plan and deliver infrastructure projects in strategic regional locations in NSW. Investment in these specific areas of Regional NSW 'activate' State or regionally significant economic development and jobs creation as part of the 20-Year Economic Vision. A strategic need from a land use demand and supply perspective is that there is limited long term availability of readily developable land. The SAP will seek to resolve environmental, drainage and other development constraints in a coordinated precinct scale approach as opposed to a site-by-site basis.

The Williamtown SAP's vision is based on six key visions as shown in Figure 2-1. The strategic need for growth in the Hunter Region involves:

- **The Place** – leveraging the vicinity of the RAAF and civil aviation operators attract local employment and commercial investment;
- **Economy and Industry** - facilitate the development of additional employment land for Defence and aerospace industries;
- **Environment and Sustainability**– regionally coordinated approach to flooding, water cycle management and contamination while preserving and enhancing the natural environment;
- **Infrastructure and Connectivity** – providing infrastructure to resolve development constraints to reduce investment barriers to entry and enable effective connections to nearby Hunter Region infrastructure;
- **Connection to Country** – To preserve, respect and integrate Aboriginal cultural heritage, particularly the Worimi people; and
- **Social and Community Infrastructure** – Enabling high skill employment, innovation, education and skill training opportunities.

Figure 2-1 Williamtown SAP Visions

2.2.2 Williamtown SAP Location

Williamtown is located approximately 30km east of the Newcastle CBD in New South Wales.

The Hunter Region has the largest share of both regional population growth and regional employment and is in the state's fastest-growing corridor (Sydney to Newcastle). Greater Newcastle is the centrepiece of the Hunter Region with 95% of residents living within 30 minutes of the strategic centre.

Newcastle Airport and the Port of Newcastle are recognised as global gateways targeted to enable the region and the state to satisfy the demand from growing Asian economies for products and services associated with education, health agriculture, resources and tourism (Hunter Regional Plan, 2036). The Hunter Regional Plan 2036 identifies that the region's ongoing economic prosperity will depend on its ability to capitalise on its global gateway assets and as such cites a need to expand the capacity of Newcastle Airport and the Port of Newcastle.

The Williamtown SAP Structure Plan boundary covers an area of approximately 11,408ha and is low-lying coastal land on the edge of Fullerton Cove and Stockton Beach of land within Port Stephens local government area in the Hunter Region and Greater Newcastle area of NSW. It is centred around the Williamtown Aerospace Precinct (WAP)[1].

The Williamtown SAP is focused on leveraging employment and investment opportunities associated with its strategic location to the Williamtown Aerospace Precinct (WAP) which includes:

- RAAF Base Williamtown which F35 Australia Joint Strike Fighter (JSF) fleet is based in. The area has also been affected by Per- and Polyfluoroalkyl Substances (PFAS) contamination associated with past activities conducted at the Williamtown RAAF Base;
- Newcastle Airport, which is jointly owned by Port Stephens Council and Newcastle City Council, leased from the Department of Defence and shares their airport runway with RAAF Base Williamtown;

---

[1] NSW Government Planning & Environment, *2036 Hunter Regional Plant*, October 2016, p8. Available from **https://www.planning.nsw.gov.au/~/media/Files/DPE/Plans-and-policies/hunter-regional-plan-2036-2016-10-18.ashx**

- The Defence and Aerospace Related Employment Zone (DAREZ) which is intended for the development of aerospace and defence specific industries close to the adjoining Newcastle Airport;
- Bushland vegetation is prominent in the area with some areas containing threatened flora and fauna species as well as important wetland areas;
- Rural and agricultural lands;
- Small rural and low-density residential clusters including the township of Salt Ash, Williamtown and Fullerton Cove;
- Commercial and light industrial clusters associated with the airport and RAAF Base along key road corridors;
- The Tilligery State Conservation Area;
- The Grahamstown Lake is located to the north of Fullerton Cove; and
- The study area is also crossed by several transport infrastructure assets including roadways.

The study area is presented in Figure 2-2.

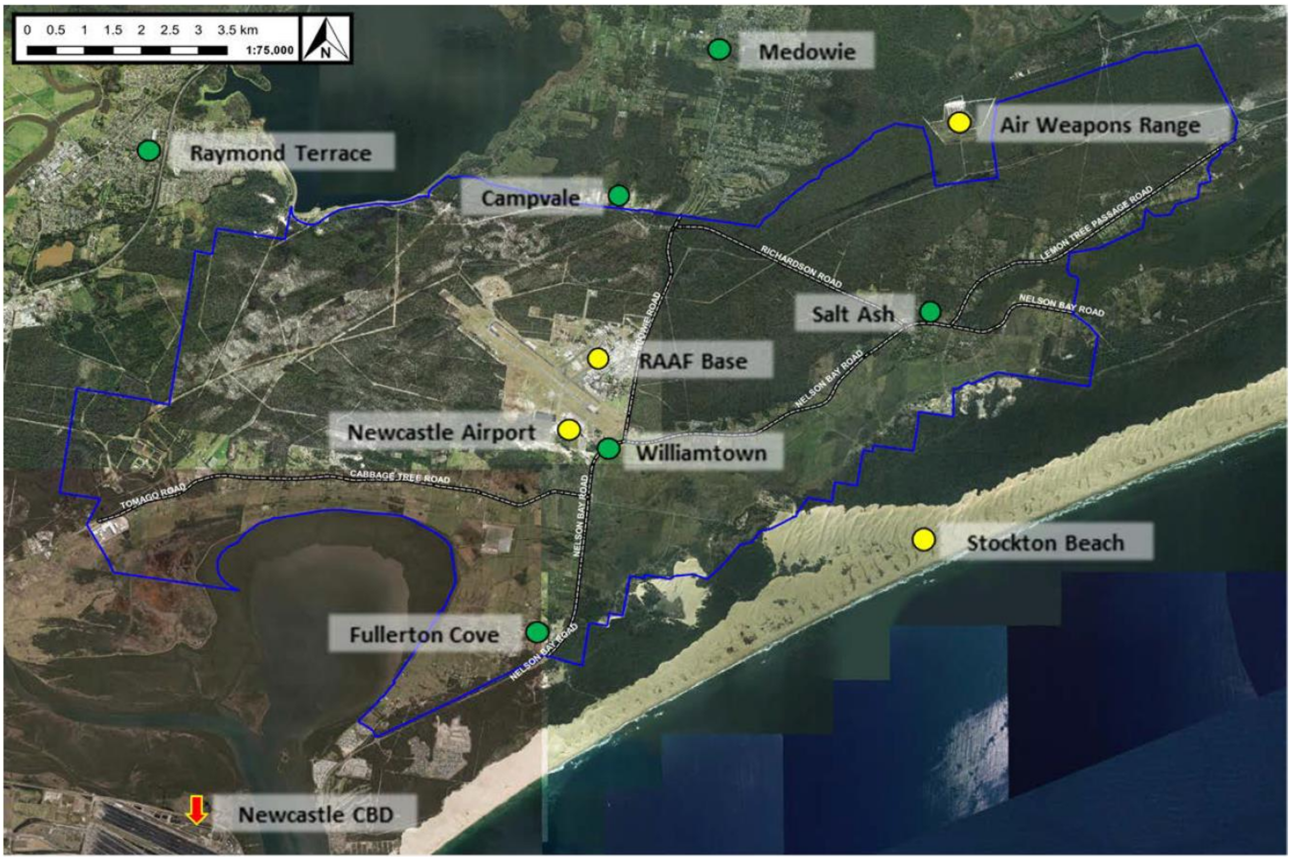


Figure 2-2 Williamtown SAP Study Area

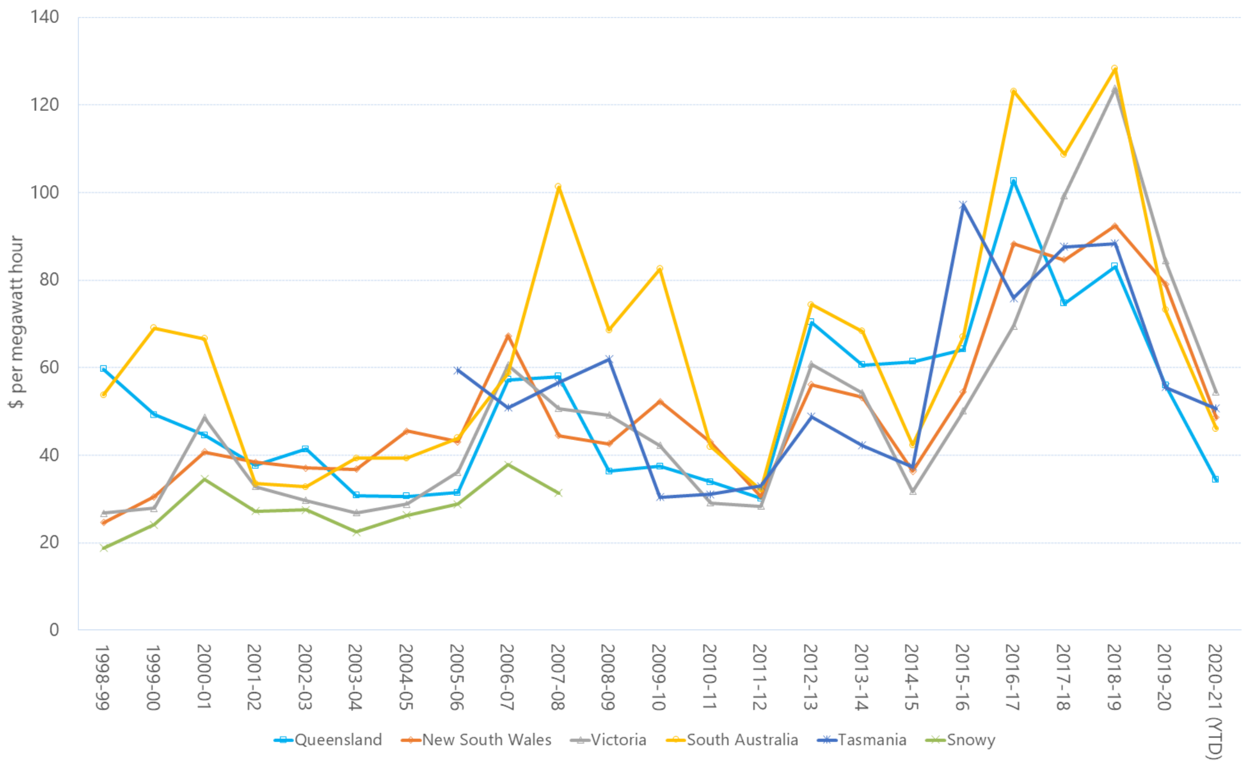
2.2.3 Williamtown Renewable Energy Context

Energy reliability and cost control will be critical for the businesses within the SAP, but sustainability will also be part of their business plans. The supply priorities described in Figure 2-3 have been used as key considerations in exploring renewable energy options and are reflected in the recommended approach discussed in this report.

The identified priorities reflect what is considered the energy trilemma: consumers at a commercial and residential level are looking for an energy solution that delivers a system that is low in emissions, low in price and highly secure. Typically, a given technology can be expected to address two of the three requirements, but it takes a holistic solution to deliver on all three.

Figure 2-3 The Modern Energy Trilemma

Energy prices have been high and volatile over the last few years. This has driven many organisations to look for alternative supply arrangements to help manage their pricing risk. For example, the wholesale electricity price in NSW averaged $92/MWh in 2018-19, as shown in Figure 2-4, which was the highest average price in the state since the NEM was started. Williamtown SAP should seek to reduce exposure to electricity price volatility and price increases while still seeking reliable supply and emissions reductions.



Source: AER; AEMO, Last updated: 9 Oct 2020 - 2:20 pm

Figure 2-4 NEM Volume Weighted Average Wholesale Electricity Prices

Strategic Approach

A holistic energy strategy needs to consider all energy use, but of course the cheapest and most sustainable energy is the energy not used. Therefore, the energy hierarchy in Figure 2-5 below starts with energy conservation and energy efficiency. Our strategy has therefore sought to find opportunities to reduce consumption through the use of smart grid technology. Most of the energy efficiency opportunities will be driven by private investment decisions by the businesses locating in the precinct. But there is still opportunity to use smart grid technology that can co-ordinate with each electricity customer's energy management system to make more sophisticated decisions about building and plant operation.

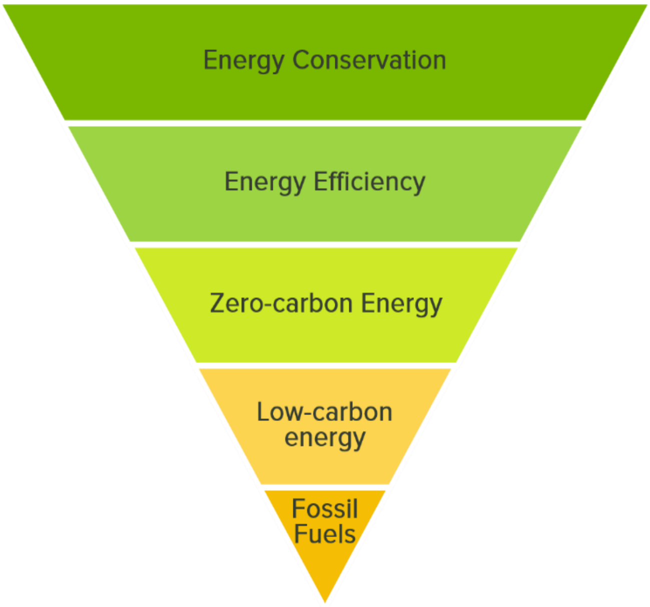


Figure 2-5 The Energy Hierarchy

Provision of energy for the Williamtown SAP, in line with the visions set out in Figure 2-1, will require coordination across many workstreams. To build a number of potential paths for the Williamtown SAP energy strategy, this section looks at the key strategy inputs, renewable energy technology options and the opportunities for innovation and co-optimisation. Through understanding these elements, it is possible to set out a number of credible and coherent energy scheme concepts for the precinct that will be developed and refined through further stages.

2.3 Key Strategy Inputs

The key inputs required for energy strategy formulation are:

- **Energy consumption requirements** – to understand the need for energy, where, when and how much.
- **Energy-related risks and value drivers –** what does the customer value most, what are their most pressing risks concerning energy
- **Targets –** to ensure alignment of the scheme outcomes with the expectations and aspirations of DPE
- **Strategic Plans and Policies –** to leverage alignment with co-incident strategic plans which apply to the Williamtown SAP area, such as regional development plans, and understand the operating context of the resulting energy scheme
- **Constraints** – to ensure compatibility of the energy scheme with the physical and developmental constraints of the whole SAP and the customer's operations and businesses
- **Enabling Infrastructure** – to ascertain whether the energy scheme can be accommodated within the existing wider energy system

With this information, it is possible to develop assessment criteria for technology options. Technologies that are assessed to have good potential for application at the Williamtown SAP become potential building blocks of the Williamtown SAP energy strategy.

We have discussed the energy consumption requirements and key risks/value drivers of specific development scenarios in Appendix B of this report. The following analysis will therefore focus on Targets, Strategic Plans, Constraints and Enabling Infrastructure.

DPE has not indicated any cost constraints at this stage. The reasoning is that the SAP can explore a range of innovative and impactful solutions. As such, the strategies developed are not limited by cost. This report should be reviewed in consideration with cost estimates outlined in the Quantity Surveyor's report.

2.3.1 Targets for the Precinct

The DPE have set out a number of energy-related expectations for the SAP, which are summarised in Figure 2-6. These are the guiding principles for the overarching strategy and the benchmark against which proposed solutions will be judged.

- Achieve a carbon neutral precinct (in operations) with ISO 14001 accreditation
- Reduce operating costs and maximising efficiency of capital investment by supplying energy through innovative technologies such as microgrids and renewable energy sources
- Investigate a range of renewable energy options, including emerging technologies such as hydrogef

Figure 2-6 Williamtown SAP Renewable Energy Aspirations

In addition to energy provision, the SAP is interested in incorporating circular economy principles where appropriate, and some renewable technologies can contribute to these. When considering the role of assets in a circular economy, it is important to employ the waste hierarchy, shown in Figure 2-7. This indicates the priority of actions for waste and will help to understand how renewable energy technologies relate to other circular economy options.

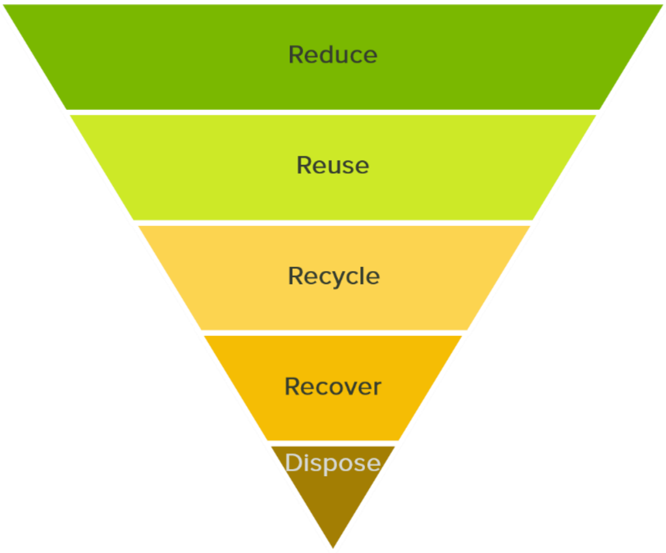


Figure 2-7 The Waste Hierarchy

The above hierarchy needs to be considered with respect to the use of solar PV and battery technology where the ability to recycle in particular is still challenging in Australia. There are very limited options to recycle batteries within Australia, though there are plans to grow the industry.[2] Nevertheless, recycling is available offshore, and it is expected that local capability will be available within the next 5 to 10 years.

Further information on the SAP's carbon neutrality goals can be found in the Renewable Analysis Report by Umwelt (on behalf of Roberts Day).

2.3.2 Strategic Plans and Policies

Strategic plans and policies that cover the Williamtown SAP Structure Plan boundary help to guide an energy strategy that is aligned with relevant governing bodies, local sentiments, and supportive policies. Understanding this context enables maximised use of programs that can assist (financially or through other development activities) the implementation of the solution and ensures avoidance of the paths of most resistance.

National

Federal Government Plans and Policies

The Australian Federal Government's Renewable Energy Target (RET) is a Government policy designed to ensure that at least 33,000 gigawatt-hours (GWh) of Australia's electricity comes from renewable sources by 2020. The RET scheme operates through two main schemes - the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES).

The LRET requires organisations that make wholesale or notional wholesale acquisitions of electricity (e.g., retailers or consumers purchasing from the wholesale market or directly from a generator) to acquire a fixed proportion of their electricity from renewable sources. The target creates a financial incentive for the establishment or expansion of renewable energy power stations, such as wind and solar farms or hydro-electric power stations, by legislating demand for Large-scale Generation Certificates (LGCs).

In September 2019, the Clean Energy Regulator announced that Australia had met the LRET. While the target has been met, the scheme will continue to require high-energy users to meet their obligations under the policy until 2030. If the SAP establishes a PPA, it will be liable for LGCs and if it incorporates grid-scale generation into the development, it will produce LGCs which could be sold as an additional revenue stream.

The SRES provides a financial incentive for households, small businesses and community groups to install eligible small-scale renewable energy systems such as solar water heaters, heat pumps and solar photovoltaic (PV) systems by legislating demand for Small-scale Technology Certificates (STCs). STCs are created for these systems at the time of installation, based on its expected power generation until 2030. Similar to the LRET, liable energy users are required to purchase a fixed proportion of STCs and surrender them to meet their obligations under the RET. The SRES is scheduled to run until 2030, with the level of subsidy available for new installations falling each year between now and the end of the scheme. This could be used to help fund small-scale solar PV and solar water systems housed at individual sites within the SAP.

Beyond the Renewable Energy Target, the federal government has designated continued support of the renewable energy sector in the 2020 Federal Government Budget. A flagship package is the $1.4 billion assigned to the Australian Renewable Energy Agency (ARENA) over the next 12 years. While less than 25% of this will be available to ARENA over the next 4 years, the agency has proven how much investment and impact it can leverage from its projects, and now has the opportunity to continue this work over another decade.

The Clean Energy Finance Corporation (CEFC) is also expected to receive a mandate to make a $1 billion Grid Reliability Fund available, in addition to the 2020 direction to provide $200 million to Clean Energy Innovation and $300 million to Advancing Hydrogen.

In a bid to secure the power system and provide reliable and affordable power to all Australians, $250 million has been assigned to critical transmission projects. This includes the Victoria-New South Wales Interconnector (VNI) West project, Project EnergyConnect and Marinus Link Project. This will unlock capacity for renewables to connect in the National Electricity Market (NEM) and provide certainty for renewable generation investment.

[2] Sarah King, Naomi J. Boxall, Anand I. Bhatt, CSIRO, *Lithium battery recycling in Australia*, April 2018, p24. Available from https://www.csiro.au/

Funding for regional and remote microgrids initiative will be provided, along with a boost for cybersecurity capability in the energy sector, and a $52 million energy efficiency package for the building sector.

These allocations of support indicate that renewables will be fundamental to Australia's energy portfolio and that emerging technologies, such as hydrogen, are worth investigating.

The development of a SAP in Williamtown could benefit from CEFC financing for energy infrastructure. Funding from ARENA for renewable energy innovation projects is also worth pursuing but will require a project that offers learning for the market and advances the uptake of renewables through its outcomes. ARENA funding is issued in rounds, with different technologies targeted with each round. This includes commercialisation, innovation of all renewable technologies, and work on future fuels, such as hydrogen and biofuels.

Of particular merit would be pursuing a CEFC or ARENA grant to explore the benefits of peer-to-peer trading in a large-scale industrial precinct. To date, peer-to-peer trials have been focussed on small residential customers. A full assessment in a large-scale industrial setting does not appear to have been carried out in Australia. But as discussed elsewhere, it will be difficult to install sufficient solar to be able to self-supply many of the industrial loads and then inject excess power for sale into a peer-to-peer trading market. However, more detailed design work is required, so it may be that some pockets can deliver power excess power. This option should at least be left open for consideration as the SAP design is further refined.

National Electricity Market Plans and Policies

There are several significant pieces of work in development that will fundamentally change the way the National Electricity Market operates. Particularly relevant to the SAP are:

1. The Australian Energy Market Operator (AEMO) Integrated System Plan (ISP)
2. The Energy Security Board (ESB) Post 2025 market design

The AEMO ISP indicates the priorities for the development of transmission infrastructure in the NEM and as such shows where generation hosting capacity (i.e. the ability of the network to accommodate additional local electricity generation) is likely to increase in the future. It is updated on a rolling basis and includes forecasts of the generation mix, capacity retirements and security and reliability issues.

This is relevant to the Williamtown SAP as it indicates where transmission capacity upgrades will be in the coming decades, allowing a forecast to be created of where new generation could connect to the network. This acceleration of renewable generation building will increase the opportunities available for Power Purchase Agreements (PPAs), driving down strike prices, which the SAP could leverage. Through competition, it is also expected that average NSW wholesale prices will also be driven down, whilst the price volatility is projected to increase.[3]

The ISP also provides scenarios of future generation capacities which show trends applicable to electricity generation in the region, enabling a better understanding of the context of the SAP in its operational phase.

The ESB Post-2025 market design acknowledges the issues of the current market design in the context of the current and future generation mix and is working to determine a more efficient and fit-for-purpose market design that will be implemented in 2025. This includes interim measures for security and reliability, a transitionary Renewable Energy Zone (REZ) regulatory framework and significant effort to improve how Distributed Energy Resources (DER) are handled in the current system. This is relevant to Williamtown SAP as the Post 2025 market design will open up opportunities in demand response and incentivise innovative commercial models. The use of smart grid technology may be able to be deployed to generate extra income in the demand response market, depending on the flexibility of the demand profile of customers within the SAP.

New South Wales

State-wide Plans and Strategies

NSW does not have a legislatively mandated renewable energy target and currently follows the Federal RET. It does however have an emissions policy known as the NSW Climate Change Policy Framework, which acts as a proxy. This policy targets an emissions reduction objective of net-zero emissions by 2050. It also seeks to make NSW more

[3] https://www.energycouncil.com.au/analysis/renewables-in-the-nem-are-they-leading-to-price-extremes/

resilient to the impacts of climate change. One of the five foundational pillars in the roadmap is to drive investment in regional NSW by delivering:

- $32bn in private investment in regional energy infrastructure investment expected by 2030
- Around 6,300 construction jobs and 2,800 ongoing jobs in 2030 mostly in regional NSW
- Improved competitiveness of regional energy-intensive industries and high-value agriculture through proximity of low-cost electricity
- Infrastructure in priority areas that deliver regional growth

This will be achieved through the state government running competitive processes for Long Term Energy Service Agreements (LTESAs) for renewable energy generation, energy storage and firming technologies in identified Renewable Energy Zones. This will underpin the private investment required by providing long-term revenue certainty. This supply will then be on-sold by the government to retailers and other organisations.

In addition, the government will create a regulatory approvals pathway for the transmission infrastructure required to deliver the REZs and coordinate this with the generation and other energy technologies to maximise the cost-efficiency of the process and prepare the state for the retirement of several major coal power plants over the next 15 years.

The final version of the NSW Government's Electricity Infrastructure Investment Bill, which is designed to implement the Electricity Infrastructure Roadmap, includes a new Central Coast / Hunter Region Renewable Energy Zone on the list of NSW REZs. This was passed by the State Parliament on 17 November 2020. The REZ was at the early scoping stages at the time of writing but it is anticipated that if the SAP was supplied under a PPA, the REZ could more than easily provide sufficient generation to cover the needed energy. is unclear. The creation of the REZ also presents an opportunity for Williamtown SAP to engage with the NSW government on how the REZ and the SAP can be co-ordinated to help support existing supply chains and workforces in the region.

Supporting the Electricity Infrastructure Roadmap, the NSW Electricity Strategy (2019) is the state government's plan for a reliable affordable and sustainable electricity future that supports a growing economy. The document identifies several strategies that are aligned with the policy framework and are relevant to Williamtown SAP:

- Delivering Australia's first coordinated Renewable Energy Zone (REZ)
- Saving energy, especially at times of peak demand
- Supporting the development of new electricity generators
- Setting a target to bolster the state's energy resilience
- Making it easier to do energy business in NSW

This policy framework, together with the formation of Renewable Energy Zones, will accelerate the NSW electricity grid towards decarbonisation. One approach for achieving a carbon-neutral Williamtown SAP is to do nothing, and just rely on grid power becoming emissions-free energy over time. Of course, it may be 20 to 30 years before grid power is fully decarbonised. As a result, achieving a carbon-neutral SAP today cannot rely on just the grid decarbonising over time. Other initiatives are required.

However, it is recommended that the energy strategy for the SAP is reviewed every decade as the grid decarbonises. There will be an opportunity to make use of decarbonised energy from the grid instead of using other measures, particularly as decarbonised grid energy is most likely to be the least cost option for a decarbonised SAP.

Additionally, in March 2021, the NSW Government published the Net Zero Industry and Innovation Program, which sets a vision and goals for accelerating the development of clean technology and industrial decarbonisation in NSW. This Program outlined NSW Government's intent to align regional programs, Electricity Infrastructure Roadmap activities, and new 'hydrogen hubs' to be developed as part of the Program with SAP development plans. The Program announced an objective to develop a green hydrogen hub in both the Hunter and Illawarra Regions of NSW, supported by at least $70 million worth of committed grant funding[4]. Williamtown SAP could be the site of this hydrogen hub, or otherwise serve to promote hydrogen industry growth through enabling infrastructure or hydrogen application trials.

[4] https://www.environment.nsw.gov.au/news/hunter-hydrogen-hub-to-drive-jobs

State Government Regional Plans

In addition to state-wide plans and policies, the NSW Government has also produced a number of regional plans which incorporate Williamtown. The most recent of these is the Greater Newcastle Metropolitan Plan 2036 (published in 2018). This plan sets an aspiration for the metropolitan area to be certified carbon neutral by 2050. This is, of course, a target with many possible routes, but it is clear that support for renewable generation will form part of the implementation.

More specifically to energy, the plan includes an action point to achieve “reuse of power generating sites for renewable energy generation and re-purposing of distribution infrastructure in West Lake Macquarie and other suitable locations”. This suggests that significant retirement of coal-powered generators will open up connection capacity which will be earmarked for new renewable generation to the south of Newcastle.

Williamtown is also covered in the wider-reaching Hunter Regional Plan 2036 (published in 2016). Which lists as one of its major strategic directions “Direction 12: Diversify and grow the energy sector”. This has specific actions to support small-scale renewable energy initiatives, including in less common technologies such as bioenergy and coalmine methane[5]. It also mentions that it will review local planning controls in order to enable opportunities for the renewable energy industry.

The Hunter Regional Plan includes a map of renewable energy potential in the area surrounding Williamtown, reproduced in Figure 2-8. This assessment looks at solar and hydro potential, with no assessment provided of any wind potential or other renewable technologies. The Plan shows that Williamtown has significant solar potential but does not provide information on other options.

Prior to the above plans, and still in its validity period is the Lower Hunter Regional Plan to 2031 (published in 2006). This is assumed to be superseded by the Greater Newcastle and Hunter Regional plans.

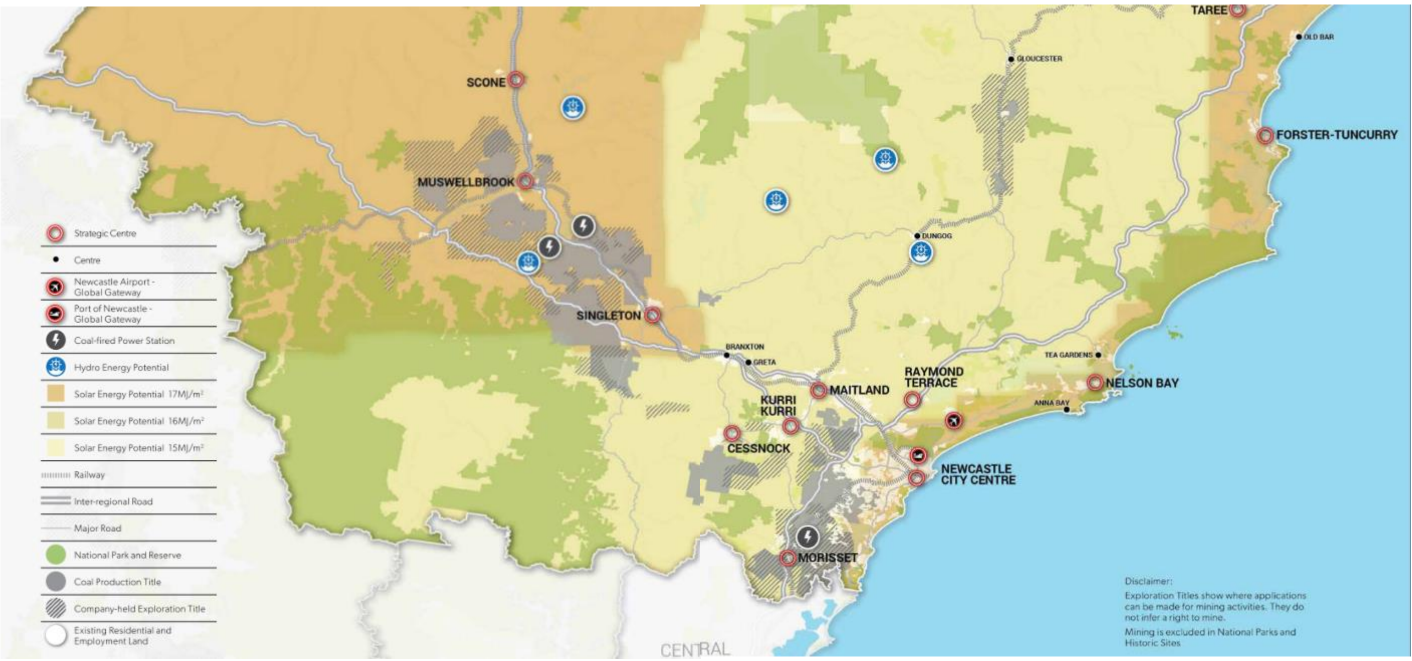


Figure 2-8 Energy resources in the Hunter region, Hunter Regional Plan 2036

Municipal

Port Stephens Council

While the area is included in the Greater Newcastle Metropolitan Plan, Williamtown and the SAP Structure Plan boundary are part of the Port Stephens Council, rather than the City of Newcastle council area. In collaboration with Climate Council’s Cities Power Partnership, Port Stephens Council is developing their Sustainability Action Plan and Roadmap to set the agenda for the council’s renewable energy, water and waste projects and to establish achievable

[5] Aurecon recognises that coalmine methane is not considered a renewable technology by many organisations and it is included here only as an illustrative example from the Hunter Regional Plan 2036. Also called Waste Coal Mine Gas (WCMG), the greenhouse abatement benefits are argued to result both from the destruction of methane that would otherwise be emitted, and the offsetting of electricity emissions from other fossil fuel sources.

emissions targets for the organisation. Pledges as part of the partnership include using renewable energy for council operations, creating a projects seed fund for energy efficiency and renewable energy projects, and installing renewable energy technologies on council buildings.[6]

The latest local area plan is the Port Stephens Futures report, published in 2010. This set the long-term directions for the area, with the initial Community Strategic Plan covering the 2010-2022 period. This included Priority E2 – "A reliable electricity supply with an increased use of renewable energy". While the specific methods for facilitating this are unclear, the council has implemented several renewable energy projects, including installing solar PV at 16 council sites. This priority also indicates that local attitudes towards renewable energy technologies are positive, with developmental support available to new projects.

Neighbouring Councils

Given its geographical proximity to Newcastle, and the shared council ownership of the airport, it is likely that City of Newcastle plans and policies will impact the SAP through community engagement and co-ordination of infrastructure, such as transport. There are currently two energy-related plans in the City of Newcastle council area:

1. Newcastle 2020 Carbon and Water Management Action Plan (CWMAP)
2. Newcastle 2030 Community Strategic Plan (CSP)

At the time of publication (2011), the CWMAP identified that around 50% of Newcastle's carbon emissions came from the generation of electricity. This highlights that electricity supply has been a major target of decarbonisation through the CWMAP.

The CSP, published in 2011 as well, set out as one of its values "*to consider long term and cumulative effects of actions on future generations*" and "*to consider principles of ecologically sustainable development*". This illustrates a long-standing commitment to the use and growth of renewable energy technologies in the region.

Given the age of these reports and their lack of specific policies that Williamtown would need to adhere to, it is assumed that they have been superseded by the Greater Newcastle Metropolitan Plan, which largely aligns with and builds upon their aims.

Summary of Policies and Plans

From consideration of the above policies and plans, Aurecon summaries the implications for Williamtown as follows:

Table 2-1 Summary of policies and plans

Plan or Policy	Key implication for SAP	Key opportunity for Williamtown SAP	Comments/ dependencies
LRET	The SAP could be liable for purchase and surrender of LGCs if it makes notionally wholesale electricity purchases.	If incorporating grid-scale generation, the SAP would produce LGCs which it could sell	Unlikely to have a big enough generator withing SAP, so very unlikely these provisions will be triggered
SRES	Small-scale renewable systems within the SAP may be eligible for the SRES	Funding from the SRES would boost the commercial case of small-scale renewable systems such as PV and solar water heating	SRES certificates should be pursued for any eligible small-scale generators connected in the SAP
CEFC	Low-rate financing is available to renewable energy projects through the CEFC. These are typically large-scale projects	The SAP could use CEFC funding to improve the financial viability of onsite energy generation and storage projects	Consider CEFC funding for peer-to-peer trading trial with industrial loads. Consider CEFC funding for green hydrogen production trials
ARENA	Grants are available to renewable energy projects that provide innovation and industry learning	If the SAP pursues emerging technologies and innovation, the commercial risk could be reduced through ARENA grants	Consider ARENA funding for peer-to-peer trading trial with industrial loads. Consider ARENA funding for green hydrogen production trials

[6] https://citiespowerpartnership.org.au/partners/port-stephens-council/

AEMO ISP	Increased transmission capacity from areas of large renewable resources, including the Central Coast/Hunter Region and Central West Orana REZ	As more large renewable generation projects can come online, the opportunities to for renewable supply through commercial arrangements such as PPAs, will increase, and the cost of these arrangements is likely to decrease Participate in community and stakeholder consultation for the Central Coast / Hunter Region REZ	ISP will deliver more decarbonised energy through the grid. No action required, though SAP carbon strategy should be updated every 10 years to use more grid power as likely to be cheapest decarbonised energy available for the SAP
ESB Post 2025	Changes to the NEM structure will make it easier for demand-side participants to engage with the market	The SAP can open up additional revenue streams through the explicit value of system services which will exist from 2025	Ensure each building within the SAP is future-ready for demand response opportunities by requiring the installation of compatible Energy Management Systems

2.3.3 Site Constraints

The Williamtown SAP Structure Plan boundary covers an area of approximately 11,400ha and is low-lying coastal land, on the edge of Fullerton Cove and Stockton Beach. It is centred around the Williamtown Aerospace Precinct (WAP) and Newcastle Airport. The topography of the site is largely flat, presenting few constraints to development.

Besides physical site constraints, energy assets within the Structure Plan boundary will respect the connection of the Aboriginal community to their country. Infrastructure will not be proposed on culturally significant land.

There are large areas of 'National Park and Nature Reserve' within the Structure Plan boundary, as shown in Figure 2-9, and existing developments such as Newcastle Airport and RAAF Base Williamtown. As a result, developable land is at a premium within the Structure Plan boundary and land use for energy infrastructure must be carefully considered in terms of the opportunity cost for other types of development.

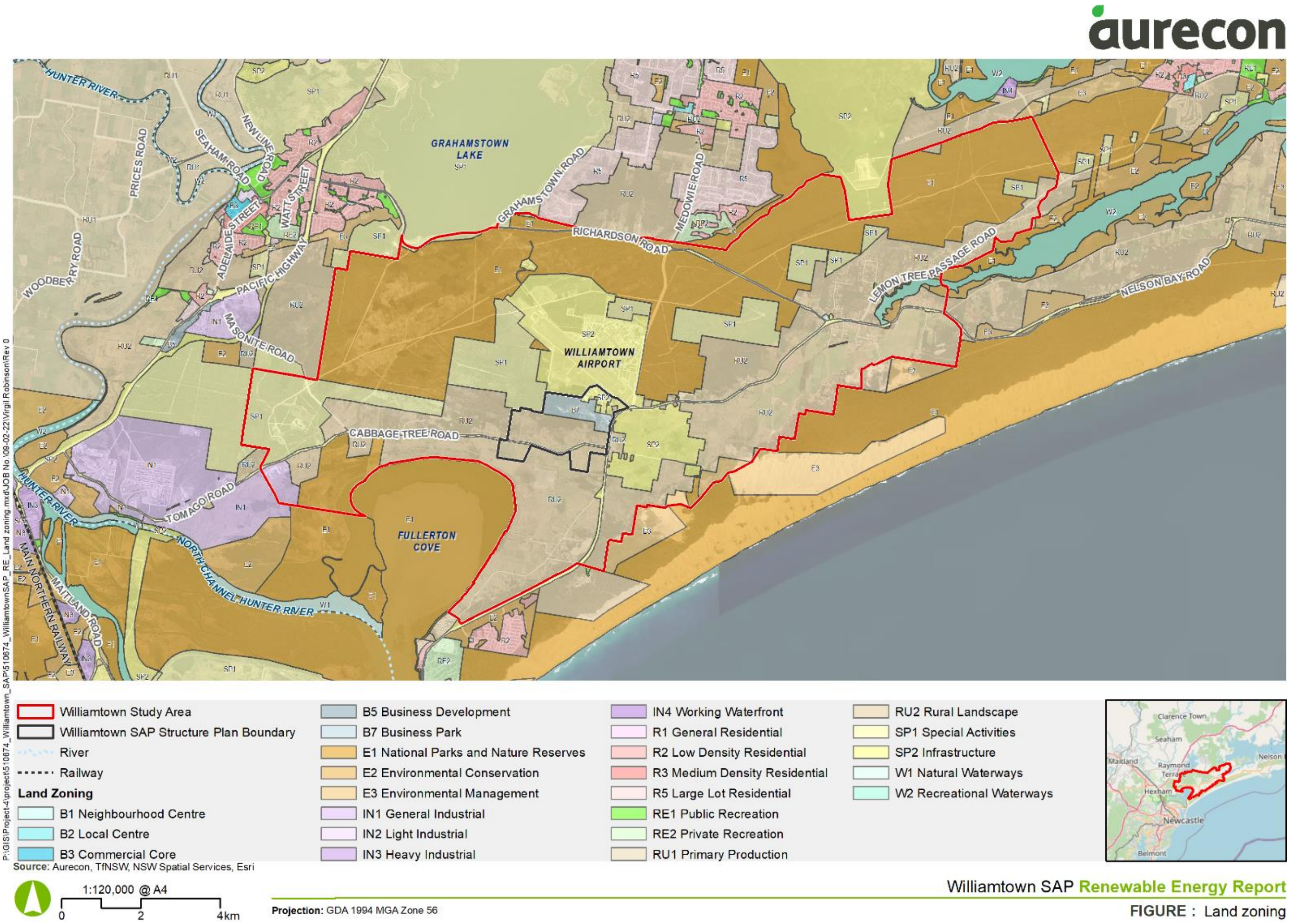


Figure 2-9 Williamtown SAP Structure Plan Boundary Land Zoning

With the airport approximately centrally located in the Structure Plan boundary it is important to also consider the height restrictions on structures in the surrounding area, as indicated by the Obstacle Limitation Surfaces (OLS) set out in Figure 2-10. This shows significant restrictions on structures over 7.5 m across large parts of the Structure Plan boundary, and limitations in most of the rest of the area on structures over 45 m. This will limit the locations available to develop certain types of energy technologies, such as wind turbines or generators with tall chimneys (e.g., direct-fired bioenergy plant).

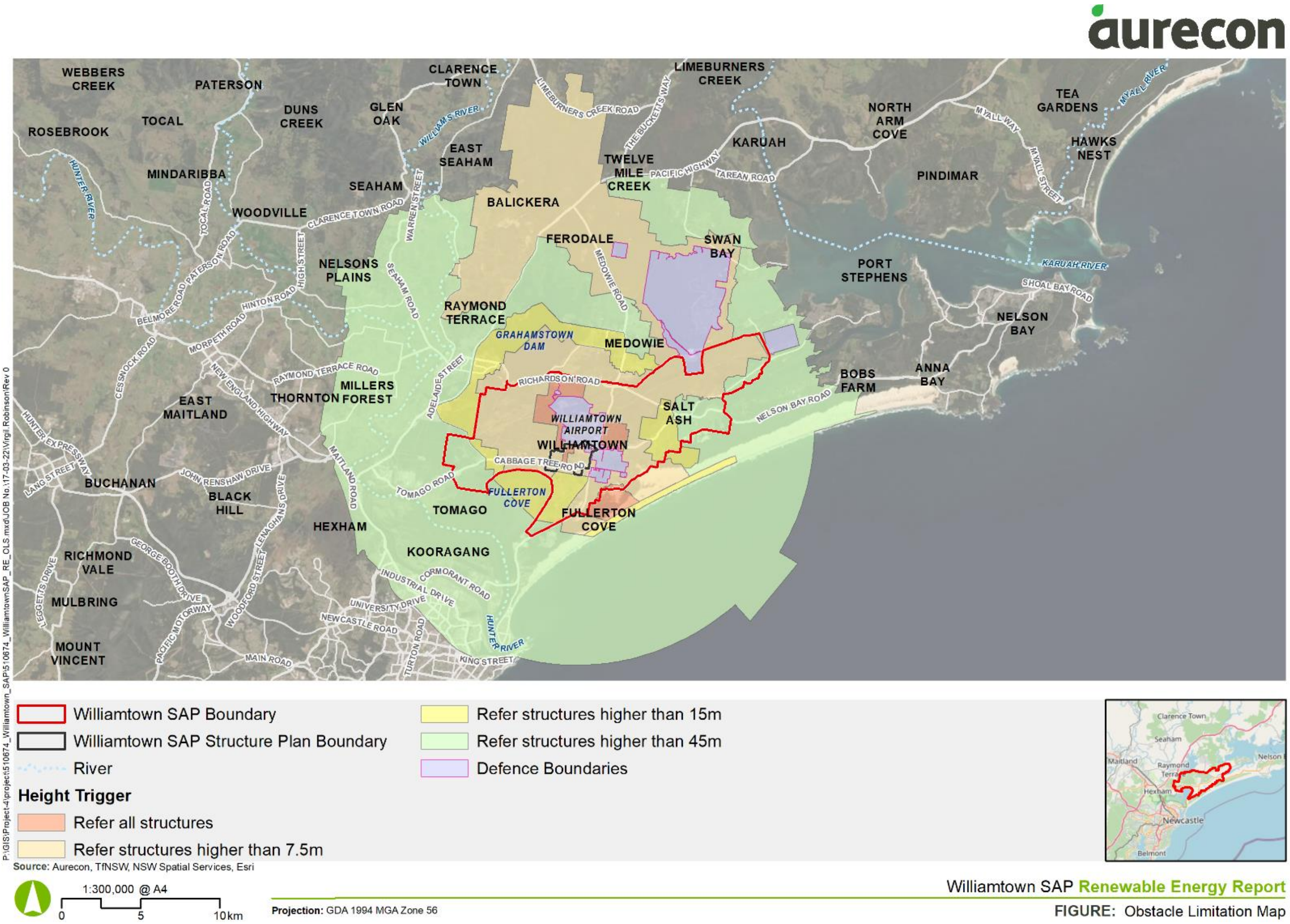


Figure 2-10 RAAF Williamtown obstacle limitations, Port Stephens Development Control Plan 2014

Airport safeguarding, as set out by the National Airports Safeguarding Framework, also includes guidance around sources of light near airports. It has been a concern in the past that solar arrays would cause distractions due to glare, however, several airports in Australia have installed solar arrays within their boundaries or nearby. These airports include Adelaide and Brisbane airport, indicating that there is not a developmental limitation of solar arrays close to airports, based on glare. Further design guidance for solar PV installations can be found in The US Federal Aviation Administration's (FAA) Technical Guidance for Evaluating Selected Solar Technologies in Airports.[7]

In addition to zoning restrictions, other constraints preclude certain areas from development for buildings. It is possible that these areas, affected by flooding and/or PFAS contamination, would be suitable for certain types of energy infrastructure, making use of otherwise 'unusable' land. These areas are the intersection of those indicated in Figure 2-11 as the areas that are not highlighted within the Structure Plan boundary, and areas not precluded by zoning.

[7] https://www.faa.gov/airports/environmental/policy_guidance/media/FAA-Airport-Solar-Guide-2018.pdf

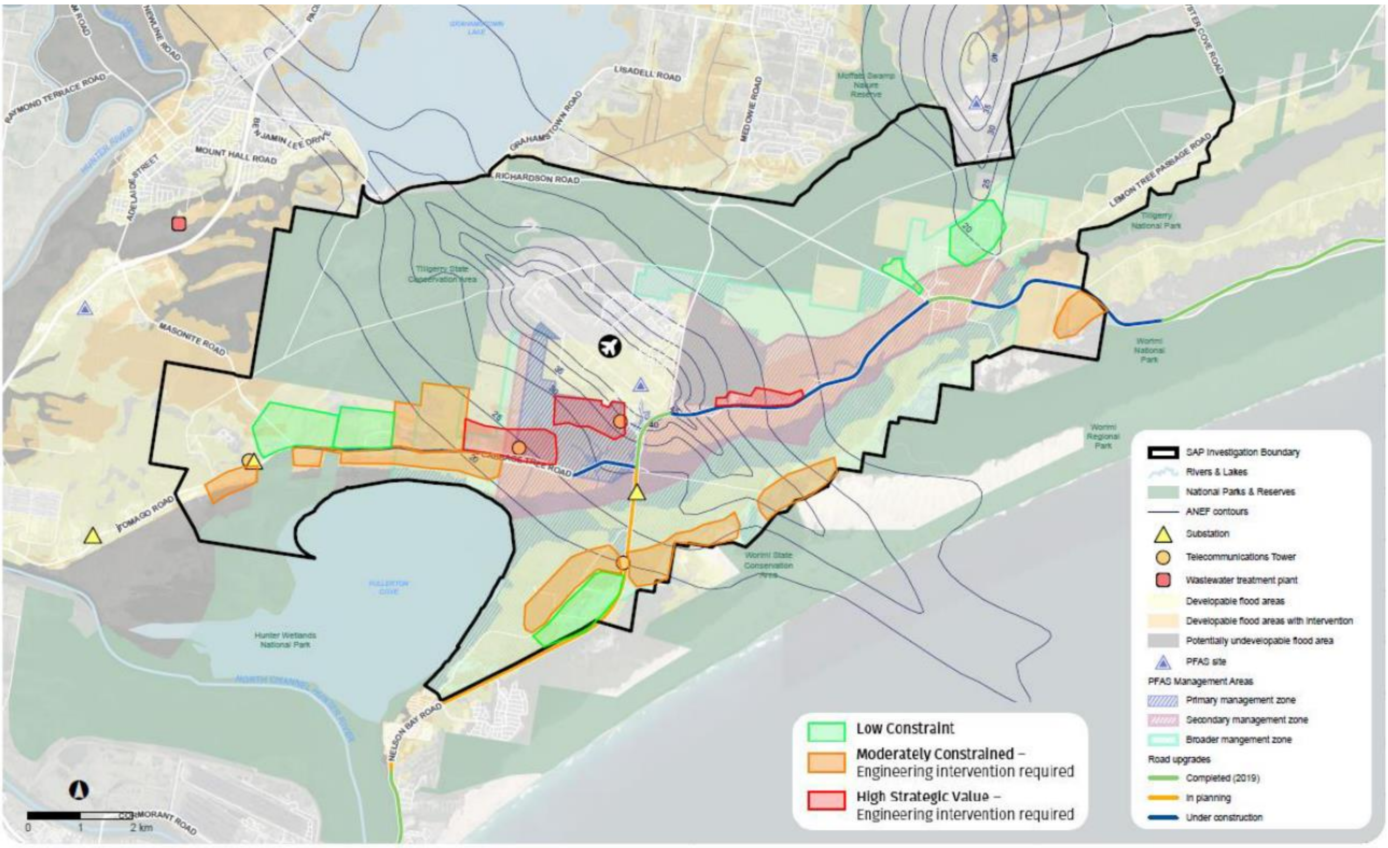


Figure 2-11 **Indicative Constraint Levels across Structure Plan boundary**

2.3.4 Enabling Infrastructure

This section provides a high-level overview of local distribution and sub-transmission electricity infrastructure factors which may require consideration for renewable energy development at the SAP. For a detailed analysis of the current state of electricity infrastructure and potential required upgrades, refer to the Utilities Infrastructure Scenarios Report.

The Newcastle load centre, which includes the Port Stephens distribution load area, is supplied at a transmission line from the TransGrid 330 kV network. The TransGrid Transmission Annual Planning Report (TAPR) 2020 does not identify any ongoing or upcoming augmentation works in this area or capacity limitations on the connecting 330 kV lines.

The Williamtown SAP lies within the Port Stephens load area and is supplied via the 132 kV sub-transmission and 33 kV distribution networks managed by Ausgrid. The layout of the local network is indicated in Figure 2-12, with site boundary overlay.

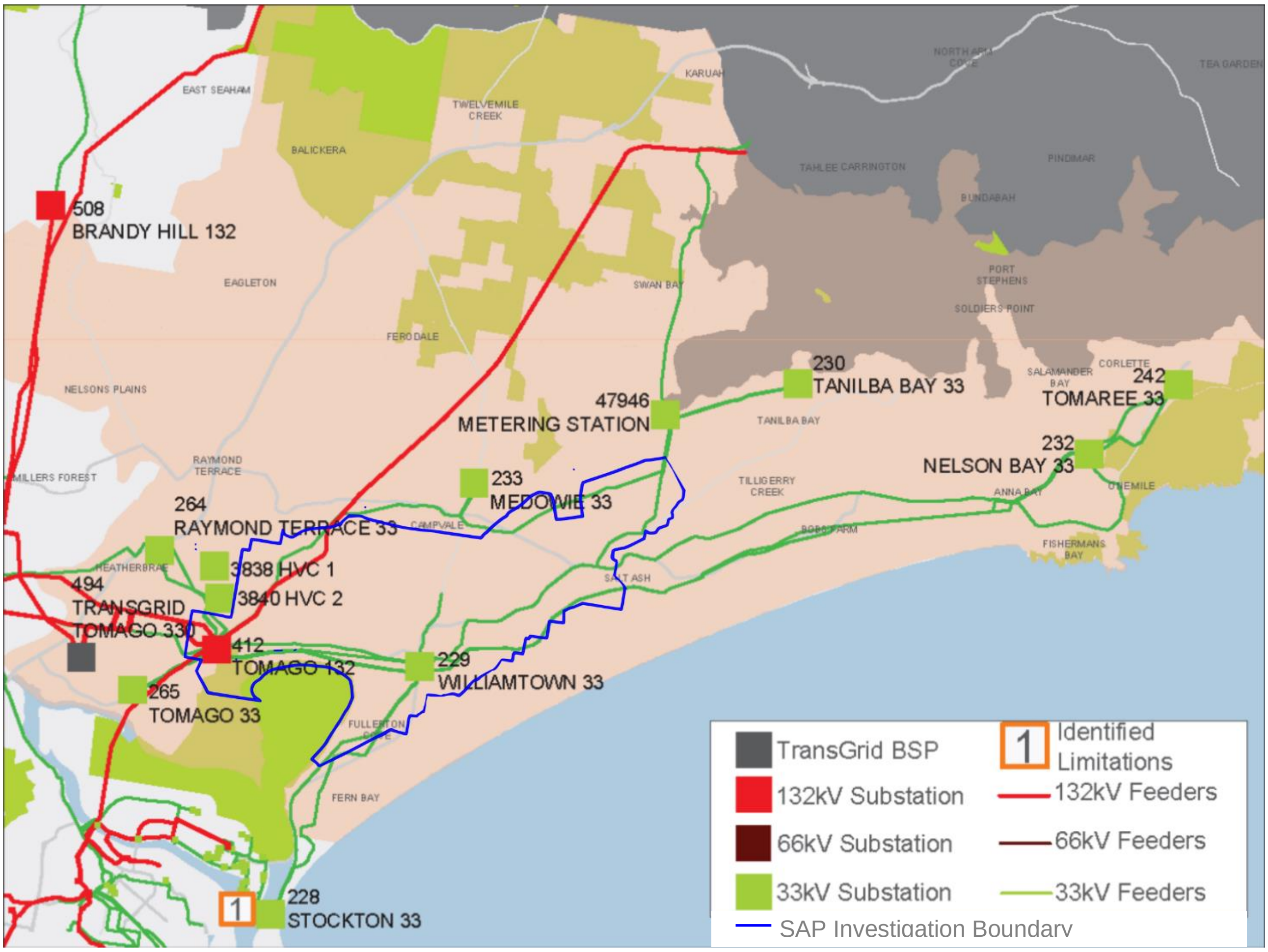


Figure 2-12 **Port Stephens Load Area network layout, Ausgrid DAPR 2019, with site boundary overlay**

Sub-Transmission Infrastructure

The area of investigation for the Williamtown SAP is supplied via the TransGrid Tomago Bulk Supply Point (BSP) and has a 132 kV sub-transmission line running along the north-west edge of the site, as shown in Figure 2-12. Proximity to this supply point means that there will not be any meaningful constraints to supply to the SAP, either from a load or generation point of view nor any costs incurred to SAP for transmission investments.

The Ausgrid 2019 Distribution and Transmission Annual Planning Report (DTAPR) indicates that increasing penetration of rooftop PV in the Lower Hunter Region has pushed up voltage levels in the 132 kV network and this is no longer manageable through existing assets as the tapping range (the factor by which voltage is reduced in the transformer) at the Static Transfer Switch (STS) is not sufficient to achieve the required voltage levels in both the distribution and sub-transmission networks. Projects are underway to understand the work required to remediate the voltage level in the local network BSPs, including Tomago. The key takeaway for the SAP is that Ausgrid has a process in place to resolve this problem and it is not anticipated from this review that there will be any constraints to supply to the SAP from issues on Ausgrid’s sub-transmission network.

However, the development of the SAP may require the construction of new capacity by Ausgrid, possibly in the form of a dedicated 132/11 kV zone substation. This would be the case even with embedded generation being installed within the SAP, as the amount of generation will only be covering some percentage of native demand. It is very likely that Ausgrid would fund this substation as there would not be one single customer that would trigger a capital contribution. These considerations are covered in more detail in the Utilities Infrastructure Scenarios Report.

Distribution Infrastructure

The Williamtown distribution network is currently supplied via the Williamtown Zone Substation (ZS), which is one of the eight zone substations in the 33 kV network supplied from the Tomago STS. The only emerging limitation identified in the Ausgrid 2019 DTAPR is the asset condition of the 11 kV switchgear at the Stockton ZS. This is scheduled for replacement in 2021, which will resolve this limitation. The maximum total available supply capacity of local zone substations to serve demand is 144.4 MVA (refer to Williamtown SAP Stage 1 Utilities Capacity Assessment, Section 2.4.2.10).

Ausgrid may choose to supply the precinct via new 11 kV feeders connected to existing substations in the surrounding area. There is available capacity in these zone substations to do that. However, any new 11 kV feeders may need to be funded by the first business to locate to each new part of the SAP. A pioneer scheme would then be applied, whereby additional businesses that use that funded feeder must contribute to use of the feeder, and this funding is redistributed back to the first business that funded the feeder.

Other considerations are that the SAP is unlikely to present any material limitations in hosting generation in-feeds so long as the amount of generation does not exceed the native load by more than 15% to 20%. That is, if the final load of the SAP ends up being 40 or 50 MVA, then the 11 kV network could be expected to accommodate 44 MVA to 55 MVA of embedded generation. This is on the presumption that this generation also has complementary technology such as STATCOMS, on-line tap changing distribution transformers and other general smart grid technology to manage voltage levels within appropriate levels.

The Williamtown SAP project will be required to submit an application for an Ausgrid Planning Study during the next phase of the project planning when precinct location and demands have been further defined. Ausgrid will provide servicing options during the undertaking of this study prior to providing a design information pack on the preferred option. Ausgrid will provide servicing options to supply the proposed development, including options for redundancy, if required, to service specific industry or defence requirements.

The Ausgrid study will determine if the existing available capacity of Williamtown only can service the additional power demand of the proposed SAP loads or does it require to be supplemented by the other zone substations it is connected to. As discussed in the Utilities Infrastructure Report, demand from the SAP is estimated to reach between 170 and 320 MVA.

Generally speaking, 11 kV feeders can carry a peak demand of 5 MVA to 8 MVA, so the precinct could be supplied via about five to eight 11 kV feeders. Given potential demand and future growth in the SAP, it is possible that Ausgrid may choose to supply the precinct by constructing a new dedicated zone substation. Even if a new substation was constructed, the 11 kV feeders supplying the site would be designed with open points that can allow each feeder to be fed from across from another zone substation, providing a level of redundancy in the case of a total loss of supply at the new substation. Understanding this arrangement is important when considering the implementation of smart grid technology. This is because any such technology would need to be compatible with adjacent non-smart grid substations whenever one of the SAPs 11 kV feeders needed to be back fed from one of those adjacent substations. Given the proximity to existing network, an off-grid solution to supply the SAP would not be economical, when compared to the level of reliability performance accorded by a conventional grid connection.

3 Structure Plan

3.1 Methodology and Approach

Section 3 of the report provides a summary of the scenario development during the second Enquiry by Design workshop held on the 27th to 30th of April 2021. This workshop involved the further testing of the previously prepared scenarios and development of the Williamtown SAP Structure Plan.

For detail on the Baseline Assessment (Stage 1) and Scenarios Assessment (Stage 2) process and artefacts developed throughout the creation of the Structure Plan, see Appendix A and B.

Like in the previous Enquiry by Design workshops, the structure plan considered land use, transport, infrastructure, PFAS, environmental, social, aboriginal heritage and economic matters in conjunction with the SAP vision.

Figure 3-1 provides an outline of the key principles that were incorporated into the masterplan.

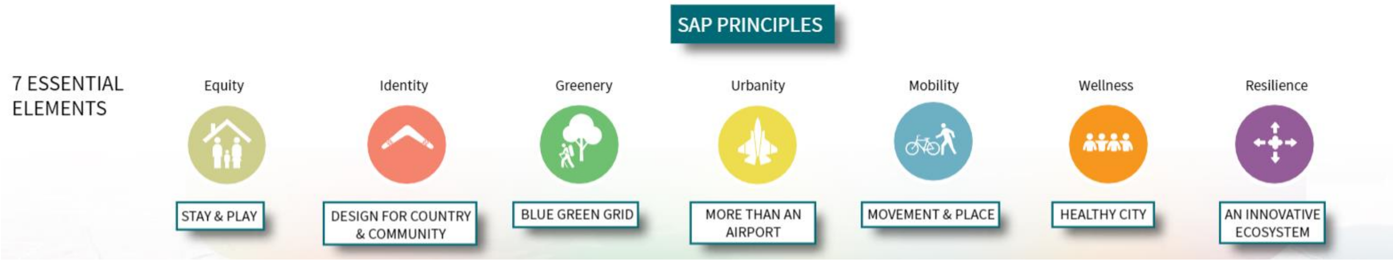


Figure 3-1 The 7 SAP Principles which governed the masterplan

The structure plan leverages the preferred elements of all the scenarios developed, further explores the items under investigation and avoids the earmarked no-go zones. The previously identified strengths and opportunities of each scenario were pursed while weaknesses and threats mitigated. This approach was taken to maximise the positive development outcomes rather than considering the previous scenarios as options and adopting one as the preferred structure plan.

3.2 Proposed Structure Plan

The Structure Plan refined by Roberts Day is centred around the existing Williamtown Airport Precinct, which includes Newcastle Airport, Williamtown RAAF base and Astra Aerolab. The precinct incorporates a core development area south of the existing airport. Initial stages of the SAP development are to incorporate aerospace and defence contractor industries around the southern airside boundary of the airport. The land uses within the SAP's Northern sub-precinct focuses on defence and aerospace, commercial centres, freight and logistics and research and development industries. The later stages of the SAP, which includes the Western and Eastern sub-precincts, focus on a more flexible land use application which focuses on complimentary industries such as commercial centres, advanced manufacturing, light industry and research and development.

The plan shown in Figure 3-2 adheres to the existing drainage and flooding characteristics and incorporates the inclusion of the Dawson's and Leary's drain reserve. Additionally, it maintains hydrological regime for the biodiversity corridor, facilitates controlled flooding throughout the SAP precinct and utilises floodplains South of Cabbage Tree Road to offset impacts.

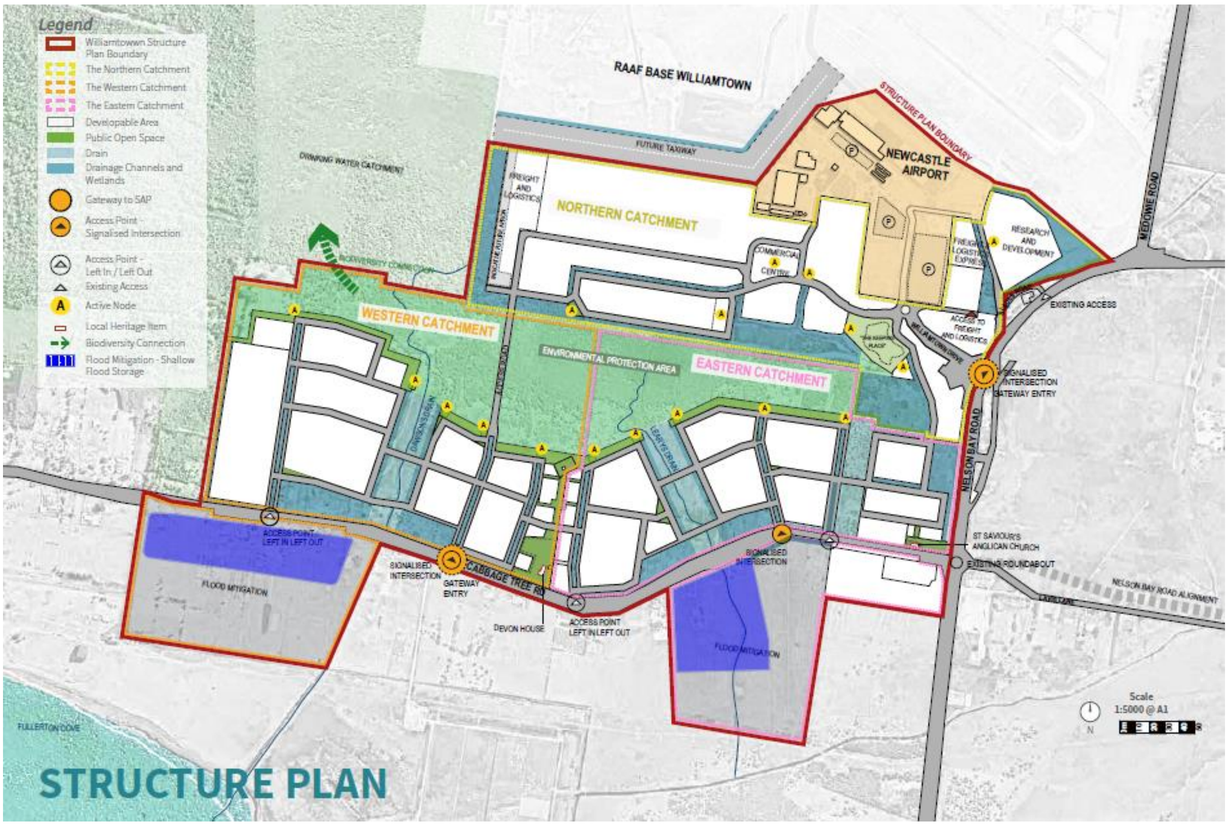


Figure 3-2 Williamtown SAP Structure Plan

3.2.1 Renewable Energy Vision

The Williamtown SAP aims to be a carbon-neutral precinct. This has been the first priority in developing the renewable energy plan for Williamtown. Following close behind the carbon-neutral goal is energy reliability and cost control for the businesses within the SAP. As mentioned earlier in this report, these identified priorities are considered the energy trilemma: delivering an energy solution that is low in emissions, low in price and highly secure. As shown in Figure 3-3, achieving all three at the same time is the challenge as they can to some extent compete with one another.

Figure 3-3 The Modern Energy Trilemma

Typically, a given technology can be expected to address two of the three requirements, but it takes a holistic solution to deliver all three.

As discussed in Section 2, energy prices have been high and volatile over the last few years. They are not expected to return to 2014-15 levels for many years. This has driven many organisations to look for alternative supply arrangements to help manage their pricing risk. Williamtown SAP should seek to reduce exposure electricity price volatility and price increases while still seeking reliable supply and emissions reductions.

The final structure plan combines elements from the three preliminary options proposed in Appendix B. However, it should be noted that the final structure plan is also markedly different from any of the three preliminary options. The main change is that the final structure plan is significantly smaller in size. The decision to reduce the size was realised in the second Enquiry by Design workshop, when there was a collective realisation that a much smaller SAP was the only viable approach when economic land demand analysis and the constraints of flooding, wetlands and key areas of aboriginal significance were taken into account.

Nevertheless, the underlying approach that underpinned the three options was brought forward and adopted into this final plan. This vision has been used to guide the energy strategy definition.

Vision for renewable energy

Renewable energy used to offset energy demand, support the local grid, and stimulate circular economy opportunities.

Combination of mature and emerging technologies applied to mitigate risk while stimulating economic growth and local jobs.

In support of this vision for renewable energy futures in the SAP, the design principles outlined in Figure 3-4 were developed. These were used to drive technology selection in each land-use scenario.

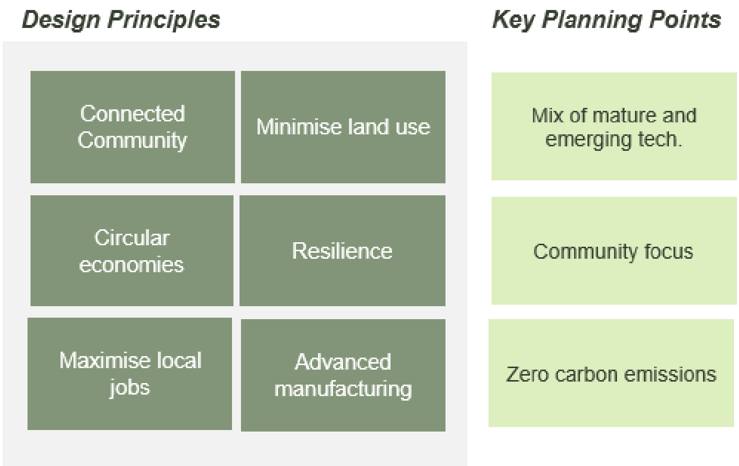


Figure 3-4 Design principles and key planning factors for renewable energy strategy

The above provided another layer of consideration to view each proposal while also keeping in mind the core goals of being carbon-neutral, delivering reliability and keeping energy affordable.

3.2.2 Constraints and Opportunities

Location and Space for Solar

Within the structure plan, the key location for renewable energy generation will be on rooftops. It should be noted that in the Stage 2 plan there was space earmarked as an energy corridor, with the intention of using at least some of the space for a solar farm. However, after the decision to achieve the carbon-neutral goal primarily through green energy contracts was agreed, the energy corridor concept was removed from the plan.

The decision to remove the grid scale solar farm from the precinct plan was a simple case of asking the question: what is the problem we are trying to solve here? The answer is achieving carbon neutrality in the best way possible, and the bottom line is there is no immediate reason to build a local solar farm when there are already multiple sources of renewable energy available in the market already. While a very visible and local presence of renewable energy certainly brings renewable energy front-and-centre in the minds of SAP tenants, that is all it really does – there is no compelling commercial or technical reason to have a local solar farm as opposed to a 'non-local' solar farm (or wind, or hydro source for that matter).

Indeed, the construction and ongoing operation of a solar farm requires the identification of a third party prepared to invest in a small-scale solar farm which is very likely to be more expensive (because of a lack of scale in particular) than what could be readily sourced in the competitive market. Delivery costs are also compounded by the highly constrained land around Williamtown and the construction of the solar farm would also need to consider flooding, geotechnical, hydrogeology and other technical constraints noted in the other Williamtown SAP reports. These parties can be found, but they typically represent a higher cost source of renewable energy because of that lack of scale. The alternative is to source green energy in the market, and this can already be done through power purchase agreements, and other contract arrangements. They can be expected to provide a higher degree of flexibility in sizing the amount of energy required, with better prices on offer and more satisfactory contract terms. They can be expected to represent less risk for the SAP as a result. In contrast, the local solar farm will only be able to ever supply a fixed amount, at a higher price (because of a lack of scale) and likely require 'top-up' contracts for the shortfall for the SAP in any case. On the balance of this background, it was decided to remove the 'grid-scale' solar farm from the plan.

The majority of the new building development proposed for the SAP will include rooftop space which can be utilised for rooftop solar PV (or other renewable generation if it is technically and commercially feasible in the future). This is typically connected 'behind the meter' to the building on which it is installed and used to directly offset energy demand.

A high-level assessment concludes that there is 43 ha of rooftop area available in the SAP, resulting in a maximum potential solar PV capacity of 27.4 MW.[8] Assumptions are outlined in Chapter 4 - Conclusion of this report.

Location and Space for Grid level Batteries

Excess solar generation can be stored in a battery. The main solution proposed for this plan is the use of a grid level battery rather than each business buying and installing their own battery on their premises. The use of a shared battery resource will be cheaper for each business because of benefits from scale – the capital recovery will be managed by Ausgrid over time, rather than each business being burdened with having to spend capital upfront. A discussion on the economic rationale for a grid level battery is provided further below in the report.

A potential constraint with the installation of grid level batteries will be finding a spatial allowance for them. An example of a grid level battery installed by Ausgrid is shown in Figure 3-5 below.

Figure 3-5 Ausgrid Grid level Battery commissioned in February 2021 at Beacon Hill, NSW

These grid level battery cubicles have a battery stack inside together with an inverter. The inverter converts the DC voltage of the batteries into 400V ϕ-ϕ AC output that then connects to Ausgrid's LV network. In this installation at Beacon Hill in Sydney's northern beaches, the battery has been connected directly to the LV busbar of an Ausgrid

[8] High level modelling and analysis conducted by Aurecon using common planning assumption derived from the draft structure plan.

11kV/400V kiosk substation (seen in the background of the photo above). Ausgrid controls the charging and discharging of the battery on behalf of the customers who have signed on to use some of the capacity of the battery to soak up their excess solar generation.

Co-ordinating the Solar and Batteries for Backup Supply

One of the business sectors targeted to locate into the SAP is aerospace and defence. This is due to the SAP's proximity to the RAAF base and Newcastle Airport. In particular it is expected that a number of businesses will locate to the SAP in support of a significant number of the RAAFs F35 strike fleet being based out of Williamtown. With this in mind, another key goal of the SAP will be to provide an additional level of energy security. It is proposed that this will be delivered through a combination of the installed solar within the precinct being co-ordinated with the fleet of grid level batteries. This will only be called upon when there is loss of grid supply.

As such, the backup supply as a microgrid will only come into play when power is lost. Even under these circumstances, it will only provide energy supply for 25% of the typical demand for up to 60 hours, however this is dependent on battery charge when power is lost, as well as amount of solar generation during the hours where grid supply is not available. If more than 25% of typical demand is required, the duration of battery supply is significantly reduced. This could be extended if more batteries are installed, but this is likely to be cost prohibitive and provide little additional incremental benefit. Other options are for private investment on behind the meter battery to increase their energy security.

Back up diesel generators are also a viable option however, is not aligned with the SAP vision. Thus, is not recommended.

Gas demand Alternatives

At present for the SAP, an expansion of the gas network is planned as described in the Utilities Infrastructure Report. Thus, a gas connection will be available for customers in the SAP. It has been assumed that carbon offsets will be used to account for any gas use in the SAP. Customers should also be encouraged to electrify their energy use wherever possible. Industrial and light manufacturing customers should be required to use heat pumps where viable or to use sustainable biofuels such as ethanol.

Gas alternatives, such as hydrogen and renewable gas (described in Appendix B of this report), are not technologically and commercially mature, nor is there a compelling case that they will be within the development window of the SAP.

The one obvious application for green fuels is for process heating. But according to research published in August by Lowes and colleagues, the heating industry "Incumbents are over-selling 'green-gas' to policymakers in order to protect their interests and detract from the importance and value of electrification."[9] Their paper says:

> "*Techno-economic analysis by academia, the UK government and its advisors has repeatedly suggested that electrification of much heat demand, primarily using heat pumps alongside the reduction in heat demand, represents the lowest cost pathway to near fully decarbonised heating.*"

This comment gives pause to the use of green gas for heating in Australia, but also strongly advises the use of electric heat pumps as the best cost option for businesses with the SAP. Bloomberg New Energy Finance's Meredith Annex says using hydrogen in particular for heat is an "expensive use case" and that the fuel "struggles" relative to heat pumps, even on a total cost-of-ownership basis.[10]

The use of hydrogen for other uses is also difficult to justify. Recent modelling conducted by the International Energy Agency (IEA) and published in their Energy Technology Perspectives in September 2020 sees hydrogen use meeting less than 7% of final energy demand in 2050, of which transport (44%), industry (28%), power (19%) and buildings (9%).[11]

---

[9] Richard Lowes, Bridget Woodman, Jamie Speirs, 'Heating in Great Britain: An incumbent discourse coalition resists an electrifying future', *Environmental Innovation and Societal Transitions*, Volume 37, 2020, Pages 1-17.

[10] Carbon Brief, In-depth Q&A: Does the world need hydrogen to solve climate change?, 30 November 2020, available at https://www.carbonbrief.org/in-depth-qa-does-the-world-need-hydrogen-to-solve-climate-change.

[11] International Energy Agency, Energy Technology Perspectives 2020, p111 (quoted from Carbon Brief, In-depth Q&A: Does the world need hydrogen to solve climate change?, 30 November 2020, available at https://www.carbonbrief.org/in-depth-qa-does-the-world-need-hydrogen-to-solve-climate-change.

According to the report, by 2070, in a scenario keeping warming well-below 2C, the IEA sees hydrogen meeting 13% of final energy demand, with this total spread unevenly between sectors. Hydrogen would meet large shares of energy use in shipping and aviation, but hardly any for buildings. Therefore, there is expected to be little market for hydrogen consumption (or hydrogen related fuels) in the precinct. In addition, the production of hydrogen for export would best be located close to the Newcastle port some 20km south of the precinct. It would make no sense to locate a production facility at the precinct to then have to build significant hydrogen pipeline infrastructure to get it to market via hydrogen ready tankers at the port.

Taking account of the above commentary with the lack of a business case for green fuels for heat production and with the increasing maturity of electric heat pumps as a viable solution for process heating, the proposal to use green hydrogen and other green fuels such as ammonia or methanol has therefore been explicitly removed from consideration for the structure plan.

Of total energy demand, it is estimated that 28% will be related to gas consumption without any intervention in the choices of the business's in the SAP. With the interventions proposed, it is anticipated that the gas requirements will be well below 10% initially, and tracking toward alternative fuel options with zero emissions within 20 to 30 years.

3.3 Energy Strategy

3.3.1 Overview

This Section presents the plan for the energy strategy that is believed to provide the SAP with the most benefit, in alignment with the renewable energy vision and design principles. The working energy strategy has a key focus on community while incorporating an effective mix of mature and emerging technology.

A grid level battery with local use of network pricing system have been proposed. This technology involves strong community engagement and create value streams for the SAP while involving minimal land development.

Similarly, rooftop solar PV has been proposed. This technology furthers the community focus with onsite generation, although it also represents a mature and robust means of renewable energy production. Batteries have also been proposed as these emerging technologies are highly complementary of distributed PV and have already been technically proven.

In order to achieve net zero carbon aspirations while maintaining energy security, some level of grid supply must be incorporated in the overall energy strategy. PPAs are a mature method of renewable energy procurement in the absence of available resources. There is strong interest in REZ developments in NSW with particular focus on surrounding areas near the SAP, providing ample opportunity to secure PPAs.

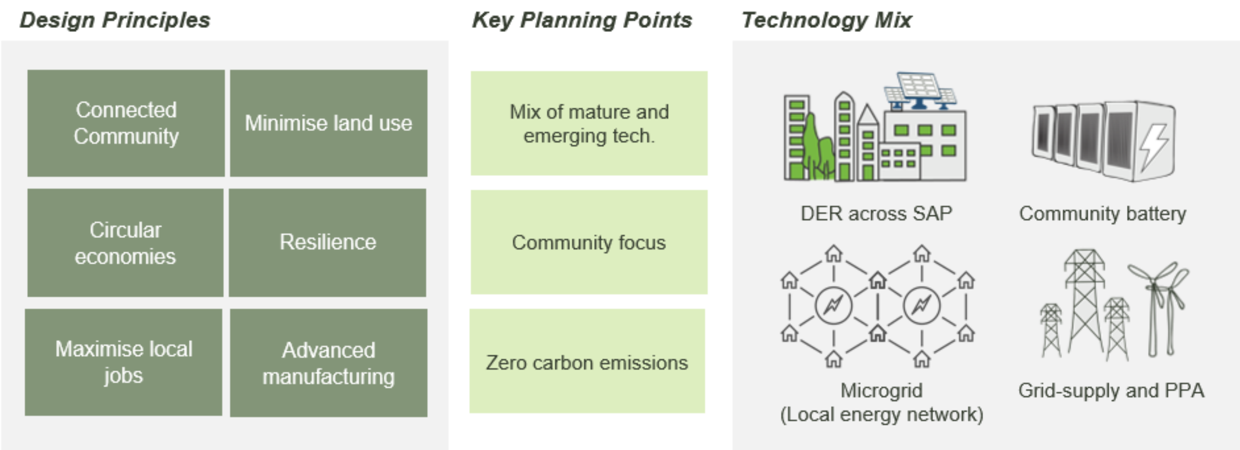


Figure 3-6 Structure plan design principles and technology summary

3.3.2 Technology Mix

The overall technology mix for the final energy strategy will consist of:

- Rooftop solar as a distributed energy resource (DER) on the majority of applicable new SAP developments;

- Small-scale battery energy storage systems (BESS) scattered throughout the precinct;
- Microgrid with a Local Use of System (LUoS) network pricing arrangement with Ausgrid to store excess solar generation in peak times, to provide bill savings to businesses in the SAP; and
- Grid supply and PPA contracts.

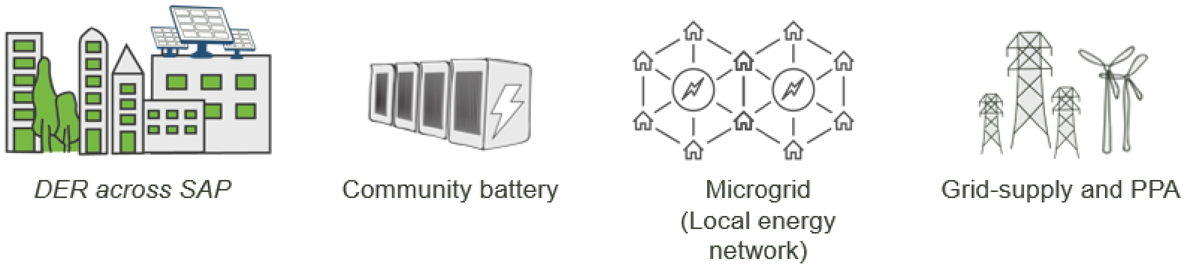


Figure 3-7 Structure plan technology mix

Table 3-1 presents a high-level SWOT analysis of the base technology mix, as it applies to the final energy strategy.

Table 3-1 SWOT assessment of base technology mix

Strengths	Weaknesses
▪ **Net Zero Emissions:** The working strategy has the potential to achieve net-zero outcomes for the SAP via PPAs. ▪ **Technology Maturity:** Solar and BESS technologies are technologically and commercially mature, presenting few risks for planning or cost estimation for the project. ▪ **Wholesale market participation:** Grid level ownership model allows residents/businesses to participate in the wholesale market, generating revenue streams, in the long term. ▪ **DER hosting capacity**: Increase ability to integrate more solar PV energy generation into the distribution network ▪ **Grid connection:** As renewable generation is available indirectly through PPA contract arrangements, grid connection supports DPE's ability to meet net-zero goals for the SAP. ▪ **Reliability:** Increase reliability and resilience by generating enough energy to power the grid level and/ or critical infrastructure during outages. Defence and military operations can benefit from this technology.	▪ **Missed revenue stream:** The current arrangement of BESS will not allow for SAP customers to directly participate in FCAS and other ancillary markets. The customer may benefit indirectly through their tariff arrangement with their retailer. ▪ **Complex commercial arrangements** may be required to implement and operate the grid level battery. Using an aggregator service can help to access some of the ancillary services and reserve services available. ▪ **Capital intensive:** Battery storage is still expensive compared to other power generation/grid balancing services ▪ **Difficulty aligning revenue streams:** Although one of the strengths of storage is the range of potential sources of revenue open to it, this is also one of its weaknesses as those revenue streams are not easily aligned. ▪ **Community equity stake:** Relies on willing to invest from local residents or businesses.
Opportunities	**Threats**
▪ **Capex deferral opportunities:** The modular nature of solar and BESS assets will allow for staging of development in line with SAP progression. ▪ **Evolving regulation:** The regulatory frameworks to enable Demand Response (DR) and Virtual Power Plant (VPP) participation are being developed. Ownership and operational models regarding the supporting infrastructure (i.e. the local energy network, BESS, etc.) are maturing. ▪ **Improved resilience:** A microgrid could be designed to be able to island from the main grid in times of network issues, providing resilience to key loads in the precinct.	▪ **Falling price of wholesale energy** – might be cheaper to "buy" green power rather than build any rooftop solar or battery at all

3.3.3 Grid Connection Arrangements

Across the SAP, it is anticipated that 11kV/ 400V distribution kiosk substations will be constructed to supply the precinct. As each substation is constructed, it is anticipated that a grid level battery will in built and connected adjacent to the substation. The staging of the construction of the electricity network and grid level batteries would rest with Ausgrid as part of their existing planning obligations.

More detail on the construction of the new dedicated 33kV/11kV Williamtown SAP electrical substation and relevant 11kV feeder works is set out in the Utilities Infrastructure Report.

3.3.4 Estimated Energy Demand and Supply Analysis

The SAP is expected to contain a variety of load categories, including manufacturing, industrial, commercial, accommodation, and food and beverage. Industrial and manufacturing loads are more consistent and provide a baseload of demand that requires supply, whereas commercial and other loads have a load profile that reflects increased demand during daylight and normal working hours due to increased air-conditioning, water heating (when not heated by gas), and equipment usage.

Expected peak demand values have been provided by Ausgrid and are listed in Table 3-2 below.

Table 3-2 Demand values and assumptions

Sub-precinct development	Demand (MVA)	Assumptions
Northern Sub-Precinct		
Defence and Aerospace (including DAREZ/Astra Aerolab)	40.6	▪ 75% offices, 25% light industrial
Commercial Centre	4.3	▪ Commercial office space
Freight and logistics	2.8	▪ Assume similar demands to warehouse plus 50% provision for extra refrigeration demand
Research and Development	6	▪ Commercial office space
Eastern & Western Sub-Precinct		
Commercial Centre	57.8	▪ Assumed 100% office space as worst case scenario for electricity demand
Advanced Manufacturing		
Light Industrial		
Research and Development		
Total	**111.4**	

Generation in the SAP microgrid under the proposed operating model will be provided by behind-the-meter rooftop solar. For simulating the expected output, the following assumptions were used:

- Solar irradiance, temperature, and wind speed typical meteorological year data from Williamtown RAAF
- Array tilt 32 degrees
- Array azimuth north facing
- Fixed, roof mounted panels
- DC to AC ratio of 1.2
- Expected 0.35 MW/ha of rooftop solar was calculated assuming the following:
- Panel density of 0.4
- 55% of rooftop available for solar panels
- 260 W per 1.63m^2

The calculated electricity demand and upper limits for rooftop solar and grid level batteries are shown in Table 3-3. Electricity demand peak values are summated from Table 3-2. Demand load factor has been assumed to be on the low end of typical profiles as it is expected that the SAP buildings will operate with high green ratings, for example, commercial buildings will not run air-conditioning outside of office hours. Manufacturing/industrial is also expected to have reduced load outside of working hours. If manufacturing/industrial in the SAP operates 7 days a week load factor will increase and there will be a corresponding decrease in battery resiliency.

Table 3-3 Upper Limit of Technology Mix Sizing

	Capacity (MW)	Generation/Demand (GWh/yr)	Assumptions
Electricity demand	111	214	▪ Significantly reduced load on weekends for both Commercial and Industrial loads ▪ 7:30am to 4:00pm work days ▪ 0.9pf ▪ Overall 22% load factor
Rooftop solar	27	41	▪ As listed above ▪ 17% capacity factor
Grid level Batteries	45	Varying depending on use	▪ 400 kW per 1,000 kVA sub (significant potential for variation per site and to suit commercial model) ▪ Substations to meet peak load. Aero and industrial sites have N-1 (2,000 kVA capacity per 1,000 kVA load). Commercial sites N-1 capability will be determined by customers
Grid supply and PPA	Dependent on battery & solar profiles	173 (assuming all solar utilised)	▪ **GWh value assumes zero battery use (maximum value)**. Reduction of GWh supply from grid will depend on use of batteries ▪ Capacity doesn't include oversize for N-1 scenarios

Figure 3-8 compares the indicative total annual demand and PV generation in the SAP. It is expected that there will be a shortfall of 173 GWh that needs to be supplied by the grid. Depending on battery use, this value may increase however it would be offset by PV exports. To increase the generation, additional roof space may be required or designed such that greater than 55% coverage can be achieved.

Increasing roof-space coverage to 70% improves MW/ha to 0.45, allowing 35 MW of solar to be installed. This reduces the generation deficit to 162 GWh.

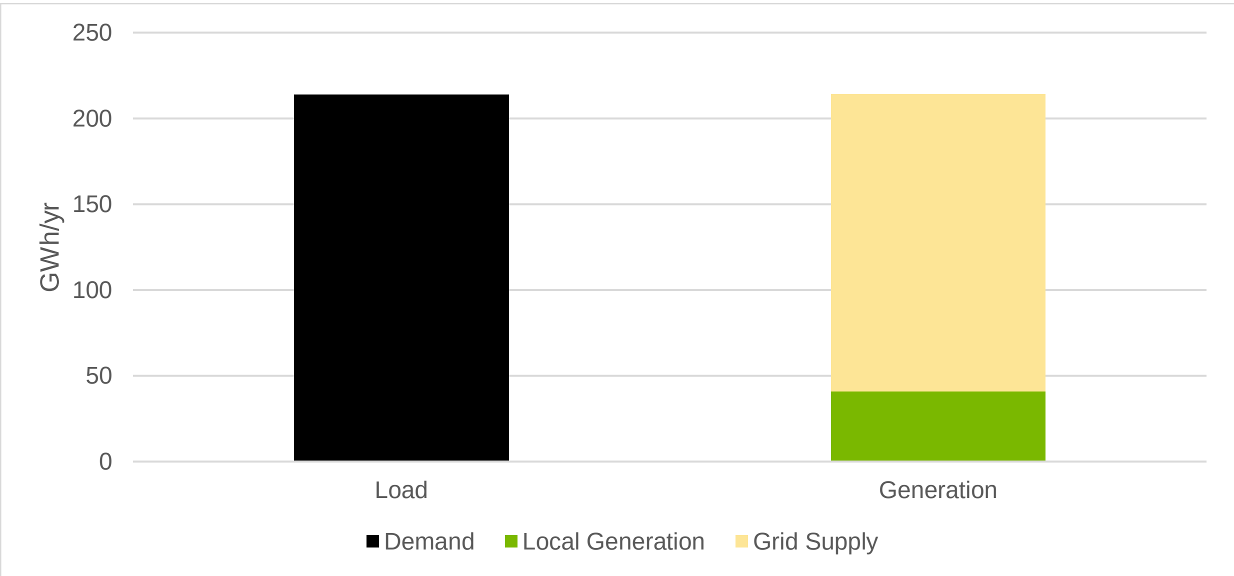


Figure 3-8 Comparison of indicative total annual SAP demand and generation

The average expected solar generation profiles for the roof-top solar in the SAP are shown in Figure 3-9. Due to the fixed nature of roof-top mounted solar, the profile peaks briefly during the middle of the day with significantly reduced generation during the shoulder periods. This results in less overall generation than single- or double-axis solar, increasing the amount of grid supply required.

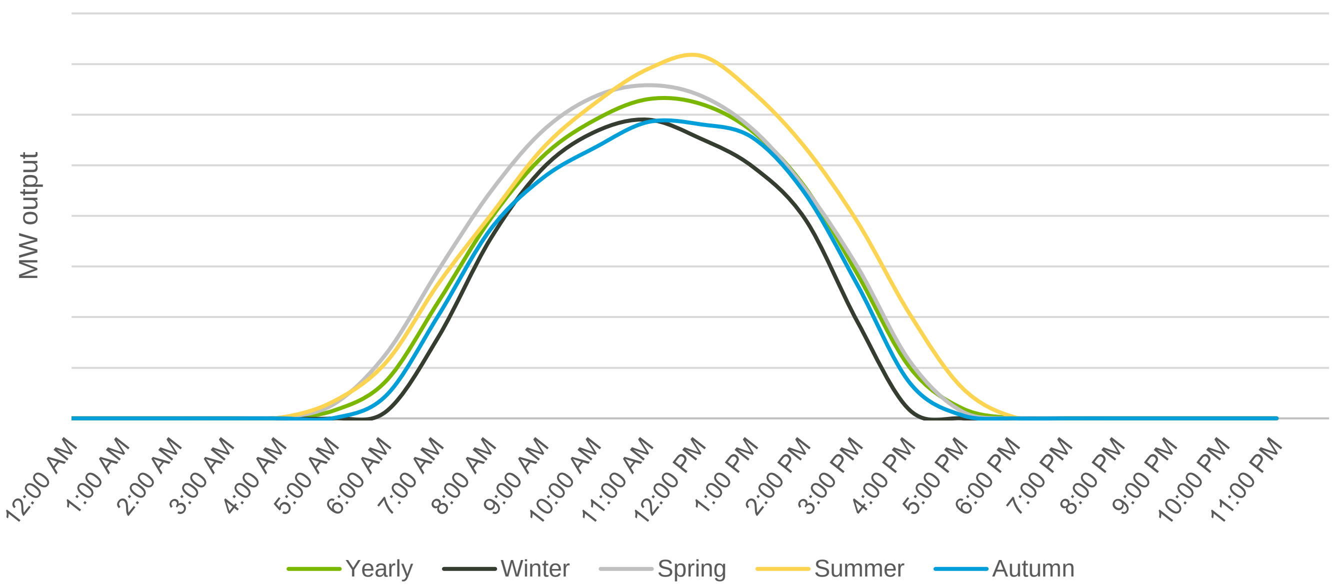


Figure 3-9 Average roof-top solar generation in the SAP

The annual average estimated supply and demand profiles for the SAP are shown in Figure 3-10. Due to the nature of solar PV not generating outside of solar hours, baseload of the SAP must be supplied by battery or grid. Additionally, the average demand exceeds the average generation provided by the roof-top PV. To fully offset the SAP demand power purchasing agreements may be required with external solar and/or wind farms.

More detailed demand calculations can be performed during the design process once further information on build-out within the SAP is known. This may result in lower demand than used in this high-level assessment, reducing reliance on the grid.

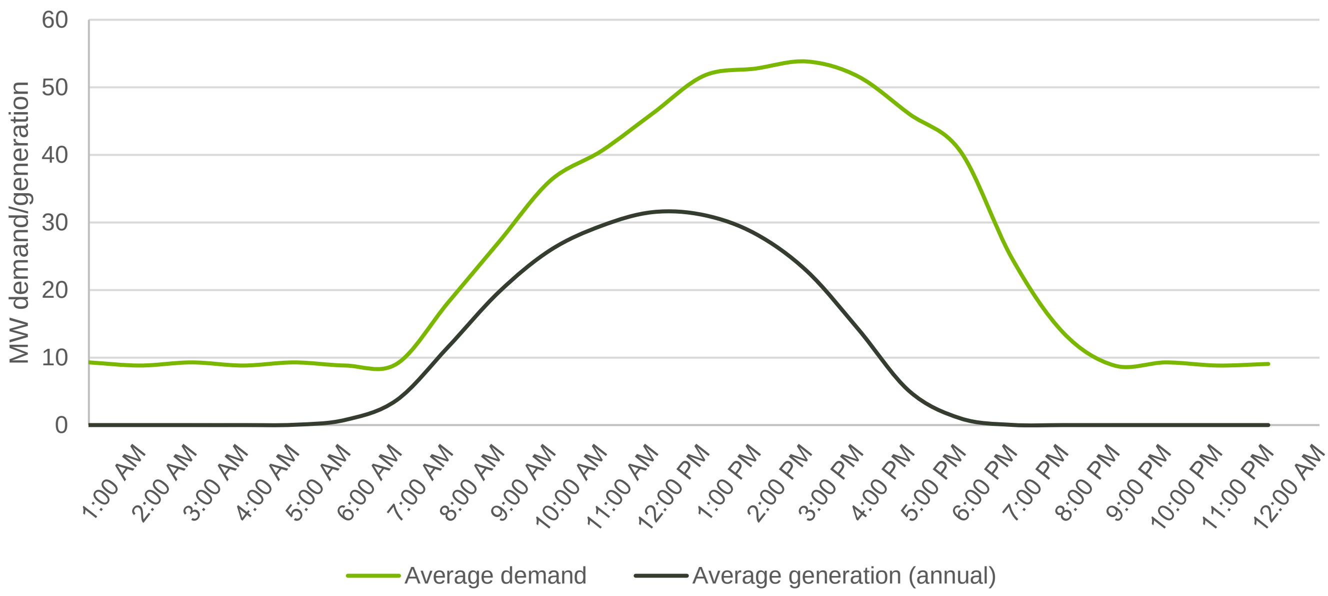


Figure 3-10 Comparison of annual average estimated supply and demand profiles

3.3.5 Operating Model

Aurecon has identified three different operating models available when considering the renewable technology mix proposed to be used in the Williamtown SAP. Key stakeholders that may be involved include the local SAP users consisting of residential or business energy users, the Distribution Network Service Provider (DNSP) Ausgrid, and energy retailers such as Origin Energy, AGL, etc.

The different operating models will involve these stakeholders to varying amounts with different asset ownership and funding agreements. The following operating models are proposed for consideration in the Williamtown SAP – these are based on the options and technology mix identified in Appendix B. An options analysis has been conducted to investigate the different operating models available to the SAP.

Table 3-4 Description of the proposed operating models available to Williamtown SAP

Operating Model	Description	Ownership and operation of assets	Key SAP Benefits
Microgrid (recommended)	A decentralised group of electricity sources and loads that normally operates connected to and synchronised to the traditional wide area synchronous grid but can also disconnect to "island mode" — and function autonomously as physical or economic conditions dictate.	▪ Rooftop Solar PV systems – SAP customers ▪ Grid level BESS - Ausgrid	▪ Improves resilience ▪ Cost minimisation as the infrastructure will be owned and operated by Ausgrid. ▪ Discount on tariffs and charges from avoided cost of upstream network upgrades
Virtual Power Plant	A virtual power plant uses a cloud-based control system to aggregate distributed energy resources (DER) and coordinate flexible loads.	▪ Rooftop Solar PV systems – SAP customers ▪ Grid level BESS - Ausgrid ▪ VPP platform - Third party retailer	▪ Connected grid level through the coordination of demand and generation ▪ Potential discount on tariffs and charges from direct or indirect revenue from the third party retailer
Peer to Peer trading	Similar technical requirement to the VPP. This model involves the implementation of a peer to peer trading platform which, enables SAP customers to direct buy and sell energy from one another – creating a local energy market.	▪ Rooftop Solar PV systems – SAP customers ▪ Grid level BESS - Ausgrid ▪ VPP platform - Third party peer to peer trading facilitator	▪ Connected grid level by enabling sharing of renewable energy on site ▪ Supports circular economies by sharing excess energy with the wider grid level ▪ Lower electricity bills

Note for all three options smart meters or other data loggers are required to be installed. Data access agreements with participants are needed before customer data can be collected as per consumer data rights rule.

Options Analysis

The options analysis considers the high-level ownership and operations of the proposed assets in regards to its alignment with the renewable energy vision set out for the structure plan. This section does not include details on the financing and payment pathways and service programs and agreements as they will require strategic conversations and partnerships with key stakeholders later in concept design.

Operating Model Option 1: Microgrid (Recommended)

A microgrid will be implemented in the SAP. The SAP will remain connected to the grid supply in addition to the microgrid. The microgrid will provide resilience to the SAP through its island mode capabilities such that it will be able to operate and supply energy to the SAP independent of the grid for extended periods of time. This will be a partial microgrid where it will have the capacity to meet part of the SAP's demand until normal grid operations resume. This will ensure that a supply of energy is made available to the SAP during loss of main grid supply. The microgrid will consist of the following infrastructure:

Table 3-5 Components of the microgrid operating model

Component	Description
Behind-the-meter solar PV	▪ Behind-the-meter rooftop solar PV to be located on applicable new SAP developments. ▪ The solar PV systems will be funded and owned by the SAP energy users. This forms the generation capability of the microgrid. ▪ It is proposed to integrate PV ownership into the DPE approval pathway to be located in the SAP with the option to opt out if residents are part of an existing renewable PPA. This will promote uptake of solar PV in order to develop sizeable DER capacity.
Front-of-meter small-scale grid level BESS	▪ Grid level BESS will be co-located in the different SAP sectors to serve the needs of their respective sectors ▪ The grid level BESS and enabling infrastructure will be funded, owned and operated by Ausgrid. This forms the storage capability of the microgrid.
Microgrid control system	▪ Microgrid control system to be funded, owned and operated by Ausgrid. ▪ The microgrid control system will manage the distributed generators (solar PV) and battery to ensure that generation and consumption is appropriately balanced for the safe and stable operation of the microgrid. ▪ The contractual arrangements for this control will be negotiated between Ausgrid, the SAP businesses and their respective energy Retailers.

A simplified model of how this arrangement operates can be found in the figure below.

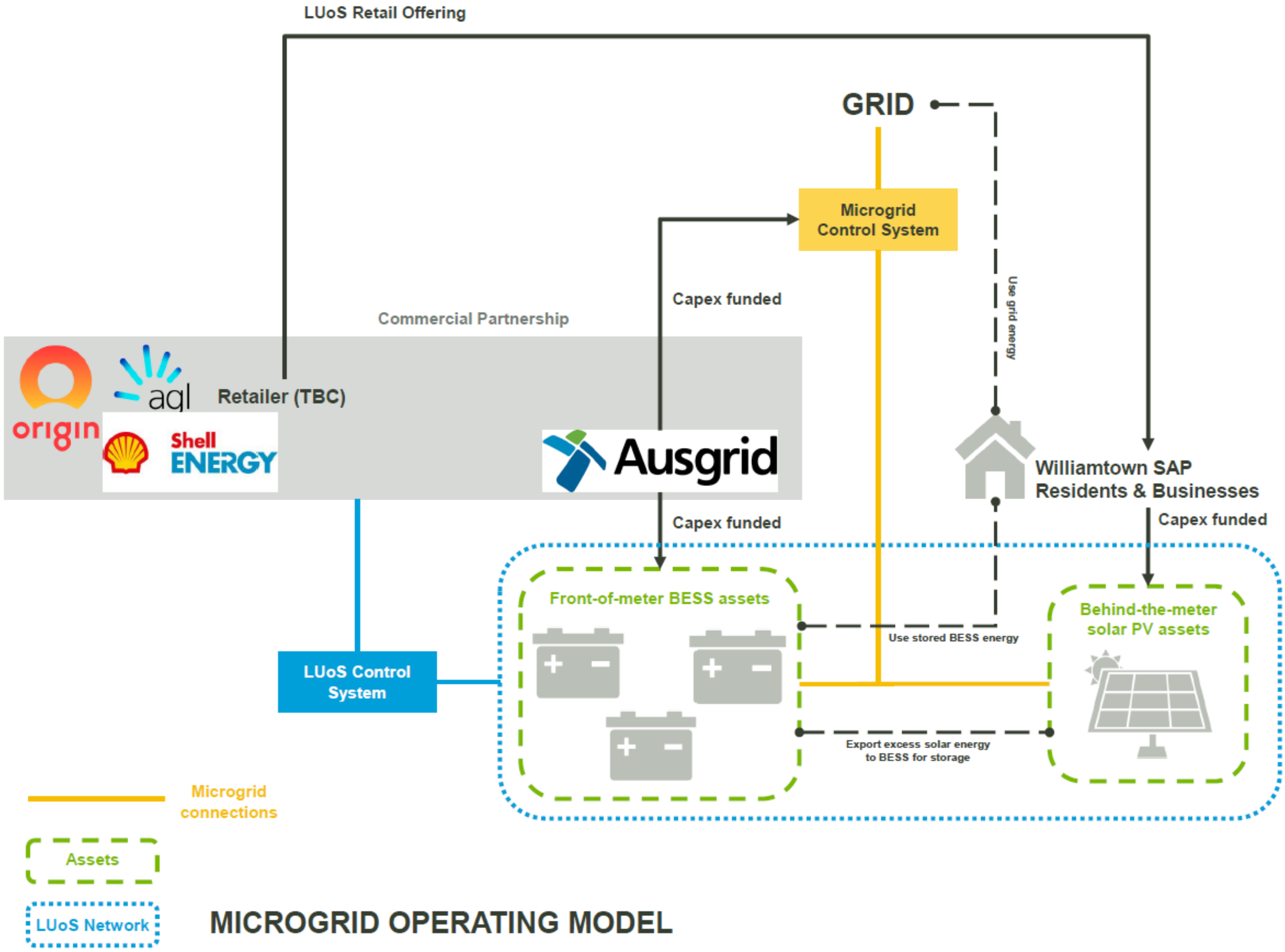


Figure 3-11 Simple block diagram of the microgrid operating model

Early conversations with Ausgrid suggest that the usual electricity billing arrangements will function with this microgrid operating model. Ausgrid will install, own and maintain the battery and offer a LUoS tariff to retailers who will then bundle that with their retail costs through to end users. It is anticipated that Ausgrid and 3rd party retailers will collaborate on the details of this commercial offering to end users. The developed LUoS tariff is expected to cover both periods of island model (when the main grid is down and end users are partially supplied by the installed solar and batteries alone) and normal grid supply mode as well. The proposed pricing arrangement will involve the supply of electricity to the energy user through a single Local Use of System (LUoS) tariff charged to the end user, thus allowing all parties within the SAP to form an arrangement similar to an embedded network, but with the network infrastructure being owned by Ausgrid rather than a 3rd party network owner.

It is anticipated that Ausgrid, in collaboration with the retailer, will have to develop an optimisation algorithm to coordinate the solar PV, battery and grid interactions. Optimisation of the BESS operation will have to consider elements such as market price signals, grid generation, and transmission and distribution capacities. This control algorithm will be a separate entity from the microgrid control system whose purpose and priority will be the stable operation of the microgrid network during island mode. Ausgrid is able to comply with their ring-fencing obligations by partnering with the retailer who acts as the contractual party with the SAP energy user. Further implications on the ring-fencing regulations are explored in Section 3.3.6 below.

The benefits for the stakeholders involved in this operating model are summarised in Table 3-6 below. A more detailed analysis of the stakeholder benefits can be found in Section 3.3.7 further in this report.

Table 3-6 Benefits of the microgrid operating model to the stakeholder

Stakeholder	Benefits
SAP Energy Users	▪ A lower LUoS tariff when compared to the grid usage tariffs – this lower LUoS tariff is a flow on effect of the reduced network charges passed on from the retailer and Ausgrid ▪ A discounted LUoS tariff will be made available for solar customers which will incentivise sizing up solar systems to enable exports to the BESS ▪ Access to the local battery stored energy during load shedding periods when demand is high or when generation, transmission or distribution capacity is low.
DNSP - Ausgrid	▪ Reduced strain on the transmission and distribution network during periods of high demand ▪ The reduced need to update network infrastructure upstream of the BESS. The Williamtown SAP distribution network is near capacity and the development of the SAP will increase demand on the infrastructure. The introduction of a BESS would add electrical capacity to the SAP within the local network and provide a means for local avoid the need for upstream network infrastructure upgrades to expand capacity.
Retailer	▪ Minimising excess solar exports into the grid network where it has been observed to drive wholesale prices down ▪ Reduced network charges pass onto the retailer due to Ausgrid minimising the need to upgrade network infrastructure upstream of the BESS

Operating Model Option 2: Virtual Power Plant (VPP)

A Virtual Power Plant (VPP) could be implemented in the SAP. The VPP would consist of the aggregated DERs located across the Williamtown SAP – the following infrastructure will form the VPP:

Table 3-7 Components of a VPP operating model

Component	Description
Behind-the-meter solar PV	▪ Behind-the-meter rooftop solar PV to be located on applicable new SAP developments. ▪ The solar PV systems will be funded and owned by the SAP energy users. This forms the generation capability of the microgrid. ▪ It is proposed to integrate PV ownership into the DPE approval pathway to be located in the SAP with the option to opt out if businesses are already signed up to an existing corporate renewable PPA.. This will promote uptake of solar PV in order to develop sizeable DER capacity.
Front-of-meter small-scale grid level BESS	▪ Grid level BESS will be co-located in the different SAP sectors to serve the needs of their respective sectors ▪ The grid level BESS and enabling infrastructure will be owned and operated by Ausgrid. This forms the storage capability of the microgrid.
VPP control system	▪ VPP control system to be funded, owned and operated by a 3rd party retailer. ▪ The VPP control system will manage the DERs across the SAP including the solar PV systems and grid level BESS.

A simplified model of how this arrangement operates can be found in the figure below.

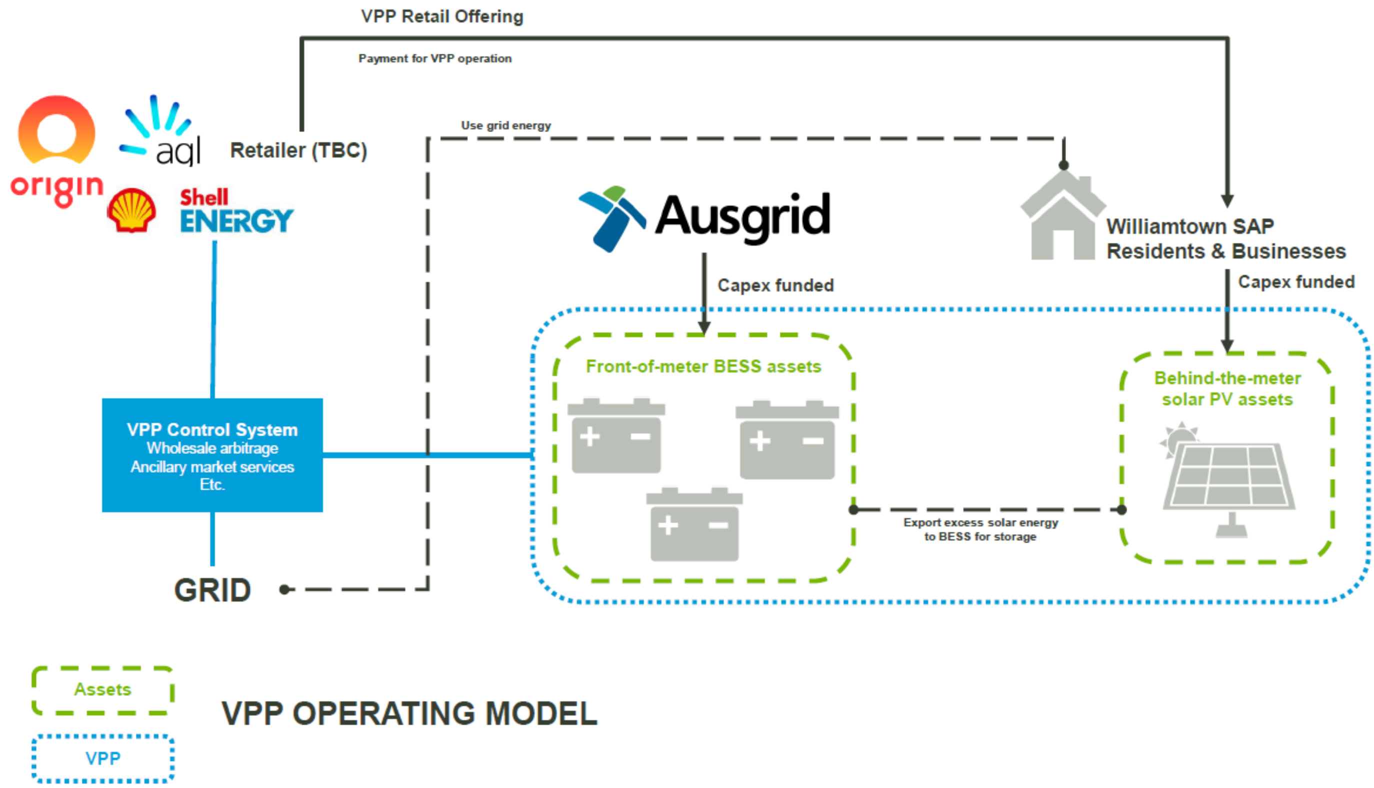


Figure 3-12 Simple block diagram of the VPP operating model

The VPP arrangement enables the SAP energy users to participate indirectly in the wholesale market by using the retailer as an intermediary who acts on behalf of the SAP energy user. The VPP operating model requires all parties, including the SAP energy users and Ausgrid, to sign up to this agreement with the retailer. The LUoS tariff will be charged from Ausgrid to each end user's respective retailer, and then the retailer will bundle that up with their VPP offering to the end user.

The VPP will enable demand response during times of grid shortage and provide voltage support services. The retailer will respond to electricity price signals to determine the appropriate times to import grid energy to charge the BESS or discharge the BESS to meet demand. The retailer will do this by potentially directing Ausgrid on the BESS behaviour, or they might establish a contract where a agreed protocol directs Ausgrid on behalf of the retailer.

The benefits for the stakeholders involved in this operating model are summarised in Table 3-8 below. A more detailed analysis of the stakeholder benefits can be found in Section 3.3.7 further in this report.

Table 3-8 Benefits of the VPP operating model to the stakeholder

Stakeholder	Benefits
SAP Energy Users	▪ A financial reward under the VPP retailer program for exporting excess solar generation to the battery. This may involve an annual payment in addition to the normal solar feed-in tariff or access to discounted electricity rates or bill credits through the retailer.
DNSP - Ausgrid	▪ Reduced strain on the transmission and distribution network during periods of high demand ▪ Ausgrid is unlikely to offer a discounted LUoS tariff under this business model, so a significant cost savings for businesses would not be available under this operating model.
Retailer	▪ Access to a battery energy storage system that allows them to generate revenue through wholesale arbitrage and ancillary market services such as FCAS

Although the VPP has the capability to orchestrate the charging and discharge of energy locally to SAP energy users thus allowing a commercial arrangement between the retailer and the user, the current network tariffs for a front-of-meter battery present a financial disincentive to the retailer from doing so. These network tariffs apply whenever energy is transported into or out of the battery, and there is greater battery revenue to be obtained from arbitrage or participating in ancillary market services. This option would only be progressed if Ausgrid is willing to enable the participation of their BESS within a VPP retailer program.

Operating Model Option 3: Peer to Peer Trading

A Peer-to-Peer arrangement could be implemented in the SAP, allowing the Williamtown SAP energy users to buy and sell energy to each other through a trading system operated by a 3rd party operator. This could involve the following infrastructure:

- Behind-the-meter rooftop solar PV to be located on applicable new SAP developments. This is proposed to be an opt-in system, with funding and ownership to sit with the SAP energy users.
- Front-of-meter small-scale BESS to be funded, owned and operated by Ausgrid.
- Front-of-meter small-scale BESS and peer-to-peer trading system to be operated by a 3rd party retailer.
- A simplified model of how this arrangement operates can be found in the figure below.

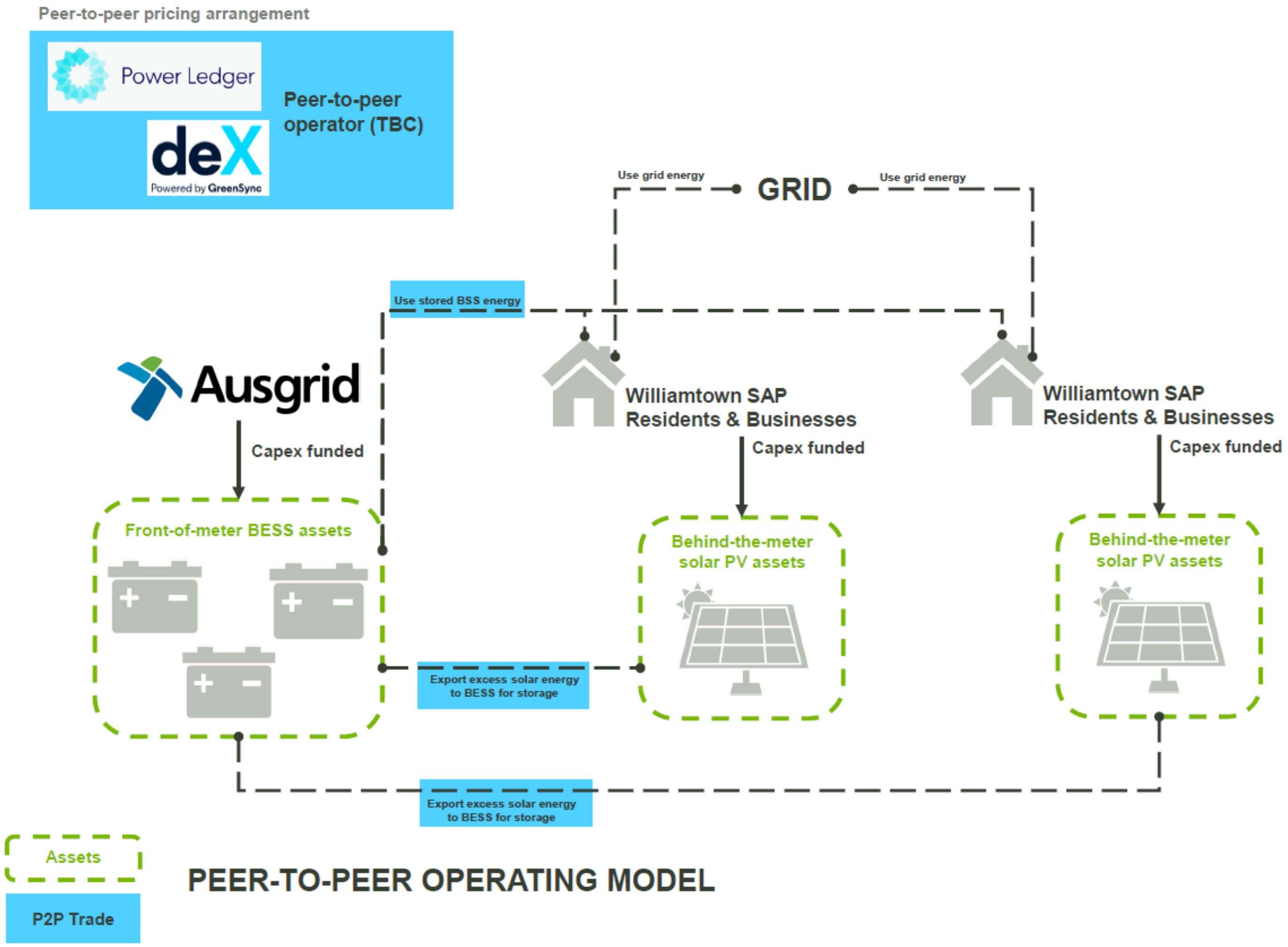


Figure 3-13 Simple block diagram of the peer-to-peer operating model

Participation in the peer-to-peer trading system would be opt-in. The peer-to-peer trading scheme would enable consumers to purchase and sell their generated energy at their own price limits via the 3rd party operator. The BESS is a fundamental requirement for a peer-to-peer trading scheme as it will allow for the trading to be unlimited by the generating period.

This option would only be progressed if it was allowed within whatever terms and conditions that Ausgrid might be willing to offer as they will retain ownership and operation of the BESS.

Recommended Operating Model

The advantages and disadvantages of each operation model explored above provides an insight into the best solution from a reliability, risk and market perspective. It is noted that Ausgrid is subject to ring-fencing regulations imposed by the Australian Energy Regulator (AER) – this is further explored in Section 3.3.6 below.

This means that any commercial arrangement with the SAP energy users must involve a retailer as the contractual party so that Ausgrid is able to maintain their ring-fencing obligations. Consequently, the risks and benefits to the SAP energy users, Ausgrid and the retailer must be carefully considered in order to provide sufficient incentive for all parties to participate in the operating model. A high-level comparison is provided in Table 3-9 below.

Table 3-9 Comparison of the proposed operating models for Williamtown SAP

	Microgrid with LUoS tariff	VPP	Peer-to-peer trading
Procurement simplicity	★★★	★★	★
Integration into Ausgrid operations	★★★	★★	★
Potential for innovation and additional revenue streams	★	★★	★★★
Grid level focused	★★	★★	★★★
Cost minimisation for SAP customers	★★★	★★	★

Legend	
Good	★
Better	★ ★
Best	★ ★ ★

The VPP operating model does not provide sufficient incentive to the SAP energy users or Ausgrid who will seek to prioritise the use of the BESS as a means to export excess generation for storage and usage in periods of low generation. The network tariffs remain a prohibitive factor for the retailer to provide this arrangement as they will seek to maximise the BESS revenue from wholesale arbitrage and the ancillary services market instead.

The peer-to-peer operating model is the least incentivising operating model to Ausgrid as it effectively cuts them out of the commercial arrangement by having the 3rd party facilitate the trading directly between the SAP energy users. This would disincentivise Ausgrid from allowing the participation of the BESS, which they have funded and retain ownership of, in any proposed peer-to-peer arrangement.

Based on the options analysis conducted, an Ausgrid operated microgrid utilising a Local Use of System arrangement is the recommended operating model for the Williamtown SAP. The following key points are noted for this:

- The microgrid operating model allows the SAP energy user to sell their excess generated solar energy and buy energy at a lower LUoS tariff when compared to the normal grid tariff.
- Ausgrid is able to minimise potential upstream transmission and distribution network upgrades by allowing the usage of the BESS to charge and discharge energy locally to the users, thus expanding the electricity capacity downstream from the grid network.
- The savings in network upgrade costs is passed onto the retailer and is realised in lowered network tariffs. The retailer is then incentivised to provide the LUoS commercial arrangement with the Williamtown SAP energy users.

Further elements of the commercial arrangements involved in each operating model is explored in detail in Section 3.3.7.

3.3.6 Regulatory Framework

This section details the existing regulatory framework in place for the use of a grid level battery. It should be noted that many of the regulatory hurdles in the deployment of DNSP-owned grid batteries is an item that sits with Ausgrid to progress. Indeed, it is understood that Ausgrid has been already working closely with the AER to progress their grid level battery trial to its current deployment. Nevertheless, this section explores the issues relating to the AER's ring fencing arrangement and various registrations and approval for the Williamtown renewables structure plan.

Ring fencing arrangement

Ring-fencing is required with Ausgrid's grid level battery to ensure separation between network and retail functions. This is because network functions are regulated and retail functions are contestable. Ausgrid will not be participating directly in any retail or wholesale market arrangements that do not provide distribution services. As a result, the existence of retailer/entailer is necessary to carry out retail or wholesale market arrangements.

Ring-fencing issues will be for Ausgrid to resolve if it participates with the SAP microgrid and owns the BESS. It is understood that they are already progressing these with direct conversations with the Australian Energy Regulator.

Approval of new Local Use of System Network Tariffs

Ausgrid's current grid level battery program is currently in a trial phase. Implementation of the LUoS tariffs will provide a lower-cost energy pricing structure when compared to conventional network tariffs, thus minimising energy costs for the Williamtown SAP consumers. It is understood that The Local Use of System (LUoS) tariffs used in the program are only approved on a trial basis. As such there are no approved LUoS tariffs available for public use.

For the grid level battery arrangement to proceed as proposed, new business LUoS tariffs would have to be developed by Ausgrid and then reviewed and approved by the Australian Energy Regulator. This represents a risk for the SAP – to mitigate the risk of using the untested LUoS tariff structure, the LUoS tariffs would initially be only trial tariffs, and would at some point need to become approved publicly available tariffs (probably within 3 to 5 years of approval). Otherwise they would be retired, and businesses within the SAP would revert to standard business tariffs.

It is understood that the AER is very receptive to the development of new LUoS tariffs, so there does not appear to be any immediate impediment to their creation and approval for the SAP.

Registrations and approvals

The first option plan will consist of dispersed small (~1MW) scale solar generators across the SAP with unique metering and no shared parent connection – rather these generators are to be connected directly to NEM. This solution allows these generators to be classed as small-scale generators with automatic exemption from generator registration. A registration fee is required to be paid to AEMO to be exempt from generator registration.

An application to AEMO for an exemption must be submitted – it is expected the responsibility for this will sit with the solar PV generation system owner, with DPE to inform businesses applying to be located within the SAP of this application requirement and associated fees.

The next most likely plan in lieu of approval would be the VPP proposal with privately owned grid level batteries. The same arrangements would apply here, as with the above.

3.3.7 Commercial Arrangement

This section will review the feasibility of the commercial arrangements proposed for Williamtown SAP. The commercial implications of the SAP's objectives (resilience, sustainability and energy affordability) will be identified before an assessment of the baseline operating model along with any extensions to that model.

Relevant site characteristics

The commercial arrangement will be structured around a variety of business types. Small business will be operating offices or warehouse space that consume 100MWh p.a. whereas potentially large manufacturers could develop greenfield sites that consume 100MWh in just one day. It is expected that most precinct businesses will operate on a weekday basis with minor or moderate energy consumption after business hours (730am-4pm, weekdays only).

- It is expected that 152 GWh of demand will be required per business annually (400-600MWh on a typical workday)
- Of that 152 GWh, approximately 55% or 82 GWh is expected to be generated.

Commercial implications of SAP Objectives

The commercial arrangements recommended for Williamtown SAP reconcile three main strategic objectives: resilience, sustainability and consumer affordability. The microgrid opportunity will simultaneously pursue all three objectives and this section will analyse ways in which they interface.

Resilience

Energy resilience is achieved when energy supply is maintained during unforeseen outages. For Williamtown SAP this will be achieved by maintaining a grid connection and developing a network of small-scale generation backed up by energy storage. A combination of self-generated solar PV volumes and stored energy will be used in the event that supply from the main grid is cut. This offers protection from any transmission, distribution or generation issue that occurs upstream of the microgrid.

Table 3-10 Key considerations for energy resilient SAP

Key Consideration	Description
Less than 100% of demand will be serviced in island mode	▪ It is recommended that energy storage and solar PV is developed such that critical SAP business operations can continue but this redundancy should not target full capacity output due to the prohibitive cost. ▪ The duration of back-up supply requirements (i.e. the duration and proportion of demand covered) need to be assessed as individual cost-benefit studies. The intention and recommendation is that 24hours of at least 25% is covered. However, an analysis of precinct participant resilience requirements should be undertaken and a broad window considered (anywhere from 1-14 days offering 25-75% of demand coverage should be the initial focus of the enquiry and any marginal increase/decrease can be assessed in terms of the impacts on participating businesses and costs of providing resiliency. ▪ A summary of costs for battery storage and rooftop PV is included within this section, as is a discussion on how prospective business types may value resilience.
Redundancy	▪ Maintaining a grid connection means the battery will only be relied upon as a supplier of last resort in the event that the grid faces an outage at Williamtown.
Marketing to parties who place high value on resilience	▪ Different sectors suffer varying levels of economic loss when faced with power outages. ▪ From an economic efficiency standpoint, SAP participation should be sought by (and marketed to) businesses that can least afford outages. There are different motives for avoiding outages: - financial motives as listed in the following row - strategic motives: businesses offering a product or service that is differentiated by maintaining continuous service (for example security/monitoring, data hosting) ▪ Business and sector types that would place higher commercial value on resilience include; - Manufacturing or biotech operations with a critical need for uninterrupted power - Security and safety services - Data centres and hosting - Food processing, particularly where produce must be kept within a temperature range (for example seafood)
Insufficient resilience | SAP avoided costs	The potential losses from insufficient resilience are highly variable based on business type and whether the risk can be mitigated (and indeed is mitigated). Types of financial loss from outages that Williamtown SAP will be avoiding or minimising: ▪ Damage to property, plant or stock ▪ Loss of trading or production, including damage to client/customer relationships ▪ Ongoing fixed costs in shutdown periods (fixed wages, inflexible pre-contracted supply chain arrangements) ▪ Re-commencement costs (jump-start and ramp-up) ▪ Individual back-up infrastructure and systems costs

Key Consideration	Description	
Measuring resilience & its commercial value	▪ The most prominent threshold for reliability in the NEM is 0.002% of total demand per NEM region per financial year. ▪ Microgrid resiliency has been reviewed and trialled across the world with particular interest from military operations and critical infrastructure exposed to regular natural disasters. ▪ We know from historical incidents that outage incidents lasting just a handful of hours will cost a large business well into the tens of thousands of dollars whereas sensitive operations will face stock losses upwards of $100k.[12]	
Resiliency threats to Williamtown SAP: causes and likelihood	**Resiliency Threat & Causes**	**Likelihood**
	▪ Technical – majority of unserved energy in the NEM ("USE") is a distribution fault or system security issue.	▪ High possibility based on historical precedent
	▪ Extreme weather - climate change and weather volatility	▪ Likely/occasional based on historical precedent, increasing
	▪ Geopolitical/security: physical or cyber attack	▪ Possible and high impact due to the malicious intent of the actor involved

Consumer Energy Cost Minimisation

The microgrid proposed for the Williamtown precinct is expected to reduce energy costs for participants. This advantage is structured around the avoidance of peak grid purchasing costs and the relative economics of the investment required. The microgrid should allow for a system that optimises the use of solar PV generation, making more self-generation available during peak consumption periods and avoiding full network costs. Currently, NSW businesses face a bill structure described in the following table and chart. Crucially, there is a significant difference between peak and off-peak variable tariffs. This creates temporal arbitrage, which can be utilised by the microgrid's energy storage technology. A key observation is that the arbitrage is greatest for small customers and drops off considerably for larger customers.

Table 3-11 Key considerations for cost effective SAP

	Small Business	Large Business
Threshold	<100 MWh p.a.	> 100 MWh p.a.
Bill Structure	Bundled; fixed daily supply charge and variable usage charges based on time of day and occasionally seasonal rates.	Unbundled, negotiable and varied (tariffs not publicly listed). Ausgrid's network charges are passed through by the retailer.
Peak & Off-Peak Periods	Workday peaks: 1400-2000 Workday shoulder: 0700-1400, 2000-2200 Workday off-peak: 2200-0700 Weekends: varies between retailers but usually all off-peak or a 0700-2200 carve out to shoulder Some retailers also implement a seasonal peak (Summer and Winter months) which follows the network charge structure.	Ausgrid's peak period is 1400-2000 on summer and winter month workdays. Shoulder period starts at 0700 on workdays and runs until 2200 except for the 1400-2000 peak period within. Off-peak periods are all weekends and 2200-0700 on workdays.
Feed-in-Tariff ("FIT"	A flat, variable rate usually between 8 and 10 cents per kWh for small systems in NSW. Larger systems will face lower rates.	
The Williamtown Microgrid will aim to minimise grid purchases during these peak periods and favour self-generated solar PV volumes.		

[12] Business SA, Blackout Survey Results; Related ACCC submission February 2017

The range of bundled retail prices faced by a small business consumer in NSW is shown in the following chart (left-hand side)[13]. The network contribution to this bundle is also shown for all small and large business consumers.[14]

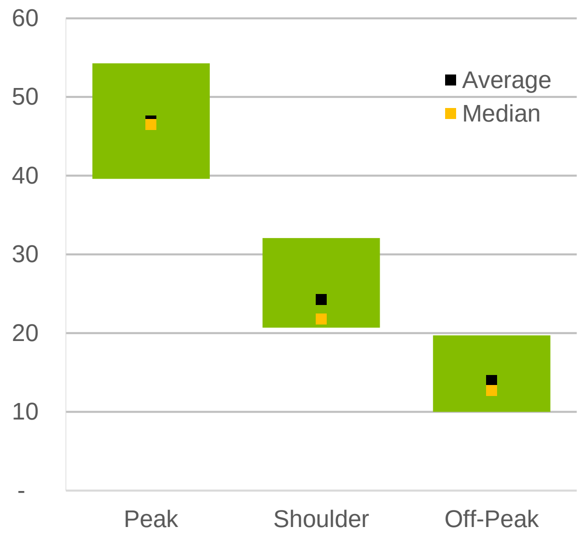


Figure 3-14 Small Business User Bundled Variable Tariffs | c/kWh

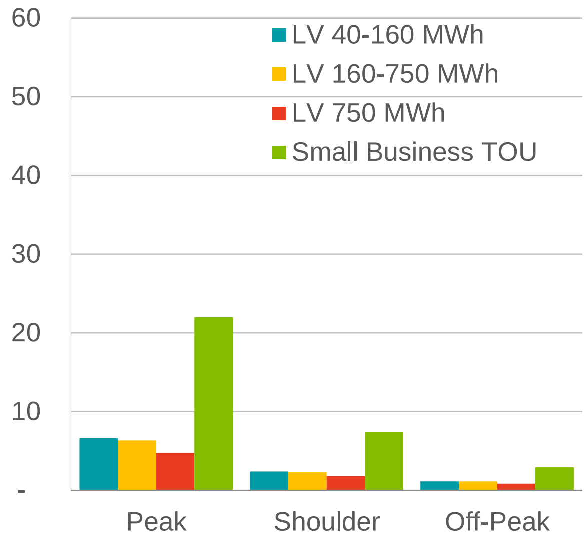


Figure 3-15 Ausgrid Business Consumer Usage Tariffs | c/kWh

The financial incentive for participation in the Williamtown grid level battery / Microgrid model is predicated on the following:

- Substituting peak period energy demand with generation from over-sized solar PV that charges the battery during high solar periods.
- Lower electricity costs achieved by a reduced network cost
  - This is referred to as a Local Use of System ("LUoS") charge
  - A LUoS charge is cost reflective for a microgrid where energy is mainly being transported between proximate and confined points.
  - This is a concessionary network charge which would ultimately have to be granted by Ausgrid. This would likely require a trial in the next 1-3 years and then be proposed to the AER as part of Ausgrid's next electricity determination period (2024-2029). Aurecon believes there is a strong possibility Ausgrid will pursue this due to the following commercial incentives:
    - A well-functioning microgrid will require less future investment in transmission and distribution in order to service the demand within that microgrid.
    - Ausgrid's stated corporate values align well with an innovative and sustainable project. Ausgrid signed up to The Energy Charter in January 2019 which reflects an ambition to improve energy affordability and deliver energy in line with grid level expectations. Offering LUoS to a sustainable microgrid like Williamtown SAP, is an endorsement of its commitment to Affordability (Principle 2), Sustainability (Principle 3) and Customer Expectations including Fairness (Principle 1).

In addition to the energy usage charges discussed above, large users also face a demand capacity charge of 33.55 cents per kW per day. If the battery can help shave peak demand, then further financial gains will be realised. This would require the business to identify when its peak capacity will occur and then use battery volumes to reduce the maximum demand.

---

[13] *Aurecon analysis of major retailer market TOU offers for New South Wales; Ausgrid 2020-21 Published Tariffs*

[14] The Ausgrid network tariff is buried within the retail tariff shown on the left graph and represents about 40% of the total tariff. Note also that there is a capacity component for Ausgrid's tariff above 40MWh, but there isn't in the Small Business ToU, which explains why that tariff seems high. These graphs only cover the energy components of tariffs with the fixed charges and capacity charges left out of the analysis for simplicity.

Environmental Sustainability

The final objective of the Williamtown SAP Microgrid operating model is environmental sustainability with decarbonisation being the main consideration for electricity usage. The commercial implications of this objective are centred on the various options for green energy. The relative economics of enabling technology (solar PV and energy storage) will also be reviewed here.

Solar Rooftop PV

It is expected that precinct participants will implement solar PV independently and be incentivised to over-size (relative to their demand during solar hours) due to the battery technology being developed by Ausgrid. Rooftop PV has undergone accelerated growth within Australia and is a proven concept for businesses pursuing self-generated renewable energy.

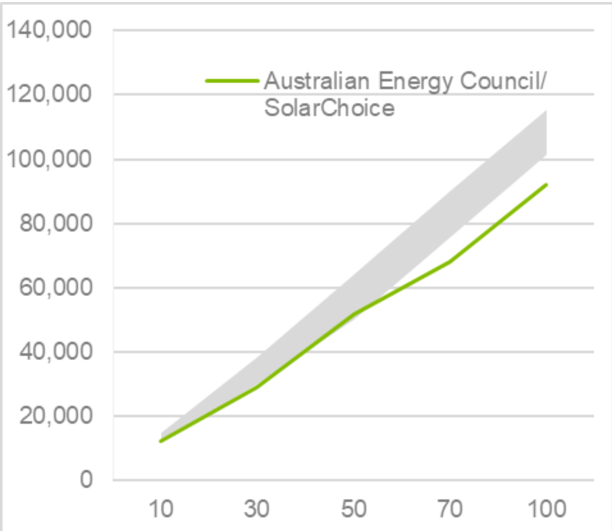


Figure 3-16 Rooftop PV Upfront Capital Cost | AUD[15]

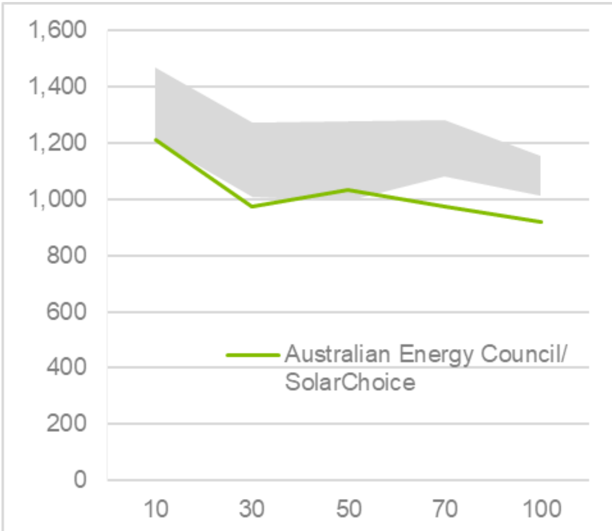


Figure 3-17 Rooftop PV Upfront Capital Cost | AUD/kW[15]

In addition to the sustainability benefit, the commercial incentive for generating solar is shown for small business users in the following chart. Payback periods for solar PV improve for every unit that can be used to offset grid purchases (as opposed to just exported to earn the feed in tariff). It is expected that SAP participants will use the majority of solar for their own coincident demand and be somewhere between the 0% FIT and 50% FIT columns below. Importantly, the battery provides an opportunity to improve the value of 'FIT' volumes as rather than earning the 8-10 cent FIT, the energy can be stored and used to offset further peak grid purchases. So overall, Aurecon is confident that solar PV offers sufficient economic return for small businesses before the battery but adding the battery will simple provide further upside potential for the volumes that would otherwise have been exported into the grid.

[15] SolarChoice; Australian Energy Council; Clean Energy Council

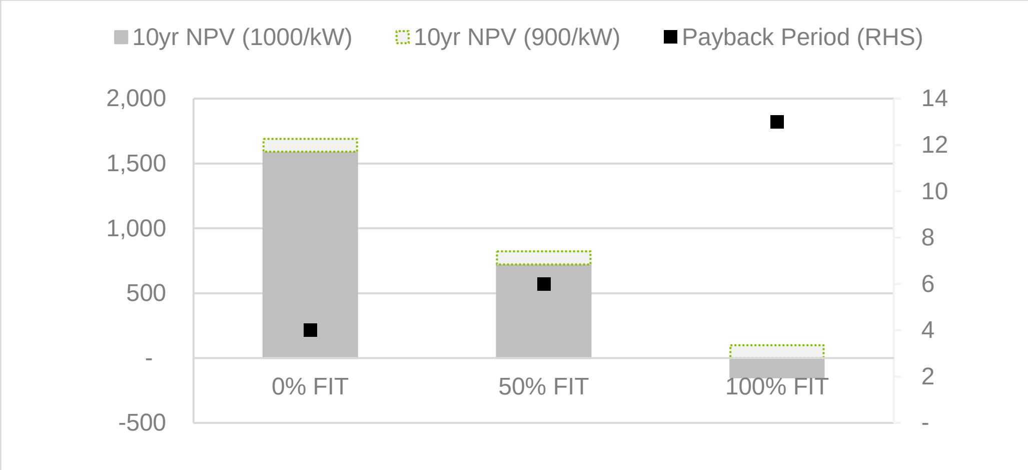


Figure 3-18 NPV after 10 years per kW of installed solar; payback period (years)[16]

Table 3-12 Relative tariff comparison

Scenario	PV value during peak (c/kWh)			PV value during off-peak (c/kWh)		
	If consumed	If exported	If sent to battery	If consumed	If exported	If sent to battery
Rooftop PV only, no storage	39-55c (peak tariff avoided)	8-10c (FIT earned)	Unavailable	10-20c (off-peak tariff avoided)	8-10c (FIT earned)	Unavailable
Rooftop PV and access to storage	39-55c (peak tariff avoided)	8-10c (FIT earned)	If stored and recalled during peak: 39-55c minus LUoS and fee for using the battery	10-20c (off-peak tariff avoided)	8-10c (FIT earned)	If stored and recalled during peak: 10-20c minus LUoS and fee for using the battery

The battery provides greater opportunity to 'over generate' during the day, store this and use it to offset grid purchases in low solar hours. A comparison of relative tariffs is shown in the table above. The critical metric is the battery arrangement that will have to reward the PV owner with at least 8-10 cents per kWh to incentivise their participation (the FIT they would otherwise earn). A small business is paying 39-55 cents for peak usage so the battery operator (i.e. third party retailer) has significant arbitrage to work with (purchasing the excess solar for 8-10 cents and selling this back to the precinct small business users at anything less than the 40-50 cent peak grid purchase costs they would avoid. Naturally this arbitrage has to also cover the large capital and moderate operational costs of the battery.

For larger business users, we know that peak network usage costs are around 5-10 cents. Retail costs are variable and not publicly disclosed but Aurecon understands the peak can be as low as 8-10 cents in low months and around 20 cents in high months.[17] So rather than the 40-50 avoided grid cost, a large business may be avoiding as low as 13 cents (or up to 30 cents).

Energy Storage

The preferred option for the Williamtown precinct is for a shared grid level battery. Small-scale batteries are currently not viable given that the payback period for the typical use-case is longer than the average 10-year warranty period, exposing the business owner to unacceptable risk.

In the operating model discussed previously, Ausgrid is well positioned and incentivised to develop and own the battery while a third-party retailer incorporates it within their retail portfolio (to comply with ring fencing requirements).

[16] Source: Aurecon analysis. Stacked chart compares the marginal NPV if installation cost is $900/kW rather than $1,000/kW. Assumed PV degradation is 2.5% in the first year and 0.7% pa thereafter. A discount rate of 5.5% is used, reflective of current long term busines loan rates.
[17] Aurecon reviewed default rates put in place my large energy retailers in NSW and a broader assessment of NEM wholesale pricing (upon which the retail energy prices are based).

Large scale battery costs are less than half of the cost from 4-5 years ago.[18] As a high-level assumption, Ausgrid would face development costs of around $1000 for each kWh of energy storage. A key consideration is that this battery can be deployed for system security purposes, a source of value which can only really be captured by Ausgrid and should be factored in when they assess the viability of their own participation in the Microgrid. Avoided investment cost for system security would effectively offset a portion of the battery's upfront investment cost.

The battery is discussed here in the context of sustainability as it provides an incentive for precinct businesses to over-size their solar PV thus resulting in increased VRE. The advantages for resilience and affordability are further drivers for the use of a grid level battery.

Alternative Sustainability Mechanisms

Green power purchasing could also be pursued by the precinct. For a small business consumer this is arranged with the retailer who applies a surcharge to the peak and off-peak tariffs. As shown in the chart below, current premiums for green power are typically in the range of 0.4 to 6 cents per kWh depending on the retailer and the proportion of green power sought (between 10% and 100%).

Green purchasing should be used as a supplementary or marginal source of sustainability due to the fact that the sites are well positioned to self-generate a lot of their own energy usage using rooftop PV. Green purchasing merely outsourcers any sustainability commitments and contributes less to energy transition overall. Furthermore, there is an opportunity to reduce net energy costs via combinations of rooftop PV and grid level energy storage. Aurecon recommends that green purchasing be considered for the unavoidable grid purchases.

One possibility that strengthens the commercial arrangement and assists with grid purchasing is the concept of a green buyers group. This is where multiple energy users merge their energy procurement and seek an offtake arrangement as a combined entity. There is an opportunity to increase the purchasing outcome via:

- Increased market power which aids negotiations and puts downward pressure on energy prices
- Reduced fixed costs associated with the procurement process
- Marketing compatible loads (if they exist within the precinct) that are rewarded by lower tariffs. For instance, two manufacturing processes that peak at different times of the day.

A buyers group or centralised procurement could also help to guarantee commitment to this objective by precinct participants.

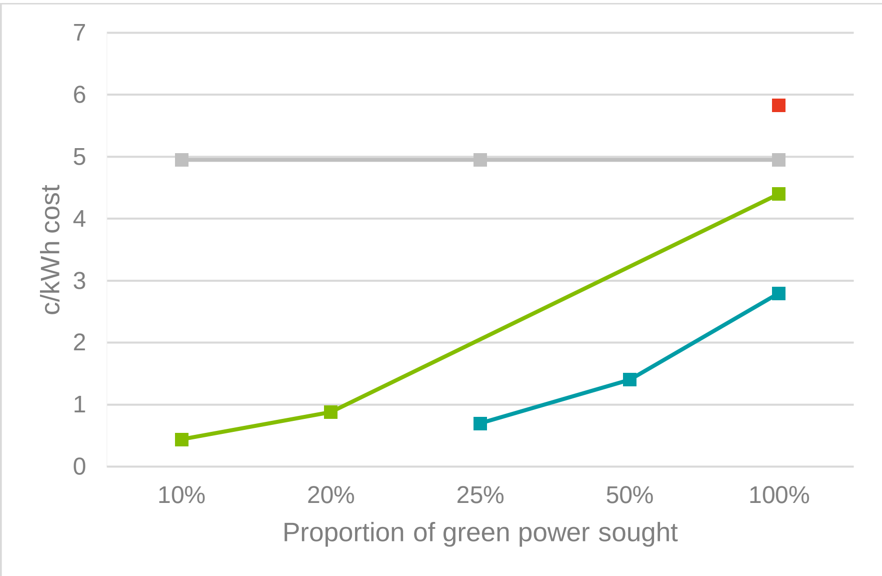


Figure 3-19 Green Power Purchasing Surcharges from 4 major retailers | c/kWh as a function of green power percentage[19]

[18] Bloomberg New Energy Finance; Aurecon analysis

[19] Source: Aurecon review of major energy retailer green purchasing market offers

A Comparison of Commercial Arrangements

The baseline commercial arrangement is for Ausgrid to own the grid level battery, around which the microgrid is developed. Practical/operational control should also be allocated to Ausgrid for system security, but any energy trading and retailing will have to be allocated to a third party. Natural extensions to this model include VPP and Peer to Peer Trading but these front of meter interactions will force a recalibration of LUoS decisions given that energy will be traded upstream.

Table 3-13 Comparison of commercial models – arrows indicating improvement relative to no Microgrid arrangement

Objectives & Criteria	Baseline Commercial Model		Extensions – VPP or Peer2Peer Trading	
Resilience	↑	Resilience achieved with full redundancy (maintaining grid connection and battery used to provide emergency power during grid outages.	↔	VPP or Peer2Peer would not increase resilience. If battery costs decreased such that individual businesses are incentivised to install their own smaller systems (for the purpose of P2P) then resilience of the entire precinct could increase based on higher storage levels.
Sustainability	↑	Participants incentivised to over-size PV systems relative to daytime demand levels.	↔	Similar to resilience, no increase to sustainability expected from VPP or P2P unless sufficient profit motive develops such that participants seek to increase PV capacity.
Energy Affordability	↑	Subject to a suitable LUoS, the microgrid is expected to offer reduced energy costs for precinct participants.	↑	The front of meter opportunities are significant for energy storage and include FCAS, RERT and wholesale arbitrage opportunities.
			↓	However, this would jeopardise the concessionary LUoS as energy would have to be traded with the upstream meaning that the microgrid would be liable to pay NUoS again.

The optimal commercial solution for the Williamtown precinct is to pursue a microgrid that incentivises over-sized solar PV and uses the battery to provide resilience and avoid peak grid purchases. A microgrid will reconcile sustainability, resilience and affordability by compelling Ausgrid to offer a cost reflective LUoS on the basis that the precinct will regularly be operating as a localised, confined system. The custom LUoS is a pre-requisite, particularly to incentivise large business users who face a small gap between each unit of peak and off-peak energy costs.

Commercial Conclusions

Implementation Cost and Achieving Performance Outcomes

A key hurdle for the microgrid will be the willingness of SAP participants and Ausgrid to provide upfront capital investment for different technology:

- Small businesses will likely be more risk averse to large capital expenditure whereas Ausgrid has to meet stringent regulatory hurdles.
- However, Ausgrid is more accustomed to capital investment decisions of this larger scale (the battery cost will be comfortably in the tens of millions once a 10MWh requirement is demonstrated) and can justify this as part of its role as a system security provider and investor.
- The precinct businesses will still face upfront capital costs for rooftop PV. Given the financial incentives and strong uptake Australia-wide, this shouldn't be a significant barrier.
- Options to guarantee participation and preserve objectives long term.
- A precinct charter or leasing agreement could be used to compel individual commitment to the SAP objectives.
- Furthermore, the tariffs for return-purchase from battery stored energy could be tiered based on whether a participant is meeting the requirements of the SAP and contributing to the charging of the battery.
- Retaining flexibility for future scenarios

- The implementation of the microgrid will have to ensure that the technology can survive the initial participants and that departure of corporate knowledge doesn't pose a threat to the continued operation on shared/communal technology. If Ausgrid owns the battery, then this risk is reduced (versus a communally owned asset).
- Energy storage and solar PV systems are modular and scalable. This positions the precinct to take advantage of different utilisation of the site over time. It also allows for the scale up and down based on technology changes.

Table 3-14 Funding & Commercial incentives

Organisation/ Type	Incentivised by…	Likelihood of Funding or Investment
Ausgrid	Reducing investment in the Williamtown area of the grid as less capacity will be required to service the SAP and it may also help defer investment in nearby existing substations. R&D, branding and corporate strategy The battery will contribute to their regulated asset base, the pool of assets over which their regulated rate of return is applied as part of their determination for each 5-year regulatory period. All else equal, absolute revenue increase as the asset base increases.	Plausible - Strong
Governance: DPE, ARENA	An established recent precedent of supporting similar technologies and projects	Possible
Commercial partners	A third-party retail role for the battery's energy trading will be incentivised by the arbitrage opportunities between the precinct businesses' solar PV payback requirements and the avoided peak costs when battery storage volumes are sold back to them	Strong
	Some opportunity for VPP and P2P but as discussed previously this may jeopardise the concessionary LUoS arrangement.	Unlikely

Key Risks and Unknowns – Commercial Arrangement

The recommendations for the Williamtown SAP ensure that the participating businesses sit at the forefront of energy transition without being exposed to unnecessary risks from immature technology or unproven commercial arrangements. The intention is for the precinct to be innovative and contemporary without being a testbed - profit underpinned by proof of concept. Nonetheless there are some exogenous risks and unknowns. Risk identification and potential mitigation is collated within the following table. **It shows there is an acceptable level of risk, particularly if robust mitigation is implemented.**

Table 3-15 Key Risks and Unknows

Risk or Unknown	Description	Mitigated by…
Technology Cost Path	Energy storage costs are on an aggressive downward trend. Solar PV costs also continue to fall.	Developing a modular microgrid that can scale up or down incrementally as the marginal unit of investment becomes viable (and precinct energy users grow their energy requirements)
Funding & Regulatory Treatment	There are significant upfront capital costs faced by various participants	Collaborating to reduce costs of fact-finding. Maximising any grant opportunities or concessionary funding from governance bodies
Wholesale Energy Market	Future NEM prices and the swing between peak and off-peak periods provide the underlying rationale for the microgrid to be installed. If wholesale prices decrease overall and/or prices smooth between peak and off-peak, the commercial incentive is eroded.	The microgrid approach is relatively modular and flexible. Capital decisions cannot be reversed but incremental increases can be pursued as price paths become clearer. The commitment can also be viewed as a hedge against a widening gap between peak and off-peak pricing (or just increased wholesale prices generally).
Participation churn	Corporate knowledge turnover and initiatives lost.	Precinct charter, leasing agreement, some other legal arrangement that guarantees the objectives in perpetuity (subject to long-term recalibration from the ultimate custodian in DPE). Ensuring the battery is owned by Ausgrid will avoid any grid level-owned infrastructure and 'tragedy of the commons' situation.[20]
Securing Space for the Grid level Batteries	Securing space for each of the grid level battery may be challenging. The structure plan does not explicitly deal with this issue, and while it is expected that there will very likely be sufficient space for each battery in common spaces, this still needs to be verified.	Ensuring that sufficient space is earmarked through the concept design please for grid level batteries
No green retail tariffs to complement LUoS network tariffs	There may not be a green energy retail tariff that is available with an Ausgrid LUoS tariff. Resolution of this issue is simply a case of progressing negotiations between Ausgrid with various retailers to develop such a tariff and should be relatively straightforward for retailers to develop and implement.	Ausgrid would have already had similar conversation for the standard retail tariffs with their current grid level battery trial, and would simply request creation of a green tariff for LUoS (if one doesn't exist already).
LUoS tariff concept may exclude a PPA option for energy purchases	The Ausgrid LUoS and grid level battery arrangement may lock the precinct in to green retail tariffs and therefore exclude the opportunity for pursuing a buyer's consortium power purchase agreement. This needs to be investigated further.	Further discussion likely to offer an alternative tariff arrangement with Ausgrid and retailers to allow for a PPA arrangement.
Does the government have the power to compel installation of solar and demand certain size of solar?	The requirement for each business to install roof top solar will need more consideration on how businesses can be legally compelled to install solar, and also more consideration about what sizing of solar system the business should be required to install. Clearly the larger the load, the more solar is required.	Commercial drivers coupled with good information may be enough to achieve sufficient solar levels
Only initial financial assessment of grid level battery and solar completed	While some initial assessment of the commercial benefit of grid level batteries with privately owned solar has been completed within this report, a full financial assessment will be required once there is robust information on all the inputs such as LUoS prices and the cost of solar installations.	Complete detailed financial assessment during concept design stage.

[20] Tragedy of the commons describes a situation how individual incentives can result in behaviour that devalues a shared asset. It's a theory that concludes all goods should have well defined ownership or a robust framework in place to support optimal shared use.

Risk or Unknown	Description	Mitigated by…
LUoS tariffs and grid level batteries are still only in trial	The regulatory treatment of grid level batteries and LUoS tariffs is still in flux. There is always the risk that the Australian Energy Regulator decides that this arrangement of DNSP owned grid level batteries should ultimately not be allowed, and that grid level batteries should be progressed by Retail businesses or other private businesses. If this occurs then while it will not stop the grid level battery concept from progressing for the SAP, it will require a fresh assessment of the commercial risks and opportunities on the SAP and the businesses within it	DPE to continue dialogue with Ausgrid and provide support in promotion of these arrangements with the AER where possible

Despite the uncertainties set out above, all of them have a clear path to resolution, so there is a high likelihood of the overall renewables structure plan progressing in close to the form proposed in this report.

3.4 Delivery Plan and Staging

This section addresses the costs, impact and staging considerations of implementing the proposed renewable energy strategy for the structure plan.

3.4.1 Design and Costs

In line with the SAP's renewable energy vision, the renewable energy strategy is developed to minimise cost to the SAP and its customers by proposing strategic partnerships with Ausgrid and other organisations in the SAP.
The Requirements for each technology are outlined in the Table 3-16 below along with indicative costs. Besides the implementation of rooftop PV and the cost of grid supply energy, which are the responsibility of the SAP customer, the proposed shared infrastructure will be owned and operated by Ausgrid. For further details on the cost and operating model, refer to section 3.3.4 and section 3.3.7.

Table 3-16 Infrastructure Requirements

Renewable Energy Technology	Infrastructure requirements	Ownership
Kiosk Substation	11kV/400V Ausgrid kiosk substation	Ausgrid
Smart meters	One smart meter per energy user	Private investment by SAP customers
DER – Low rise buildings	Small-scale solar PV systems across the SAP totalling 27 MW of installed capacity	Private investment by SAP customers
Microgrid control system	Communication infrastructure to aggregate and coordinate DER	Ausgrid owned and operated
Grid level Battery	Generally, range from 100 kW – 1 MW capacity	Ausgrid owned and operated
Grid Supply / Green Power / PPA	At least 111 MW of capacity to power the precinct under the proposed renewable energy strategy	Individual SAP customers; or a consortium of organisations located in the SAP

3.4.2 Impacts Assessment

Implementation of the energy strategy may have infrastructural impacts on civil and electrical assets, social impacts on the surrounding grid level and environmental impacts on the surrounding land and wildlife.

Potential impacts are assessed in Table 3-17 below. These must be considered as part of the structure plan and be further explored for risk and mitigation in later stages.

Table 3-17 Impact assessment of implementing the energy strategy on infrastructural, social and environmental elements

Impact	Assessment
Infrastructure	Civil infrastructural impacts that must be considered include: ▪ High-risk earthworks such as trenching through RAAF and airport land, both of which are likely to have highly restricted access ▪ Interruption to existing utilities such as gas, water, HV and LV conduits requiring extensive Dial Before You Dig (DYBD) assessments ▪ Geotechnical surveying involving boring may be required to determine appropriate trenching pathways for conduit cabling and potential BESS site locations ▪ Potential land levelling required to locate the BESS containerised infrastructure – this will require an assessment of the impacts on flooding and stormwater paths ▪ Acoustic treatment of the installed electrical infrastructure may be required for sites located near airport land or RAAF bases ▪ Glint and glare assessments to determine the impact of solar PV infrastructure on the local aeronautical operations and local fauna welfare Electrical infrastructural impacts that must be considered include: ▪ BESS and/or microgrid and grid synchronisation of voltage, frequency, phase sequence and angle and waveform is required for successful integration
Social	▪ The implementation of the energy strategy in the SAP may lead to social impacts including grid level acceptance or rejection from local townships, and local council restrictions that could hinder the progress of this project.
Environment	Environmental impacts that must be considered include: ▪ Flora and fauna assessments of potential BESS sites given that the SAP is home to numerous threatened flora and fauna species and encompasses the Tilligerry State Conservation Area ▪ Acoustic treatment to mitigate negative impacts on local fauna ▪ Contamination assessments to determine impacts on the existing land which has been historically affected by perfluoroalkyl and polyfluoroalkyl contamination ▪ Heritage impact assessments of potential BESS sites

3.4.3 Proposed Staging Works & Recommendations

The issue of staging of load and generation in a microgrid is fundamentally the same problem faced by the planning function of electricity networks today, on a smaller scale. Similar to the main grid, the key is to first design for the ultimate microgrid arrangement, which is set by constraints such as land availability, upstream network capacity, expected microgrid technology capacities, etc. Secondly, the development of the microgrid must be staged out, planned, and designed in a way that minimises capital at risk, utilising an incremental build approach.

This requires staging of blocks of generation and demand to be reasonably matched over time. There is some additional complexity given the two way flows and management of a range of Distributed Energy Resources within the microgrid – the expected volume, configuration, and capacities of each must be considered at each incremental stage of development to ensure that the operational concept delivers energy supply and security to the relevant standards and requirements.

For Williamtown SAP, a time-staged plan will need to be developed that matches the energy needs of the projects in line with the expected incremental build out of each development whilst keeping the ultimate arrangement in mind as the end goal (ensuring capital at risk is minimised at all stages), and in the short term this is the approach DPE should take in partnership with Ausgrid and the development organisations. In the longer term, on an ongoing basis, an energy planning function could be housed within the microgrid operator business (i.e. Ausgrid, embedded network operator, etc.) to cater for staged expansion and ensuring that asset deployment is optimised over time. The skills required would need to include capability to not just match generation and demand, but also perform other studies such as dynamic and stability studies. This planning function might possibly be operationalised such that each load or generator request triggers a small planning update which also covers dynamic and stability studies.

Figure 3-20 illustrates the structure plan and proposed staging.

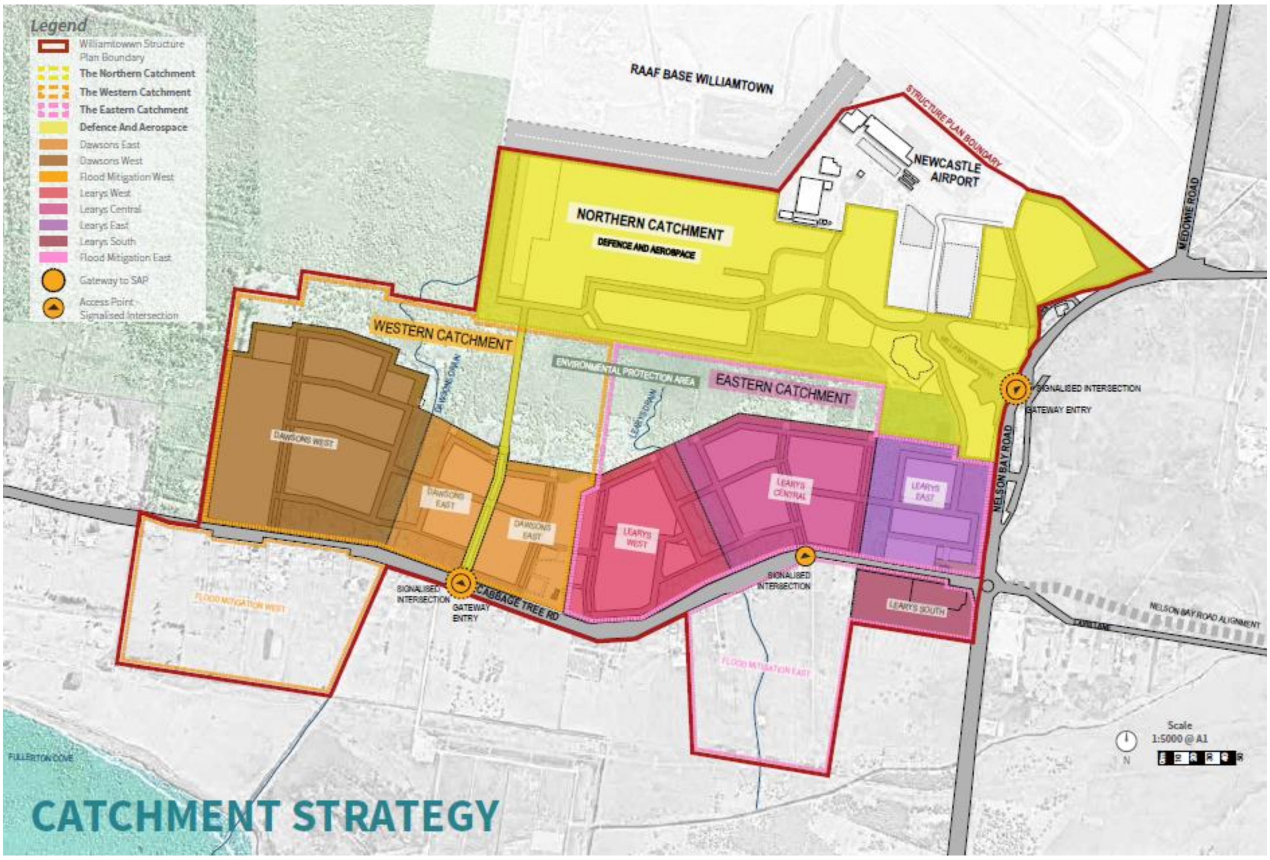


Figure 3-20 Structure plan and staging

Understanding the demand profile and indicative energy supply priorities of the customers at each stage allows renewable energy to be integrated strategically to meet the customers' needs in a cost-effective manner. Table 3-18 presents the recommendations on the potential staging of renewable energy asset development across the SAP, to support demand requirements as they evolve. The table outlines the total demand and generation estimations at each stage as well as the recommended installed battery capacity. It also provides a breakdown of key sectors associated with each development stage and their respective indicative energy user requirements – which was developed in earlier sections of this report.

Table 3-18 Demand and generation breakdown by stage

Sub-precinct development	Net Developable Land (ha)	Demand (MVA)	Cumulative generation (MW)	Proposed total installed battery capacity (MW)	Assumptions
Northern Sub-Precinct					
Defence and Aerospace (including DAREZ/Astra Aerolab)	50	40.6	8.9	16.2	75% offices, 25% light industrial
Commercial Centre	5	4.3	1.1	1.7	Commercial office space
Freight and logistics	7	2.8	1.3	1.1	Assume similar demands to warehouse plus 50% provision for extra refrigeration demand
Research and Development	7	6	1.0	2.4	Commercial office space
Subtotal	**69**	**53.7**	**12.3**	**21.5**	
Eastern Sub-Precinct					
Commercial Centre	**68**	**57.8**	**15.0**	**23.1**	Assumed 100% commercial centre as worst-case scenario for electricity demand
Advanced Manufacturing					
Light Industrial					
Research and Development					
Total	**137**	**111.4**	**27.4**	**44.6**	

The staging of the construction of the electricity network and grid level batteries would rest with Ausgrid as part of their existing planning obligations. The network infrastructure staging works are illustrated in Figure 3-21 below.

Further information can be found in Section 4.5 of the Utilities report.

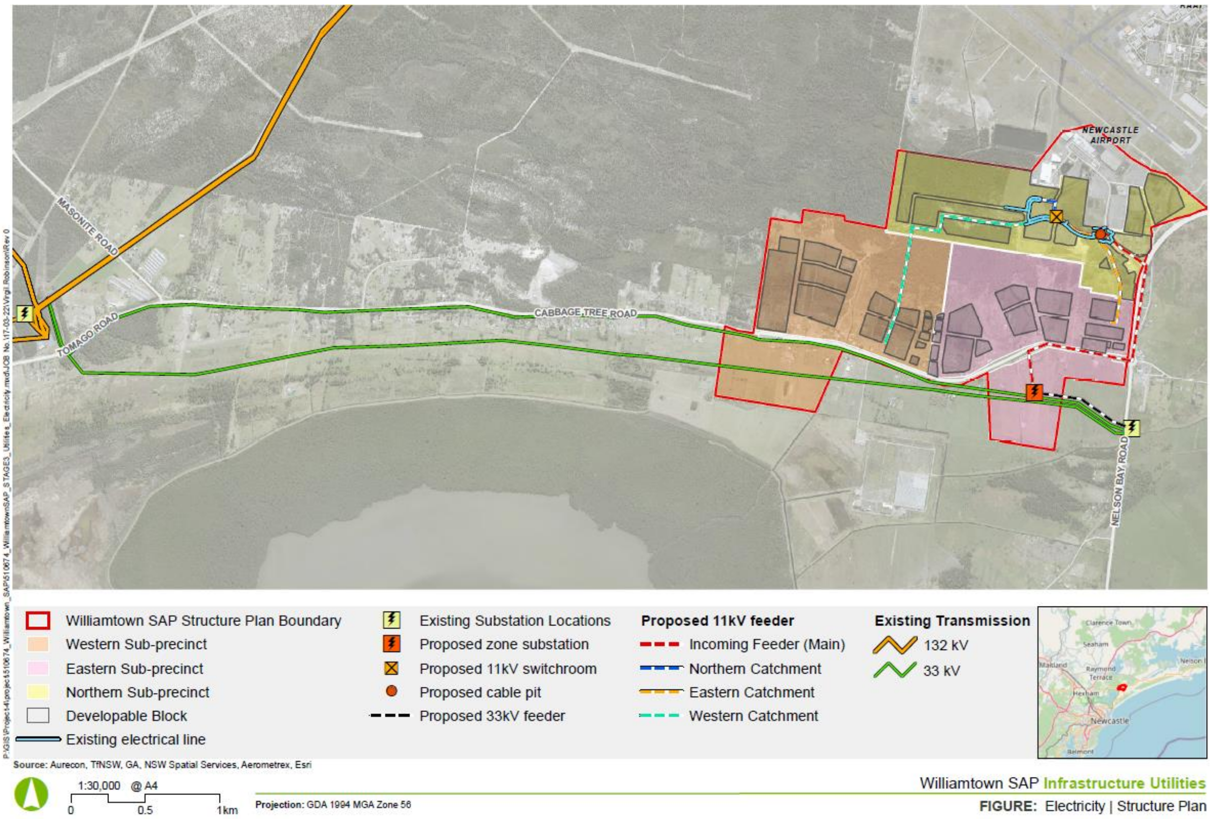


Figure 3-21 Transmission and distribution staging works

Alongside asset development, a staging plan to achieve the SAP's carbon-neutral precinct goal should be considered as part of the development plan. The SAP will be particularly reliant on grid supply and carbon offsets in the short to medium term before PPA contracts established. In the medium to long-term, carbon neutrality will be possible through a small-scale distributed generation and PPA contracts with renewable generators, with the potential for use of offsets for any remaining portion of emissions which cannot otherwise be practically mitigated.

Further work required to progress the renewable energy strategy for the structure plan includes:

1. At concept design

- Consider communication network aggregation requirements during site establishments. The regulatory frameworks and commercial arrangements will have to be resolved prior to implementation. Reliable data could be valuable to aid with this process.
- Define the SAP's priorities around the short- and long-term ownership and operation of the local energy market. Based on the SAP's objectives, the SAP can strategically establish partnerships with Ausgrid, energy retailers and/or OEMs with the benefit of their customers in mind.

2. During development:

- Encourage solar PV uptake by providing incentives to new and existing developments.
- Due to the modular nature of grid level batteries, the SAP could install them concurrent to the development stages near Ausgrid kiosk substations to promote DER uptake and link them to the BESS network as they get installed.
- A PPA and/or Carbon Credits are required to achieve carbon-neutral targets. The SAP should expect to purchase a large volume in the primary stage, but carbon emissions will decrease as more renewable energy technologies are implemented throughout the development.

4 Conclusion

To recap, the proposed renewable solution for Williamtown is:

- Rooftop solar (DER) on the majority of applicable new SAP developments. The SAP should encourage solar PV uptake by providing incentives to new and existing developments. Alternatively, solar PV could be mandated in the SAP SEPP and the delivery plan;
- Small-scale battery energy storage systems (BESS) scattered throughout the precinct;
- A Local Use of System network pricing arrangement with Ausgrid to store excess solar generation in peak times, to provide bill savings to businesses in the SAP; and
- Grid supply with carbon offset and electricity supply with green contracts or a PPA through a buyers consortium.

A boilerplate assessment of this proposal is in Table 4-1 below

Table 4-1 Summary Assessment of Renewable Structure Plan

Category	Factor	Structure Plan
Energy consumption requirements	Demand (GWh/yr; MVA peak)	214 GWh/yr 111 MVA
	Load Profile	Typical commercial / industrial load profile with evening peak.
Key values	Alignment to SAP vision	Promotes sustainability through renewable uptake with low land impact. Enhances energy reliability with the use of grid level batteries.
	Alignment to strategic plans and policies	In line with overall
	Environmental / sustainability outcomes	Very minimal land impact. SAP energy generation will be sourced from rooftop solar.
	Grid level outcomes	Supports the local aerospace and defence industries by allowing redundancy in the electrical network
Implementation strategy	Capex ($, $$, $$$) *Less $ is better*	$ - Mature technologies, relatively capital intensive.
	Opex ($, $$, $$$) *Less $ is better*	$ - Low O&M costs associated with BESS and solar.
	Stimulus potential ($, $$, $$$) *More $ is better*	$ - Will support SAP and grid level, but limited revenue potential. Potential reduction in electricity tariffs and network charges for customers.
	Overall commercial readiness	Regulatory frameworks result in complex commercial arrangements. Minor barriers to commercialisation, which stakeholders are actively resolving
	Overall technology readiness	Technical performance demonstrated through trials
	Staging and scalability	All technology proposed is scalable and modular

Appendix A Baseline Assessment

There are a large number of renewable energy technologies and supply options that are worth further investigation for the Williamtown SAP. The main developmental risks across the technologies are the restrictions on tall structures, the risks of deploying emerging technologies with their inherent uncertainties, and variable supply profiles

To determine the suitable building blocks for an energy supply strategy, this section looks at individual renewable energy generation options and lays out the fundamental principles of each. It then considers key cases for their deployment to help assess their appropriateness for this precinct. This is done by considering their technical, developmental and strategic alignment with the needs of the precinct.

Each generation option is assessed in the context of it being deployed within the SAP site, as a supplement to a grid connection. This will enable the precinct to leverage the reliability of the local network as a baseline, while taking steps to influence the emissions, price and security of its supply. Viewing each generation option in this context provides a view as to whether it will move the precinct from the grid baseline towards its aspirations.

Given the reliability requirements for the precinct's customers, as well as the abundance of existing electricity network infrastructure with sufficient available capacity in the area, an "off-grid" solution has been considered but rejected based on being uneconomical as well as impractical.

The criteria used are as follows:

- **Additional Resilience** – does the generation option provide additional resilience to the energy user under local network outage conditions, i.e. total loss of supply from the network?
- **User Profile-matching** – could the generation option supply the energy user with the amount they demand, when they demand it, reducing their use of grid electricity?
- **LCOE projection** – what is the anticipated $/MWh cost of electricity produced by the generation option if it is deployed in 2025? How does this compare to 2020 wholesale prices of 80 $/MWh?[21]
- **Commercial maturity** – Is the generation option an off-the-shelf solution? If not, how readily available is the technology in the market?
- **Technology maturity** – how progressed is the technology's development across the range of available and upcoming products?
- **Emissions reduction** – will the use of the generation option result in reduced emissions associated with the precinct's energy supply?
- **Land Use Requirement** – how much land is required to house the assets and what land types are suitable?
- **Contribution to Circular Economy** – could the generation option be part of a circular economy system?
- **On-Site potential for Williamtown SAP** – overall, how likely is this generation option to be successfully implemented at Williamtown SAP, based on the high-level information available?

[21] https://www.aer.gov.au/wholesale-markets/performance-reporting/wholesale-markets-quarterly-q2-2020

Throughout the individual assessments, the following icons are used to indicate how a characteristic of the generation option lends itself to use at the Williamtown SAP site.

- this is a strength of the generation option in the context of the Williamtown SAP

- this is a weakness of the generation option in the context of the Williamtown SAP

- this is an opportunity for the generation option in the context of the Williamtown SAP

The relevant precedent for each generation option provides an understanding of the technical and commercial maturity of that generation option. We have set out key design considerations below. We have set out the key risks and opportunities for innovation for each generation option within the SAP.

A summary of the technologies considered within this section and their assessment is set out in Table 3-1. This is an indicative assessment based on the current level of information available and may change as the specific site for the SAP is defined.

Table A-1 Renewable Generation Technologies Assessment Summary

	Additional Resilience	User Profile-matching	LCOE projection	Commercial maturity	Technology maturity	Emissions Reduction	Land Use Requirement	Contribution to Circular Economy	Potential for Williamtown SAP
Large-scale Solar PV	Poor: unless local grid island	Poor: only generates during the day	Good: less than 80 $/MWh	Good: significant uptake in market	Good: multiple products available	Good: displaces grid energy usage with renewable resource	Uncertain: large area required but can be 'unusable' land	Poor: unless refurbished cells used (reuse)	**Good**
Small-scale Solar PV	Good: some supply during outage	Poor: only generates during the day	Poor: more than 80 $/MWh	Good: significant uptake in market	Good: multiple products available	Good: displaces grid energy usage with renewable resource	Good: no dedicated land required	Poor: unless refurbished cells used (reuse)	**Good**
Large-scale Wind	Poor: unless local grid island	Poor: variable generation	Good: less than 80 $/MWh	Good: significant uptake in market	Good: multiple products available	Good: displaces grid energy usage with renewable resource	Poor: unlikely to be permitted due to height	Poor: unless refurbished turbines used (reuse)	**Poor**
Small-scale Wind	Good: some supply without grid connection	Poor: variable generation	Poor: more than 80 $/MWh	Uncertain: uptake mostly on remote sites	Good: multiple products available	Good: displaces grid energy usage with renewable resource	Poor: unlikely to be permitted due to height	Poor: unless refurbished turbines used (reuse)	**Poor**
Bioenergy	Poor: unless local grid island	Good: dispatchable generation	Poor: more than 80 $/MWh	Poor: emerging technology in Australia.	Poor: demonstrated in pilot plants	Uncertain: process can produce carbon emissions	Poor: requires developable land	Uncertain: waste biomass could be used (recover)	**Uncertain**
Waste to Energy	Poor: unless local grid island	Uncertain: Waste stream assessment required	Uncertain: data not available	Poor: emerging technology in Australia	Good: demonstrated internationally	Uncertain: reduces landfill emissions but produces emissions from generation	Uncertain: size of facility will be dependent on volume of waste. Facility must be close to a landfill	Good: incinerates non-recyclable waste to energy (recover)	**Uncertain**
Large-scale Solar Thermal	Poor: unless local grid island	Poor: only generates during the day unless there is thermal storage	Poor: more than 80 $/MWh	Poor: emerging technology in Australia	Poor: demonstrated in pilot plants	Good: displaces grid energy usage with renewable resource	Uncertain: large area required but can be 'unusable' land	Poor: limited opportunities	**Poor**
Small-scale Solar Thermal	N/A not electricity supply	Poor: variable generation	Uncertain: data not available	Good: significant uptake in market	Good: multiple products available	Good: displaces grid energy usage with renewable resource	Good: no dedicated land required	Poor: limited opportunities	**Good**
Geothermal	Poor: unless local grid island	Good: dispatchable generation	Uncertain: data not available	Poor: emerging technology in Australia	Good: significant precedent overseas	Good: displaces grid energy usage with renewable resource	Poor: requires developable land	Poor: limited opportunities	**Poor**

	Additional Resilience	User Profile-matching	LCOE projection	Commercial maturity	Technology maturity	Emissions Reduction	Land Use Requirement	Contribution to Circular Economy	Potential for Williamtown SAP
Large-scale Battery	Uncertain: can support local grid island	Good: dispatchable generation	N/A	Good: significant uptake in market	Good: multiple products available	Uncertain: can be used to store renewable energy	Poor: requires developable land	Poor: limited opportunities	**Good**
Pumped Hydro	Poor: unless local grid island	Good: dispatchable generation	N/A	Good: significant uptake in market	Good: multiple products available	Uncertain: can be used to store renewable energy	Uncertain: large area required but can be 'unusable' land	Poor: limited opportunities	**Poor**
Small-scale Batteries	Good: some supply during outage	Good: dispatchable generation	N/A	Poor: emerging technology in Australia	Good: multiple products available	Uncertain: can be used to store renewable energy	Good: no dedicated land required	Poor: limited opportunities	**Good**
Microgrid	Uncertain: can be designed as grid island	Good: balances technologies for reliability	N/A	Poor: minor barriers to commercialisation, which can be resolved	Good: technical performance demonstrated through trials	Uncertain: can be used to facilitate renewable energy	N/A	N/A	**Good**
VPP	Uncertain: could support local grid island with correct inverter types and overbuild of capacity	Good: aggregates technologies for reliability	N/A	Poor: minor barriers to commercialisation, which can be resolved	Good: technical performance demonstrated through trials	Uncertain: can be used to facilitate renewable energy	N/A	N/A	**Good**
Offtake via PPA from grid-scale generator	Poor: relies on wider network infrastructure	Good: Grid supply	Good: less than 80 $/MWh	Good: significant uptake in market	Good: multiple products available	Good: displaces grid energy usage with renewable resource	Good: no dedicated land required at SAP	N/A	**Good**
Hydrogen	N/A	N/A	N/A	Poor: emerging technology in Australia	Poor: demonstrated in pilot plants	Uncertain: can displace fossil fuels with green hydrogen	Poor: requires developable land	Uncertain: potential to use treated wastewater (recover) and use in local economy	**Uncertain**
Biofuels	N/A	N/A	N/A	Poor: emerging technology in Australia.	Poor: demonstrated in pilot plants	Uncertain: process creates emissions but could be lower than fossil fuels	Poor: requires developable land; alternatively, it can be imported	Uncertain: waste biomass could be used (recover)	**Uncertain**

A.1 Electricity Generation Technologies

At the heart of an energy strategy is the generation of electricity, as this typically accounts for the majority of energy use within a precinct such as Williamtown SAP. This section considers the possible electricity generation technologies, both established and emerging, which could be deployed on the Williamtown SAP site. Options for off-site generation are considered in Section A.3.

According to the Australian Energy Update 2020, the total provision of renewable electricity accounted for 19% of demand in NSW in 2019. This is roughly in line with the national average of 21%, but significantly behind the leading state, Tasmania, which had 94% of its demand supplied by renewables in 2019.

Given the urban location of the Williamtown SAP, there is limited large-scale renewable generation in the locality (within 50km. However, there is significant existing and proposed large-scale generation in the wider Hunter region, particularly between Mudgee and Nyngan, with a significant concentration of development around Dubbo, where the Central Coast/Hunter Region and Central-West Orana REZs are proposed. Within NSW, the Electricity Infrastructure Roadmap proposes development of 3GW of new renewable generation capacity in the Central-West Orana REZ, and 8GW in the New England REZ by 2030. An additional 1GW of renewable generation and 2GW of pumped hydro storage capacity are also planned for the state by 2030 under the Roadmap. The pace of development and change in the state generation mix will be very rapid in the next decade, with significant investment in renewable generation in the Hunter Region and beyond.

Ausgrid has also noted in its 2019 DTAPR that a significant number of connection enquiries for large generators have been received but that few of these have progressed to formal applications. This indicates that there is significant additional capacity under investigation that may join the AEMO pipeline in the area in due course.

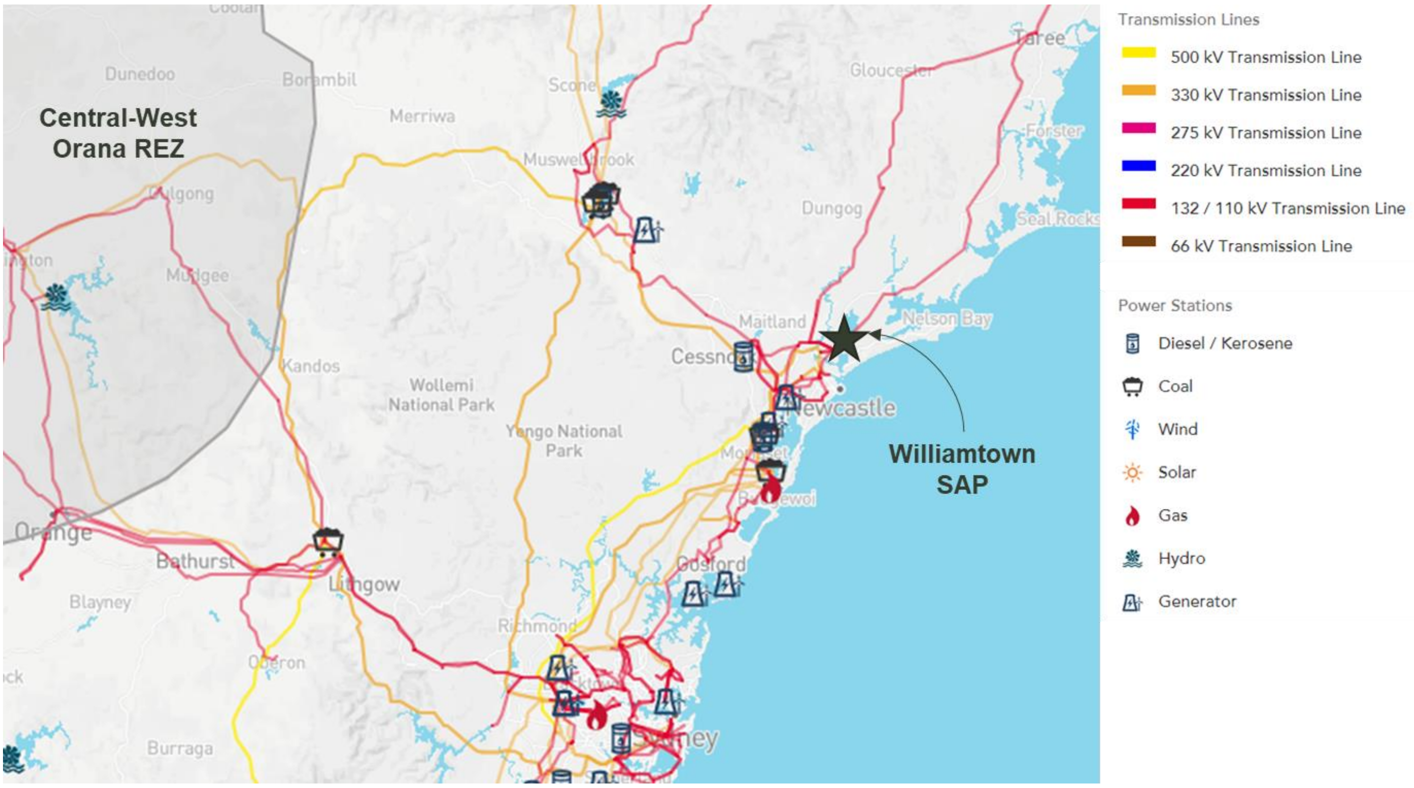


Figure A-1 **NEM Transmission and Generation Map, AEMO 2021**

A.1.1 Large-scale Solar PV

Overview

Large-scale solar PV typically comprises an array of photovoltaic (PV) collectors (solar panels), commonly monocrystalline silicon cells, with a generating capacity of over 5 MW. The reason 5 MW is the threshold is because generating systems with a capacity under 5 MW are not considered to have a significant impact on the network they connect to and as such are not required to register as a market participant, and therefore are considered to be small-scale. This can also apply to systems up to 30 MW in capacity, where an exemption is granted.

Relevant Precedent

There is only one large-scale solar project in relatively close proximity to Williamtown SAP. This project, the 53 MW Vales Point Solar Farm, is currently in the application to connect phase, and as such is likely to be a few years away from completion. In the wider Hunter region, 200 MW of solar generation projects are in the completion and commissioning phase, with more coming along the pipeline.

Figure A-2 Regional solar resource levels, AREMI

Beyond the AEMO pipeline, it appears from recent news statements that a number of different sites in the region are under investigation for solar farm development, which could boost the long-term generation capacity in the region.[22,23] When the Central Coast/Hunter Region is developed as a REZ under the NSW Electricity Infrastructure Roadmap, the build and connection of significant renewable generation resources would be accelerated over the next two decades. This creates potential renewable sources of offtake for Williamtown. Creating local demand is valuable for these emerging projects due to marginal loss factor benefits. This does not benefit Williamtown directly but may enhance the business case for these solar projects.

Design Considerations

- (+) The current Levelised Cost of Electricity (LCOE) for large-scale solar PV is projected to be 35-53 $/MWh in 2025, as a standalone plant.[24]
- (+) Due to solar farms' low structural requirements, they can be deployed on land that would otherwise be unused for development, such as disused landfill sites.
- (−) The power density of solar arrays in favourable conditions is around 20 W/m2. Therefore, an indicative 10 MW solar array would require around 0.5 km2 of land.
- (−) The capacity factor of a large-scale solar PV array in Australia is typically 20-25%.
- (−) Large-scale solar PV typically has a generation profile that peaks in the middle of the day and produces no output during hours of darkness.
- (−) The level of output is variable, depending on the weather conditions and the condition of the cells.

[22] https://www.newcastleherald.com.au/story/6421934/the-hunter-emerges-as-a-renewable-energy-powerhouse/
[23] https://www.muswellbrookchronicle.com.au/story/6912955/maxwell-solar-farm-approved/#:~:text=It%20will%20be%20located%20around,site%2C%20which%20closed%20in%202016.
[24] GenCost 2019-20, CSIRO – 2025 value assumed to be midpoint of 2020 and 2030 projections, which is likely conservative (i.e. on the high side of the 2025 value) as the rate of cost reduction is expected to reduce over time.

Potential Williamtown SAP Application

Large-scale PV could be deployed within the SAP, connecting directly to the 11 kV network within the SAP to offset local demand. This would reduce 'imports' of the SAP from the grid during the day, reducing the overall emissions profile of energy usage within the SAP.

- Large-scale solar PV is both technically and commercially mature, with over 3 GW of capacity installed in the NEM to date[25].
- There are incremental improvements and changes to specific solar PV technologies over time and as such the individual type of solar PV for use in any project should be reviewed for its suitability to the particular implementation.
- There is significant land that is unsuitable for commercial/industrial/residential development within the Structure Plan boundary. This area could be suitable for hosting a solar farm, depending on the geotechnical conditions.

Top Development Risks

- Large-scale solar PV faces significant risk compared to small-scale solar due to the complexity of the requirements for connecting to the grid as a large-scale generator.
- Given the scarcity of developable land, it may not be able to locate a suitable capacity of large-scale solar within the SAP site. This will be discovered once the SAP location is more clearly defined.
- While solar could provide for precinct demand during the day, the proportion of the overall demand it can provide for is limited by daylight hours. This could be addressed through 'over-sizing' the array and using storage to provide a larger proportion of demand.

[25] https://www.aemc.gov.au/data/annual-market-performance-review-2020/nem-generation-capacity-installed-megawatts-by-fuel-type-2001-2019

Innovation Opportunities

- There are a number of high-efficiency solar cell technologies being developed both in Australia and globally. The SAP could be used as a testing site for these technologies in real-world conditions.
- With the large amount of solar cells deployed each year, and the rate at which they degrade, significant efforts are being made to recycle or refurbish solar cells into ‘new’ PV modules and other projects. The SAP could make use of refurbished solar panels, testing their long-term performance and reducing the resources required for a large-scale solar array.
- With significant capacities of large-scale solar in operation, attention is moving to improve the operations and maintenance of these assets. There are a number of innovative tools, such as for fault detection, that could be employed at the Williamtown SAP to boost the performance of a large-scale array.

A.1.2 Small-scale Solar PV

Overview

Small-scale solar PV typically comprises an array of photovoltaic (PV) collectors (solar panels), commonly monocrystalline silicon cells, with a generating capacity of less than 5 MW. Small-scale PV systems are usually installed on the rooftops of residential or commercial buildings and are around 5-10kW in capacity. The energy generated is used by the site it is installed on at the time of generation and any excess generation is exported to the grid unless there is on-site energy storage.

Relevant Precedent

Electricity generation in Williamtown is currently limited to small-scale solar PV systems. Within the 2318 postcode area, which covers the vast majority of the SAP potential area plus the town of Medowie, there is 2.3 MW of installed rooftop PV capacity. The Ausgrid DTAPR indicates that 1 MW of this is connected to the Williamtown ZS network. This is a relatively modest amount of installed capacity compared to other postcodes in NSW. The average irradiance in the area is 4.4 kWh/sqm/day, which is typical for Australia’s east coast and represents a high potential for solar power. According to the NSW Electricity Strategy, it is estimated that almost half of Australia’s households and businesses will have installed solar by 2050, and many will also have batteries and electric vehicles.

On a slightly larger scale, the City of Newcastle constructed a 5 MW solar farm at the Summerhill waste management facility. The output from the solar farm is fed into the existing Ausgrid network and offsets the council’s energy use. It is also expected to substantially reduce the annual $4 million council electricity bill.

Design Considerations

- (+) The current LCOE for small-scale solar PV is calculated to be 100-180 $/MWh in Sydney, the closest proxy to Williamtown.[26] This is not expected to reduce dramatically in the near future.[27]
- (+) Since the panels can be installed on otherwise unused surfaces such as rooves, they can be installed without committing any dedicated land to energy generation.
- (−) The power density of solar arrays in residential or small-scale commercial settings, usually on rooftops, is up to 20W/m^2 but varies considerably on the location, orientation and physical attributes of the surface it is installed upon as these are not typically optimised for solar irradiation as they would be on a large-scale solar farm.
- (−) The capacity factor of a small-scale solar PV array in Australia is typically 10-15% due to the orientation and context of the panels.

[26] https://www.energycouncil.com.au/media/17320/australian-energy-council-solar-report-september-2019.pdf
[27] https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/green-energy-markets-der-forecast-report.pdf?la=en

- Small-scale solar PV typically has a generation profile that peaks in the middle of the day and produces no output during hours of darkness.
- The level of output is variable, depending on the weather conditions and the condition of the cells.

Potential Williamtown SAP Application

Small-scale PV could be a developmental requirement within the SAP, linked to the land usage of the building/site on which it would be installed. This would provide a minimum solar PV capacity within the SAP, which would reduce individual energy users' import from the grid during the day. This would reduce the overall emissions profile of energy use within the SAP and reduce energy users cost of energy (compared to traditional retail supply from the grid).

- Small-scale solar PV is both technically and commercially mature, with over 8 GW of capacity installed in the NEM to date.[28]
- Since much of the SAP is expected to be developed for industrial and commercial sites, there is likely to be a significant area of roof space available for small-scale PV. This could be used on a site-by-site basis to reduce grid demand and electricity costs or could be coordinated across the precinct.
- There are incremental improvements and changes to specific solar PV technologies over time and as such the individual type of solar PV for use in any project should be reviewed for its suitability to the particular implementation.

Top Development Risks

- Small-scale solar PV affects the voltage levels on the distribution network and as such there will be a limit to the capacity that can be installed within the Williamtown SAP, depending on which part of the network each asset is connected to.
- While solar could provide for precinct demand during the day, the proportion of the overall demand it can provide for is limited by daylight hours. This could be addressed through 'over-sizing' the installed capacity and using storage to provide a larger proportion of demand.

Innovation Opportunities

- Small-scale PV can be incorporated into net-zero buildings, to provide self-sufficient residences and possibly commercial sites as well.
- Small-scale PV can be co-ordinated through a VPP or included as part of a microgrid, enabling them to contribute to the energy needs of the wider precinct
- There are a number of high-efficiency solar cell technologies being developed both in Australia and globally. The SAP could be used as a testing site for these technologies in real-world conditions.

[28] https://www.aemc.gov.au/data/annual-market-performance-review-2020/nem-generation-capacity-installed-megawatts-by-fuel-type-2001-2019

A.1.3 Large-scale Wind

Overview

Large-scale wind generation projects are comprised of individual wind turbine generators (WTGs), which typically have a capacity of 1.5-3 MW each. A large-scale project is one with a total capacity of over 5 MW.

Relevant Precedent

The Crudine Wind Farm (142 MW), near Ilford, is in the completion & commissioning phase and will become the closest large-scale wind generator to Williamtown SAP, shortly followed by the 71 MW wind farm north of Muswellbrook. Beyond the AEMO pipeline, it appears that a number of different sites in the region are under investigation for wind farm development, which could boost the long-term generation capacity.[5,29] When the Central Coast/Hunter Region is developed as a REZ under the NSW Electricity Infrastructure Roadmap, the build and connection of significant renewable generation resources will be accelerated over the next two decades.

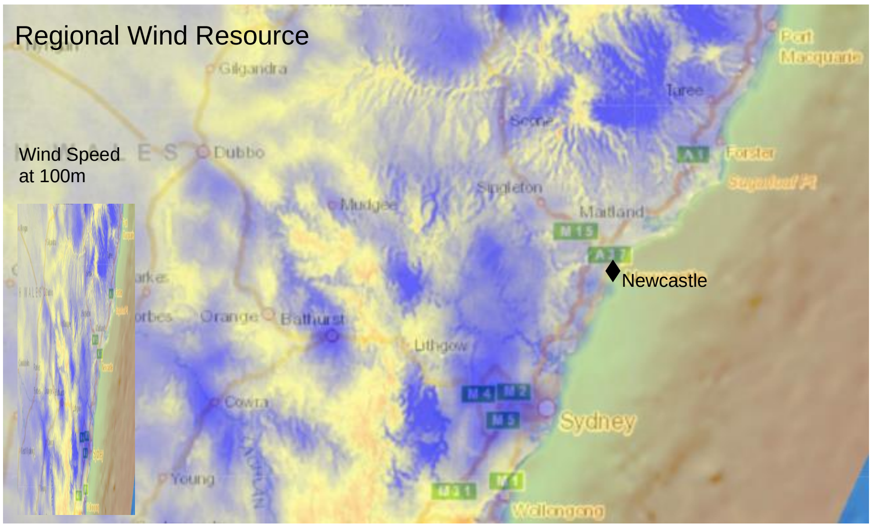


Figure A-3 Regional wind resource, AREMI

In addition to the upcoming onshore wind generation, the Maritime Union of Australia has earmarked Newcastle as a potential site for offshore wind generation.[30] It should be noted, however, that there are no detailed plans for such a development and given the current government stance on offshore wind, whether this becomes a reasonable possibility remains to be seen.

Design Considerations

- (+) The capacity factor of a large-scale wind farm in Australia is typically 30-35%, with new turbine designs pushing into 45%+ capacity factors in good resource areas.
- (+) The current Levelised Cost of Electricity (LCOE) for wind is projected to be 48-53 $/MWh in 2025, for a standalone plant.
- (+) Large-scale wind typically has a generation profile that is more level than solar PV, as it is not limited to daylight hours.
- (−) The power density of a wind farm is around 1-3 W/m^2, so an indicative 10 MW wind farm would require at least 3.2 km^2 of land.
- (−) Large-scale wind turbines often have a hub height of 100+m, which would not be suitable in proximity to Newcastle Airport, in terms of both physical impact and having a large radar cross-section (interfering with radar).
- (−) The level of output is variable, depending on the weather conditions and can be subject to low wind conditions for up to several weeks at a time.

[29] https://epuron.com.au/wind/bowmans-creek/
[30] https://www.mua.org.au/building-offshore-wind-australia

Potential Williamtown SAP Application

Due to the restrictions on tall structures in the Structure Plan boundary, large-scale wind could not be deployed on site at the Williamtown SAP.

- Large-scale wind is both technically and commercially mature, with over 6 GW of capacity installed in the NEM to date[31]. A wind asset outside of the SAP could be used to supply the SAP through a commercial arrangement.

Top Development Risks

- Large-scale wind would require the installation of tall structures within close proximity of the airport, well over the notifiable height. This makes use of large-scale wind on-site unfeasible.
- Even if the limit on structure heights could be overcome, given the scarcity of developable land, it would probably not be possible to locate a suitable capacity of large-scale wind within the SAP site.

Innovation Opportunities

- A number of projects are underway to improve wind forecasting in order to provide better information for NEM forecasts and increase the visibility for wind farm operators. These could be impleneted to improve the bidding strategy of a wind farm, or effectively balance output as part of a hybrid plant.

A.1.4 Small-scale Wind

Overview

Small-scale wind typically comprises of one or more wind turbine generators (WTGs) with a capacity each of around 1-10kW (although up to 100 kW is possible). These WTGs usually have tower heights of 24+ m and the context of the tower is important to establish suitable wind flow conditions around the WTG.

Relevant Precedent

Small-scale wind, for powering individual sites, is deployed in some remote areas of NSW.[32] However, no co-ordinated or wide-reaching uptake has been recorded in the wider Hunter region.

Design Considerations

- The LCOE of small-scale wind systems is currently around $285/MWh, considering net feed-in tariffs.[33]
- Wind generation on a small scale is very susceptible to reduced output from turbulent wind flow, particularly in urban conditions, creating variability in output in addition to the variability of wind speed
- WtGs should be placed well away from nearby obstacles such as buildings and tall trees (roughly 150 m away) and are likely to have a height of over 24 m
- Homes or businesses seeking to implement behind the meter WtGs should be located on at least 1 acre of land. [34]

[31] https://www.aemc.gov.au/data/annual-market-performance-review-2020/nem-generation-capacity-installed-megawatts-by-fuel-type-2001-2019
[32] https://www.environment.nsw.gov.au/resources/households/NSWSmallWindTurbineConsumerGuide.pdf
[33] https://www.yourhome.gov.au/energy/wind-systems
[34] **https://windexchange.energy.gov/small-wind-guidebook.pdf**

Potential Williamtown SAP Application

Small-scale wind turbines could be installed on unusable land due to their relatively low structural requirements and need for open spaces. These would be connected behind the meter to neighbouring energy users to reduce their import from the grid and thus the overall emissions profile of energy use within the SAP. The cost of energy from small-scale wind should be weighed up against other benefits as it is likely to result in a more expensive power supply.

- Given the height of small-scale WTGs and the proximity of the Structure Plan boundary to the airport, there is limited opportunity to install small-scale wind at the precinct.
- There are several small-scale wind turbine manufacturers in Australia, although the total installed capacity is not recorded. This is likely to be because small-scale wind turbines are most commonly used in remote and off-grid applications.
- Due to the variable nature of wind generation, this technology would need to be deployed with other technologies, such as storage or grid supply, to meet the reliability requirements of all energy users in the precinct. Small-scale wind turbines are recognised as having relatively poor reliability.
- Since much of the 'unusable' land in the Structure Plan boundary is on the coastal side of the area, it is possible that suitable conditions for a small wind turbine could be found, depending on other constraints

Top Development Risks

- Given the height of small-scale WTGs and the proximity of the Structure Plan boundary to the airport, it is unlikely that the installation of a small-scale WTG would be allowable within the SAP.
- There are several small-scale wind turbine manufacturers in Australia, although the total installed capacity is not recorded. This is likely to be because the small-scale wind turbines are most commonly used in remote and off-grid applications as they require significant open land to produce suitable wind conditions. It is unlikely that this is available within the SAP.
- While small-scale wind could provide for some precinct demand during the day, the proportion of the overall demand it can provide for is limited by suitable wind resource. This could not be addressed through 'over-sizing' the installed capacity and using storage due to the limited land available.

Innovation Opportunities

- If suitable land could be found in the SAP, perhaps in a coastal location where wind flow is more laminar, a small-scale turbine could be incorporated into a microgrid.

A.1.5 Bioenergy

Overview

Bioenergy uses biomass to fuel a generator. This can be through a number of means, including direct-firing, gasification, anaerobic digestion and pyrolysis. Typically, a direct-fired system is used, where biomass is burnt to heat water and create steam. The steam is used to drive turbines which generate electricity.

Bioenergy generation requires a steady supply of biomass, which can either be grown specially for the purpose or can come from industrial organic waste-stream, such as forestry and agriculture.

Relevant Precedent

While there are no operating commercial-scale bioenergy projects in the region, there are a few projects in development. One of these projects, the Redbank Biomass Power Station[35], is a biomass electricity generator, whereas the other two projects are focussed on the production of biofuels.

The Redbank Power Station was formerly a coal-fired power station that utilised coal tailings from nearby mines. This was taken offline in 2014 and has since been re-imagined as a biomass-fired power station. The project, a collaboration between CSIRO and Ecogen, last submitted a connection enquiry to Ausgrid in late 2018 but a formal application has not been put forward and negotiations are still underway, according to the 2019 DTAPR.

In addition, recent biomass resource mapping undertaken as part of the AREMI project, indicates that there are several significant biomass streams available in NSW. A common biomass stream used is residue from the forestry sector. Figure A-4 shows the regional production of residue from sawmills, indicating that there is significant available biomass resource in proximity to the SAP.

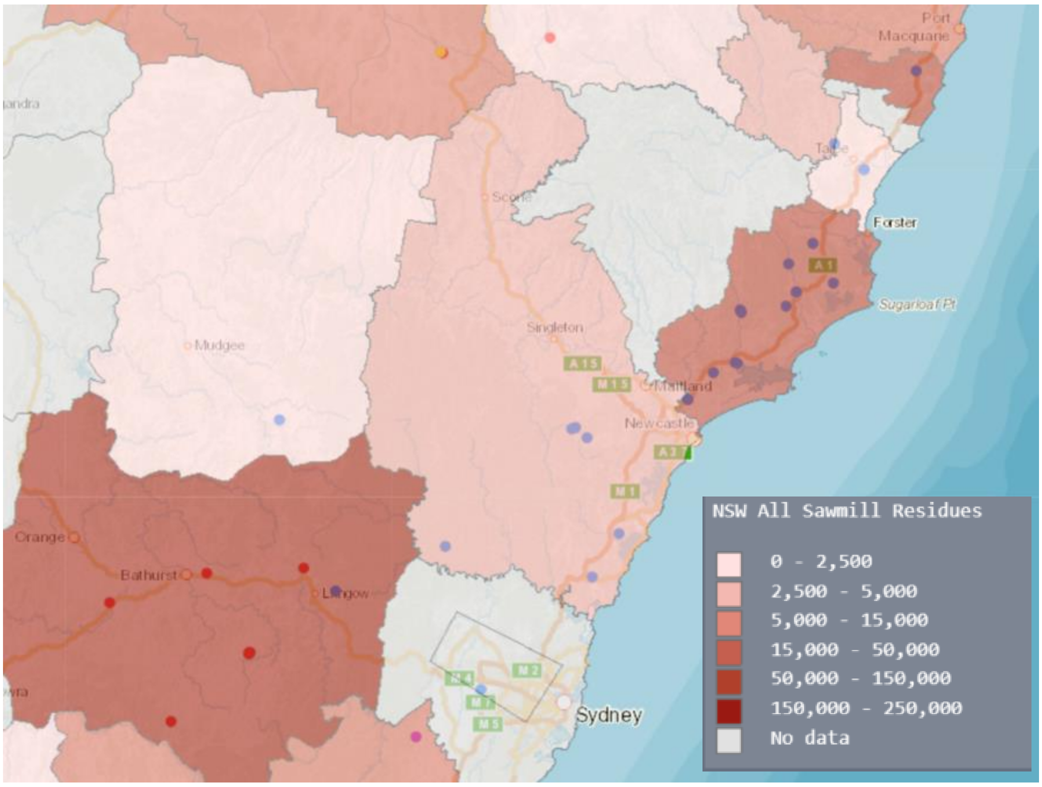


Figure A-4 NSW sawmill residues (dry tonnes), AREMI

Design Considerations

- (+) Bioenergy generation is a dispatchable supply source, so it can be controlled to match the SAP demand profile.
- (+) An indicative 8 MW biomass gasification power plant requires around 0.05 km^2 of land, with biomass being sourced from off-site.[36]
- (−) The LCOE of bioenergy is projected to be 260-400 $/MWh in 2025 for small scale plant.
- (−) The sustainability of biomass can vary considerably depending on the supply chain, including large land and water requirements. This should be considered on a case by case basis.
- (−) Transport and logistics considerations for different biomass supply chains can also significantly influence commercial and technical viability. This should be considered on a case by case basis.

[35] https://hunterenergyredbank.com.au/

[36] https://reader.elsevier.com/reader/sd/pii/S1743967115300921?token=C4E6D0BB6B1AB5446B19E9EBF142BE2EB650C865AFEACD449536A9FF4281A26C6D9634610C494D2EC0534F91AFC43E6B

Potential Williamtown SAP Application

A bioenergy power plant could be located within the SAP due to its relatively low land requirements. This trade-off with other land uses would need to be assessed. The power plant would likely have a capacity over 5 MW and would therefore be connected to the grid and offset local demand. It is likely that a supply of biomass from local forestry waste could be established. The plant could be run to provide renewable base-load supply while also having the capacity to manage a proportion of peak demand, based on the local demand profile.

- There is over 600 MW of bioenergy from biomass capacity installed in Australia.[37] The majority of these assets process bagasse (a by-product of sugar production) to generate electricity.
- Biomass can be sourced from waste-streams of industries such as forestry and agriculture. In these instances, bioenergy can contribute to a circular economy.
- Since it is controllable, bioenergy can provide dispatchable supply to meet the reliability requirements of the energy users in the precinct.

Top Development Risks

- Grid-connected bioenergy faces risk due to the complexity of the requirements for connecting to the grid as a large-scale generator. However, as it is dispatchable load this will be less onerous than for variable energy resources such as large-scale solar PV.
- Establishing a reliable and suitable biomass stream can be complex and considerably alter the economic viability of the project. This should be investigated as an early feasibility check.
- Combustion based bioenergy modes may need to consider potential aeronautical impacts resulting from an emissions plume or stack design.

Innovation Opportunities

- Bioenergy plant can be set up to produce electricity and heat, by extracting steam before it reaches the turbine, which can be used in industrial processes or district heating schemes.

A.1.6 Waste to Energy

Overview

Waste to energy in Australia involves the thermal treatment of waste or waste-derived materials for the recovery of energy. Since the local landfill, Newline Road Engineered Landfill, already produces energy from biogas, this method of energy from waste is not assessed in this section.

Thermal waste to energy (WtE) technologies convert non-recyclable municipal solid waste into useable forms of energy. The heat from the combustion of waste generates super-heated steam in boilers and the steam drives turbine generators to produce electricity. The energy value in waste can be utilised to generate electricity and heat during the thermal WtE process.

Relevant Precedent

In NSW, government policy encourages the recovery of energy from waste, if it can deliver positive outcomes for people and the environment. Waste to energy (WtE) in Australia involves the thermal treatment of waste or waste-derived materials for the recovery of energy.

Projects involving thermal treatment (i.e. waste incineration) have failed to gain traction in NSW, to date. A proposal for an WtE combustion plant at Eastern Creek was discontinued in July 2019 after the NSW Environmental Protection Authority and the NSW Department of Planning raised concerns regarding Greenhouse Gas (GHG) and toxic pollutants emitted from the waste incineration process and how the construction of the facility would undermine recycling and waste minimisation efforts. Since then, five WtE facilities have been proposed, all of which triggered

[37] https://www.cefc.com.au/media/107567/the-australian-bioenergy-and-energy-from-waste-market-cefc-market-report.pdf

public backlash due to concerns over irreversible environmental and health impacts, and the Not In My Back Yard (NIMBY) phenomenon.

One source of energy for Waste to Energy plants is organic waste, which decomposes to produce methane. The AREMI project has mapped the production of organic waste in NSW, as shown in Figure A-5.

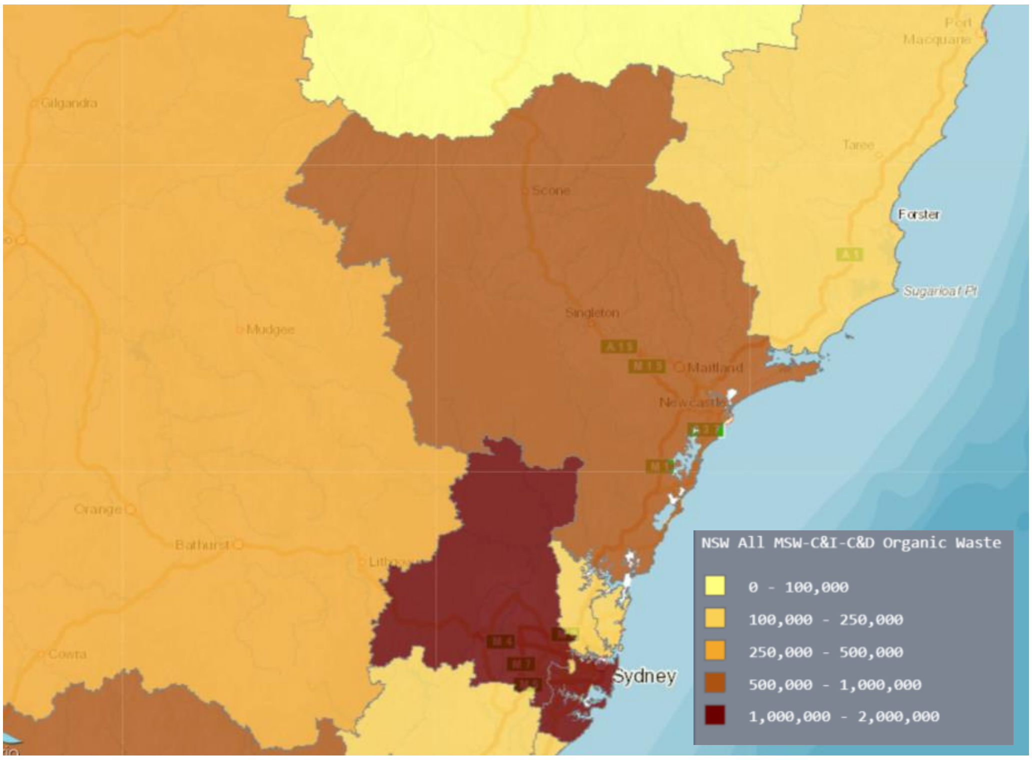


Figure A-5 **NSW organic waste production, AREMI**

Design Considerations

- Diverting waste to WtE plants from these landfills, can reduce methane generated from waste decomposition and promote a circular economy.
- The required land for WTE plants is significantly less than that needed for landfilling a similar amount of municipal solid waste.
- A large scale modern thermal WtE plant requires at least 100,000 tonnes of municipal solid waste per year over its lifetime. As with all large investment projects, thermal WtE can potentially create lock-in effects that may lead to plant overcapacity and hamper efforts to reduce, reuse and recycle.
- The overall site area needed for an indicative 200ktpa WtE plant is approximately 2.25ha.[38]
- A WtE plant requires large investment and operation costs that on average are much higher than traditional waste treatment methods.
- The process for establishing WtE processing plants is highly regulated and scrutinised. The health and environmental impacts are continuing public concerns. Community engagement and education is required to promote the benefit and increase public acceptance.
- The WtE plant should be located close to a landfill or transfer station, to main roads and to the electrical grid to reduce transportation and operational costs.
- Consistency and quality of waste are key factors in determining whether a WtE facility is feasible. Williamtown SAP should conduct a waste stream analysis to gauge how much WTE capacity is needed and then plan a pipeline of facility to support this capacity.

[38] http://large.stanford.edu/courses/2017/ph240/kim-d2/docs/wsp-may13.pdf

- Energy from waste facilities are emerging in Australia and projects seeking to harvest energy from waste are likely to be relatively industry leading. There is not yet a dispatchable off-the-shelf solution.

Potential Williamtown SAP Application

A waste-to-energy power plant could be located within the SAP however the trade-off with other land uses would need to be assessed. The power plant would likely have a capacity over 5 MW and would therefore be connected to the grid and offset local demand. It is likely that a supply of local waste could be established. The plant could be run to provide renewable base-load supply while also having the capacity to manage a proportion of peak demand, based on the local demand profile.

- Waste to energy facilities can be a low-carbon solution for energy and waste management which may be attractive to organisations who are working towards a circular economy.
- If suitable waste-streams can be captured, waste to energy can provide dispatchable supply to meet the reliability requirements of the energy users in the precinct.

Top Developmental Risks

- Given the high level of community objection to previous waste to energy proposals in NSW, it is expected that there would be a significant community acceptance barrier to development.
- Grid-connected bioenergy faces risk due to the complexity of the requirements for connecting to the grid as a large-scale generator. However, as it is dispatchable load this will be less onerous than for variable energy resources such as large-scale solar PV.
- Establishing a consistent and suitable waste stream can be complex and costly.
- Combustion based bioenergy modes may need to consider potential aeronautical impacts resulting from an emissions plume or stack design.

Innovation Opportunities

- Waste-to-energy plant is an emerging technology and as such there are processes and products being developed, which could be tested at the precinct.

A.1.7 Large-scale Solar Thermal

Overview

Large-scale solar thermal plant use concentrated solar thermal (CST) technology to generate electricity. Sunlight is concentrated by an array of lenses, onto a receiver that heats a material, typically a liquid such as water or oil, to produce steam and drive a turbine.

Design Considerations

- CST generation is a dispatchable supply source, as energy can be stored as heat in the system, so it can be controlled to match the SAP demand profile.
- The LCOE of CST with 8 hrs storage is projected to be 130-180 $/MWh in 2025.
- CST requires large areas of land (around 0.2 – 0.4 km^2 for an indicative 10 MW plant[39]) and typically includes a tall structure for the receiver to be located on

[39] https://www.nrel.gov/docs/fy13osti/56290.pdf

Potential Williamtown SAP Application

Large-scale solar thermal could be deployed within the SAP, connected to the grid, to offset local demand. This would reduce 'imports' of the SAP from the grid during the day, reducing the overall emissions profile of energy usage within the SAP.

- There is only one operational CST plant operating in Australia, which has a capacity of 9.3 MW and is located with the Liddell coal-fired power plant[40]. It is used to pre-heat water for the coal plant, rather than produce electricity in its own right.
- Due to the land requirement and tall receiver structure required for the plant, it is unlikely that suitable land can be found within the Structure Plan boundary.
- Since it provides both generation and storage, solar thermal can provide dispatchable supply to meet the reliability requirements of the energy users in the precinct.

Top Developmental Risks

- Due to the tall structure limitations in the Structure Plan boundary, it may not be possible to locate CST within the SAP.
- Large-scale solar thermal faces significant risk compared to small-scale generators due to the complexity of the requirements for connecting to the grid as a large-scale generator.
- Given the scarcity of developable land, it may not be able to locate a suitable capacity of large-scale solar thermal within the SAP site. This will be discovered once the SAP location is more clearly defined.

Innovation Opportunities

- Solar thermal plant can be set up to produce electricity or heat, which can be used in industrial processes or district heating schemes.

A.1.8 Geothermal

Overview

Geothermal electricity generation systems use heat energy underground to heat a material, usually a liquid such as water, to produce steam and drive a turbine. The systems can require wells of up to 3-5km to be drilled in order to reach layers of ground with sufficient heat energy.

Relevant Precedent

While no existing geothermal energy projects have been identified in the region, there is some geothermal resource in the area. Figure A-6 shows the temperature at 2km below the surface, which indicates the level of potential heat capture by the transfer liquid. Since the temperature at 2km in the Newcastle is less than 100°C, it would not be sufficient to produce steam to drive a turbine but could be used to provide process or district heating. It would be necessary to drill a well to at least 3km in the Newcastle area in order to achieve steam and power generation from the geothermal resource.

[40] https://www.cleanenergycouncil.org.au/resources/technologies/solar-thermal

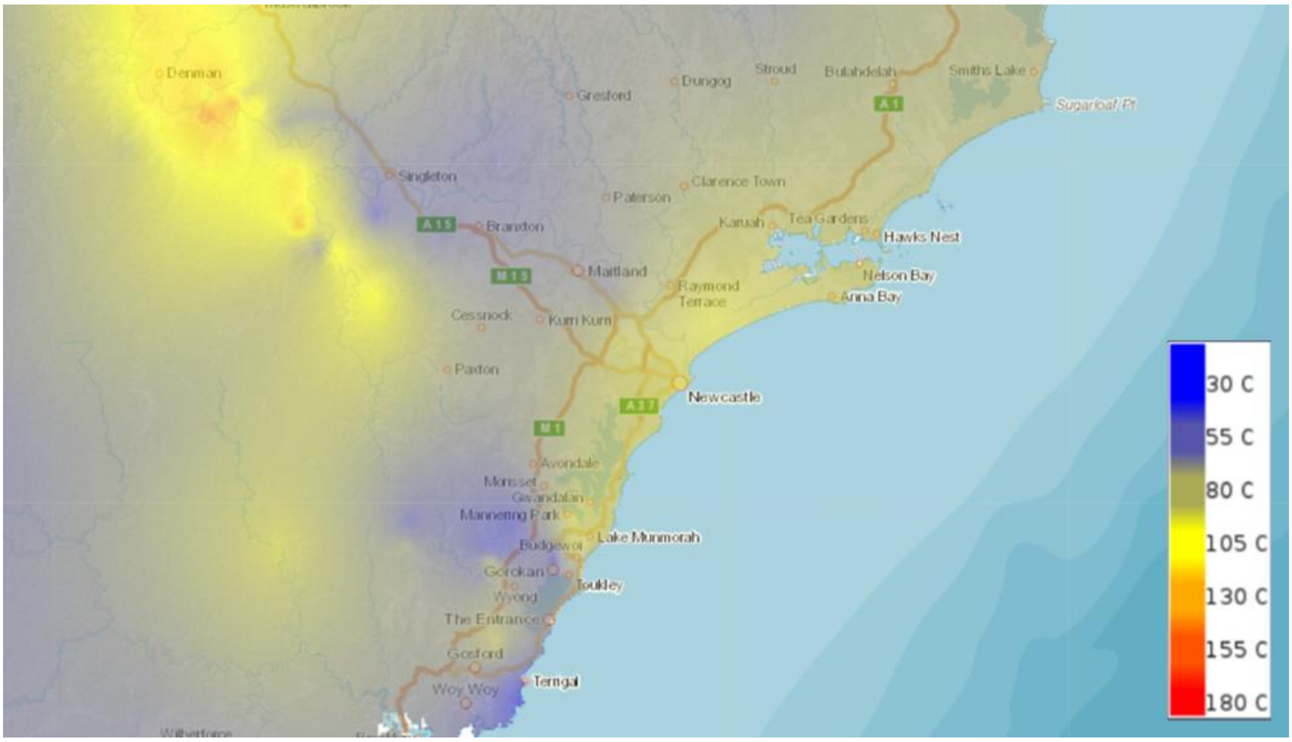


Figure A-6 Geothermal temperature at 2km below surface, AREMI

Design Considerations

- (+) Geothermal generation is a dispatchable supply source, so it can be controlled to match the SAP demand profile.
- (−) The LCOE of geothermal is projected to be 95-140 $/MWh in 2030.[41]
- (−) Geothermal generation plant requires around 0.1-0.4 km^2 for an indicative 10 MW plant.[42] More area is required during construction.
- (−) Geothermal resources sufficient to provide steam for electricity generation can be at large depths, requiring several km of wells to be drilled.

Potential Williamtown SAP Application

- (−) While geothermal generation is a technically mature method, geothermal electricity generation is not financially viable in Australia to date.[43]
- (★) Since it is controllable, geothermal can provide dispatchable supply in order to meet the reliability requirements of the energy users in the precinct.

Top Developmental Risks

- (−) With limited geotechnical data available at this stage, the possibility of creating a 3+km well is uncertain. Given the low-lying nature of the land, it is anticipated that this will present significant difficulty.
- (−) Due to the temporary land requirements of the geothermal plant during construction, the plant would need to be installed early in the SAP development, to make the land available to other developments at a suitable time.

[41] ARENA (2017) "Highlights of the barriers, risks and rewards of the Australian geothermal sector to 2020 and 2030"
[42] **https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf**
[43] https://arena.gov.au/renewable-energy/geothermal/

- Large-scale geothermal faces significant risk compared to small-scale generators due to the complexity of the requirements for connecting to the grid as a large-scale generator. However, its dispatchable nature will make this less onerous than for a variable energy source.

Innovation Opportunities

- Geothermal plant can be set up to produce electricity and heat, by extracting steam before it reaches the turbine, which can be used in industrial processes or district heating schemes.

A.2 Electricity Aggregation Technologies

A.2.1 Microgrid

Overview

A microgrid is a decentralised group of electricity sources and loads that normally operates connected to and synchronised to the traditional wide area synchronous grid but may also be designed to disconnect from the main grid into "island mode" — and function autonomously as physical or economic conditions dictate.

Relevant Precedent

Microgrids are a grid-enabling technology that developers are exploring for new off-grid sites, regional communities and critical infrastructure. The technology has been demonstrated in small commercial trials such as at the Department of Defence, remote mining applications, and a number of regional communities.

In 2019, the NSW state government-funded small-scale commercial trials in Cowra and the Byron Bay Arts & Industry Estate. These trails successfully demonstrated the technical and commercial feasibility of the application of microgrids in regional communities and business parks. These trials identified the risks and developed solutions for a renewable microgrid, giving regional communities and business parks an example they can follow.

The Department of Defence has implemented microgrids for energy security and reliability at a number of sites. Many of their off-grid sites are powered by a combination of solar PV, batteries and diesel generators. Australia's largest naval base, HMAS Stirling, is powered by renewable energy produced by the Garden Island Microgrid. The Garden Island Microgrid is a 2 MW solar PV and 2 MW/0.5 MWh battery energy storage system with the capability to connect wave energy.

Under the current Federal Government Budget, $50.4 million has been committed to feasibility studies for off-grid and fringe-of-grid microgrids through the Regional and Remote Communities Reliability Fund[44]. While Williamtown is unlikely to be eligible for such funding, there have been three projects in NSW successfully funded in the first round, awarded in June 2020. These projects could provide an important precedent for other microgrids within the state.

Design Considerations

+ Microgrids may increase energy reliability and resilience by generating enough energy to power the community and/ or critical infrastructure during outages. Defence and military operations can benefit from this technology.
+ Through the efficient management of energy supply, microgrids can both reduce costs and provide a revenue stream for their customers. They supply revenue by selling aggregated energy and services back to the grid. Customers no longer just consume energy, but also can produce and control it through their microgrids.
+ Microgrids can help diversify risk on the central grid during periods of peak demand by acting as an additional resource that grid operators can call upon, such as through demand response.
+ A wide range of renewable generation technologies can be deployed in a microgrid. These include solar, wind, fuel cells, combined heat and power (CHP) plants, and energy storage technologies.

[44] https://www.energy.gov.au/government-priorities/energy-programs/regional-and-remote-communities-reliability-fund

- Microgrids gather data through smart meters or other data loggers. Data access agreements with participants are needed before customer data can be collected as per consumer data rights rule.
- The DNSP approval process to connect the microgrid can be complicated and lengthy due to the number of components involved that determine the aggregated behaviour of the system.[45]
- A regulatory framework and legal structure are required to address risk allocation issues and consumer protection rights.
- Low return on investment may present challenges in terms of finding investors and getting the project off the ground.

Potential Williamtown SAP Application

A microgrid at the precinct could bring together multiple generation and storage assets to provide reliable and low emissions electricity supply to all energy users, backed up with connection to the wider grid. A microgrid within the SAP could include a community battery and aggregation of residential or business-level distributed energy resources.

- A microgrid could be designed to be able to separate from the main grid in times of network issues, providing resilience to key loads in the precinct.
- Microgrids can gain economic benefit by joining utility demand response programs, or by participating in state and federal clean energy programs. NSW funded microgrid projects in the past.

Top Developmental Risks

- The complexity of establishing a microgrid and connecting it to the grid is exacerbated by the emerging nature of this technology. Early conversations with Ausgrid to understand requirements will be essential.
- The responsibility of the developer, in order to protect the consumer rights of the SAP energy users, is considerable and has legal and financial repercussions. It may be difficult to find someone to take on this responsibility.
- The individual developmental risks of the technologies implemented must be considered as part of the risk profile of the microgrid.
- The downside risk is that management of the grid rests with the embedded network operator, as it will now be an embedded network. Asset failures and outages would have to be managed by the microgrid operator.
- The microgrid would not have the benefits of redundancy of interconnected feeds from other zone substations, and 11 kV cross-zone ties. Reliability would be greatly compromised, and could not be compensated for via the use of grid-scale batteries while managing energy costs to the SAP.

Innovation Opportunities

- A micro-grid with differing connection types which require different levels of reliability in supply would present an interesting case study of load control and prioritisation
- Embedded network opportunity – an embedded network is basically a network that is owned by a third party other than Ausgrid. The embedded network has a single point of connection, and this then allows any generation connected within the embedded network to be treated as 'behind-the-meter' generation, this offsetting NUoS charges and generating significant savings.
- Any smart grid technology that is able to manage the aggregate peak demand of the SAP would also deliver significant savings against Ausgrid's ratcheting capacity charge component within their NUoS tariffs.

[45] https://energy.nsw.gov.au/media/1891/download

A.2.2 Virtual Power Plant

Overview

A virtual power plant uses a cloud-based control system to aggregate distributed energy resources (DER) and coordinate flexible loads. These resources include PV, wind, solar thermal/storage, electric vehicles, and different types of electricity storage such as batteries, fuel cells, and capacitors, along with some demand response capabilities, which are all monitored and controlled by an advanced information and communications technology (ICT) platform.

Relevant Precedent

The wholesale demand response mechanism rule change (AEMC 2018) will enable a two-sided market where individual households or businesses could respond to price signals to export solar, import electricity to charge batteries or lower their usage. To enable the new demand response mechanisms, DNSPs and energy retailers are looking to virtual power plants (VPP) to help aggregate these distributed energy resources (DER) to enhance power generation, as well as trading or selling power on the electricity market. Enabling DER capability within the SAP will prepare the SAP to take advantage of the demand response market that will come into play in the national electricity market within the next 5 years under the ESB post 2025 market design.

The Power2U program, Ausgrid's battery virtual power plant project, links distributed solar and battery storage from 233 residential customers across 170 suburbs in Sydney, the Central Coast and the Hunter region to create a 1 MW VPP. Following a successful initial trial, during which Ausgrid coordinated participants' battery storage to provide demand response and voltage support services, Ausgrid has expanded the scope and scaled up the VPP. The trial's expansion means there may be the potential for additional Ausgrid customers to join the program, including households and businesses located in the Williamtown SAP.

Design Considerations

- (+) The renewable technology mix needs to be integrated and controlled through a VPP network along with suitable storage capacity for the efficient management of intermittent energy sources to meet power demand.
- (+) A VPP acts as an intermediary between DERs and the wholesale electricity market and trades energy on behalf of DER owners who individually are unable to participate.
- (+) VPPs can contribute to demand shaping and reducing the peak load of the grid, while providing security, frequency control and local power quality improvement. Defence and military operations can benefit from this technology.
- (−) VPP program participants typically have a limited choice of inverter and solar batteries available to them as the systems must be able to interface with the VPP control system.
- (−) It is necessary for the development corporation to provide an initial bridge between the VPP network provider, businesses, large scale energy storage developers (if needed) and other stakeholders to ensure effective implementation of a VPP in the SAP.
- (−) Currently economic viability of VPPs is limited, primarily due to the limited deployment of VPPs at a commercial scale, as well as the current long payback times for small scale energy storage systems.

Potential Williamtown SAP Application

A VPP at the precinct could bring together multiple behind the meter generation and storage assets to provide a reliable and low emissions electricity supply to all energy users, backed up with connection to the wider grid. A VPP within the SAP would likely include numerous installations of small-scale solar PV and small-scale batteries, with provision for demand response within certain energy users' sites. This aggregated capacity can be traded in the wholesale market as generation, system services and demand response, opening up new revenue streams.

- A number of VPP trials are underway in Australia, including Ausgrid's battery VPP and the Tesla VPP trial in South Australia. These have achieved a reasonable scale but are still developing their systems to be able to handle large amounts of customers, so are not fully technically or commercially mature.
- In space-constrained developments, such as the Williamtown SAP, a VPP can bring together generation and storage assets that are located 'behind the meter', enabling a large capacity asset to be effectively housed across multiple sites rather than on dedicated land.

Top Developmental Risks

- VPPs are an emerging technology in Australia and as such face technical and commercial performance risks. The level of these will depend on the cloud-based platform selected.
- Ensuring all DER installed can participate in the VPP requires careful and early definition of their technical requirements.

Innovation Opportunities

- VPPs can create a platform that incentivises the use of renewable energies by reducing the cost of energy delivered to energy users and by facilitating the use of controllable appliances to facilitate demand response and other system services that can be traded by the aggregator.
- VPPs are able to fill the information and technology gap in the electricity market and utilities for better incorporating the end-user participants into the wholesale market and addressing technical issues in the network. The SAP could work with the network operator to help inform the value of the services it can provide to the market.

A.3 Commercial Electricity Supply Arrangements

A.3.1 Corporate PPA

Overview

A corporate Power Purchase Agreement (PPA) is, at a basic level, an agreement with a generator to purchase a certain amount of electricity at a certain price. In reality, the arrangements can be much more complex and can involve multiple generators and off-takers.

In Australia, PPAs often include an amount of Large Generation Certificates (LGCs) equal to the amount of electricity purchased, so that organisations that are required to contribute to the Renewable Energy Target can surrender them as part of their obligation.

PPAs in Australia are typically arranged through a retailer, so that the off-taker gets security of supply. They are usually settled as a contract for difference (CfD) between the off-taker and generator.

Relevant Precedent

Rather than owning assets themselves, a number of local organisations have committed to source 100% of their electricity demand from renewable sources through Power Purchase Agreements (PPAs). These organisations include the City of Newcastle Council and the University of Newcastle.

The City of Newcastle signed a PPA through retailer Flow Power in January 2020. As a result, all operations of the council will use power exclusively from the Sapphire Wind Farm near Glen Innes in NSW. The deal has been struck for a 10-year period and will provide for the portion of the council's electricity demand which is not met by its small-scale PV installation.

The University of Newcastle has signed a more diverse PPA, provided by Red Energy, a subsidiary of Snowy Hydro. This contract will supply the university's demand for the next 7 years from Red Energy's portfolio of solar and wind projects, which are firmed with hydro storage.

Over 3,500 MW of generation capacity has been enabled by PPAs in 2020 to date[46] and this is becoming a more common system for organisations, or collectives, to obtain renewable power without the upfront capital cost of the asset.

Design Considerations

- PPAs do not require the off-taker to take ownership of a physical asset and as such do not require any upfront capital investment.
- Since the generation assets do not belong to the off-taker, there is no need for them to be located at the SAP.
- The generation assets that are contracted could be of any technology. Often technologies that have a similar generation profile to the off-taker's demand profile are chosen. In some cases, this can be achieved through having a PPA with multiple different types of generator and even storage assets.
- Establishing a PPA takes as much as 1-2 years to complete. Developing a procurement approach for the precinct requires an understanding of the precinct's demand and energy usage profile, and the drivers behind this usage. The future of the electricity sector and the spot market is also taken into consideration to manage development and cost risks.

Potential Williamtown SAP Application

A PPA for the Williamtown SAP could be sized to meet all demand of the precinct, met by a firmed generation asset, such as wind and storage, or a portfolio of renewable generation. This would effectively reduce the emissions of the precinct electricity use to zero.

- A PPA would enable the precinct to source renewable energy for its supply, without having to house any generation within the precinct and making use of the economies of scale for generation technologies such as solar PV. It could also be used in conjunction with on-site assets.
- Over 3.5 GW of renewable generation capacity has been enabled by corporate PPAs in 2020 alone. Backed by technically mature technologies, this mechanism is commercially mature and now well understood in the NEM.
- The number of large-scale solar developments under investigation in the Hunter Region creates potential renewable sources of offtake for Williamtown.
- A PPA, without any onsite generation or storage, would make the precinct entirely reliant on the wider network. This may not meet the reliability requirements of some energy users that require a 24-hour supply for critical operations.

Top Developmental Risks

- The risks associated with a PPA primarily lie with the assets that back-up the agreement. These must be investigated at an early stage in order to ensure a suitable asset is selected.
- As the asset(s) that back the agreement are likely to be large-scale variable renewable generation, these will face considerable grid connection risk.

[46] https://www.energetics.com.au/insights/knowledge-centres/corporate-renewable-ppa-deal-tracker

- The commercial arrangements around supply energy purchased under the PPA to individual energy users within the SAP could be complex and put over-procurement risk onto the PPA holder.

Innovation Opportunities

- Given the typical scale of corporate PPAs in Australia to date, a customer PPA product for smaller businesses and even residential customers which meets the unique needs of the precinct and maximises the use of renewable energy sources would set new precedents.

A.4 Other Energy Production Technologies

While electricity supply is a key focus for the SAP energy strategy, there are other sources of energy demand within the SAP that should be incorporated into the energy strategy in order to make the most of cross-sector opportunities and deliver the best value energy as a holistic package. This section looks at other sources of energy demand and the potential for renewable energy provision for these sectors.

A.4.1 Hydrogen Production

Overview

'Green' hydrogen is produced primarily through the electrolysis of water, with renewable electricity generation as the power source. This can be used as a means for using excess renewable generation in a system, but typically provides better value when run on a continuous basis, with a dedicated power supply.

Hydrogen can be used in many applications, from substituting a proportion of natural gas, to direct use in industrial systems and chemical processing. Hydrogen can also be used as a fuel for Fuel Cell Electric Vehicles (FCEVs).

Relevant Precedent

The development of a hydrogen economy in Australia is being supported by the federal government and is anticipated to provide for significant energy supply in the gas and transport sectors. Hydrogen as gas can be used in industrial processes, such as steelmaking, and is being trialled in several networks as a partial replacement for natural gas in residential gas supply. In addition, hydrogen as a fuel can be used in multiple transport modes that use Fuel-Cell Electric Vehicles (FCEVs), as demonstrated in the National Hydrogen Strategy.[47]

In August 2020, the NSW government approved the development of the State's first hydrogen gas facility at Horsley Park. The Western Sydney Green Gas (WSGG) project will utilise solar and wind power to generate hydrogen gas which will be used for cooking, hot water, and heating across Jemena's New South Wales gas network. The project will also evaluate the application of hydrogen in the transport sector as well as the storage capabilities of Jemena's New South Wales gas distribution network. The trial will run for over five years to demonstrate the commercial feasibility of power-to-gas technology. This project is an ARENA funded project and will be obligated to complete knowledge sharing activities. Williamtown SAP may benefit from the lessons learnt reports and presentations as the project progresses.

Assessing the viability of clean manufacturing possibilities, the Grattan Institute (2020) found green steel made with renewable hydrogen could become a multibillion-dollar export industry employing 25,000 people in regional areas reliant on coalmining, particularly in the Hunter Region. The green steel industry will take time to develop and investment will need to come from the private sector. An 'innovator' in this sector is the city of Whyalla, SA, where green hydrogen produced in Adelaide will be trucked to the steel manufacturing hub.

[47] http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/nhs-hydrogen-for-transport-report-2019.pdf

Design Considerations

- The levelised cost of hydrogen is projected to be 2.2-3.3 $/kg in 2025, when using solar PV as the energy source.[48] The Australian Government's ambition is for hydrogen to be produced for under 2 $/kg at a commercial scale.
- Hydrogen requires 11L of clean water for 1kg of production (approx. 120 MJ of energy), which can put pressure on water availability and exacerbate drought in water-scarce areas. Recycled water can be used in the production process given it is properly treated.
- Hydrogen can be produced using power sources other than renewable generation, such as grid electricity, but this typically incurs carbon emissions
- Hydrogen production requires a reliable power supply and can have a high electricity demand depending on the size of the plant. This could result in limitations on the local network or require additional on-site generation

Potential Williamtown SAP Application

A hydrogen plant within the SAP could be used to produce hydrogen fuel for local vehicles and industry or for export to other industrial consumers either within Australia or internationally via the Port of Newcastle. The hydrogen plant may be supplied by onsite generation but given the scarcity of space within the SAP, it would likely be supplied via a PPA with a renewable generator. This would enable a continuous supply from the grid, effectively off-set by the renewable generation. Use of hydrogen within the precinct could displace fossil-fuel consumption in vehicles and industrial processes, reducing the precinct's overall emissions from energy usage.

- With hydrogen trials growing around Australia, with particular interest in hydrogen use in industrial applications, the Williamtown SAP could attract low-emissions heavy industry through establishing a green hydrogen supply chain.
- In March 2021 the NSW Minister for Energy and the Environment announced an objective to develop a green hydrogen hub in the Hunter and Illawarra Regions of NSW, supported by at least $70 million worth of committed grant funding[49]. Williamtown SAP could be the site of this hydrogen hub, or otherwise serve to promote hydrogen industry growth through enabling infrastructure or hydrogen application trials.
- If hydrogen were to be produced using solar PV, it would require significant space, however, the solar PV could be situated on otherwise unusable land and the production plant located close to a demand centre or logistics hub.
- To provide adequate water supply for the plant, additional water treatment or desalination may be required. It may be able to combine this need with the existing water treatment within RAAF Base Williamtown, which addresses PFAS contamination.
- The SAP could create demand for green hydrogen by incentivising the use of FCEV vehicles in the area

Top Developmental Risks

- Since hydrogen production is an emerging technology in Australia, the technical development of a system suitable for the SAP area is likely to be complex, with the technical and commercial performance uncertain.
- Access to sufficient clean water for the hydrogen production will require additional water treatment or desalination capacity, which would significantly increase the land requirement of the plant. Contaminated water could be treated for use in hydrogen production, although this would require

[48] https://energy.anu.edu.au/files/2020%2009%2001%20-%20ZCEAP%20-%20CCEP%20Working%20Paper%20-%20Green%20hydrogen%20production%20costs.pdf
[49] https://www.environment.nsw.gov.au/news/hunter-hydrogen-hub-to-drive-jobs

a greater volume of water, and would result in production of a highly concentrated contaminated sludge product, which would introduce further handling, storage and disposal risks.

- Understanding the future demand for hydrogen and commercial viability of the plant in the long-term market will be complex and place commercial risk on the plant owner. Green hydrogen is in its infancy from both a technological and commercial perspective, and so the investment case must be considered very carefully.
- Potential planning impacts on land use and local aeronautical activity must be considered carefully. Exclusion zones, potential site emissions and other risks need to be accounted for when sizing and siting hydrogen applications.

Innovation Opportunities

- Given the relatively low technological and commercial maturity of hydrogen production technologies, compared to renewable electricity generation technologies covered in this report, there is a significant opportunity for innovation in this area.

  For example, the University of Newcastle Institute for Energy and Resources Hydro has developed a new 'harvesting green hydrogen' technology[50], which uses atmospheric moisture to create hydrogen. This has the potential to significantly reduce the burden of hydrogen production on fresh water supplies in Australia, if it can be deployed at a commercial scale.
- Given the sensitive nature of water as a precious and limited resource that needs to be conserved, there is an opportunity to use recycled water instead. Although the relative amount of water that will be used in hydrogen production will be small compared to other water-reliant industrial processes, there is a risk of community backlash with using fresh water. Water costs are also not anticipated to be a significant factor in the out-turn cost of hydrogen production, so this requirement is not expected to be commercially burdensome.

A.4.2 Biofuels

Overview

Biofuels are particularly attractive as an approach to decarbonising transport due to the ability to use existing infrastructure for some biofuels, reducing the capital investment required for the transition. For example, there are some biofuels which can be directly substituted for petrol and diesel in internal combustion engines, up to high blend ratios.

Biofuels can generally be broken down into two groups; conventional biofuels and advanced biofuels. Conventional biofuels are considered to be those which use food crops as feedstock and advanced biofuels are considered to be those that use non-food crops or other sources of feedstock.

Ethanol, biodiesel, and Hydrogenated Vegetable Oil (HVO) Diesel are the most widely produced biofuels and can be produced through a variety of processes. The desired end product depends on the intended use of the fuel

Relevant Precedent

Transport accounts for around 20% of Australia's carbon emissions[51], while electricity generation accounts for around 33%. This shows that while renewable electricity generation is important for reducing emissions, transport is another major contributor that needs to be tackled. There are a number of ways this can be achieved, and biofuels is one approach.

The Licella Cat-HTR commercial demonstration plant is located at Gosford and is the result of 10 years of development and an ARENA-funded project that concluded in 2012. This plant creates a developmental bio-crude from biomass, which can then be refined into biofuels and other products. Another biofuels project, which is

[50] https://www.newcastle.edu.au/newsroom/featured/new-green-hydrogen-made-from-solar-power-and-air
[51] https://www.environment.gov.au/system/files/resources/6686d48f-3f9c-448d-a1b7-7e410fe4f376/files/nggi-quarterly-update-mar-2019.pdf

operational but still developing its commercial product, is the EthTec Biorefinery Pilot Plant in Muswellbrook.[52] This plant will produce bio-ethanol for use as a fuel and for creating other products.

Design Considerations

- (+) The LCOE of biofuels is typically higher than their traditional counterpart in the Australian market but the most prominent biofuels are set to reach price parity with fossil-fuels within the next 10-15 years.
- (+) Waste biomass, such as forestry residues, can be used for creating certain biofuels, contributing to a circular economy
- (−) Sources of biomass, when grown specifically for biofuels, tend to require large amounts of land and water, which reduces their sustainability credentials
- (+) Waste biomass, such as forestry residues, can be used for creating certain biofuels, contributing to a circular economy

Potential Williamtown SAP Application

A biorefinery could be located within the SAP, using a biomass stream from off-site. The biofuels could be used to displace local fossil fuel use, reducing the emissions profile of the SAP, or could be exported to local and international users.

- (★) Production of biofuels could potentially increase value of bioenergy electricity generation, if the processes are able to make use of the same biomass supply, through logistical efficiency.
- (★) The SAP could create demand for biofuels by incentivising the use of compatible vehicles in the area

Top Developmental Risks

- (−) Since biofuel production is an emerging technology in Australia, the technical development of a system suitable to the SAP area is likely to be complex, with the technical and commercial performance uncertain.
- (−) Access to sufficient suitable biomass for the biofuel production will influence the commercial viability of the project and should be established during early feasibility works.
- (−) Understanding the future demand for biofuels and commercial viability of the plant in the long-term market will be complex and place commercial risk on the plant owner.
- (−) Potential planning impacts on land use and local aeronautical activity must be considered carefully. Exclusion zones, potential site emissions and other risks need to be accounted for in sizing and siting.

Innovation Opportunities

- (★) Biofuel production in Australia is an emerging sector and there is significant opportunity for innovation in this area.

[52] https://www.ethtec.com.au/ethtec-pilot-plant

A.4.3 Small-scale Solar Thermal

Overview

Small-scale solar thermal systems are primarily used for solar water heating. Water is passed through solar collectors, which absorb heat energy from solar irradiation. This type of system accounts for 13% of all water heating systems in Australia.[53] The solar system can be backed-up with electric or gas heating in order to meet demand.

Design Considerations

- (+) Solar water systems are typically located on the rooftops of the buildings they supply, and as such don't require any dedicated land.
- (−) A solar water system costs on average $2600 for a 270-litre capacity system. $4300 for a 410-litre capacity system.
- (+) Solar water systems are typically located on the rooftops of the buildings they supply, and as such don't require any dedicated land.

Potential Williamtown SAP Application

Within the SAP, individual energy users could be required to install a small-scale solar thermal system with a capacity related to their land use. By using solar water heating, the electricity demand of the precinct would be reduced, requiring less electricity generation capacity to be acquired or allowing for more exports. It would also reduce the emissions profile of the SAP, compared to using grid electricity or gas to heat water.

- (★) Electrical water heating (supplied form the grid) is responsible for around 25% of greenhouse gas emissions from the average Australian home.[54] As such there is an opportunity to significantly reduce emissions from residential developments by using solar water heating.

Top Developmental Risks

- (−) Since small-scale solar thermal produces only heat energy, it is limited in the energy related emissions reduction it can achieve within the SAP.
- (−) Small-scale solar thermal systems will displace traditional boiler systems and as such need to be included early in development plans in order to avoid the duplication of systems and related resource waste.

Innovation Opportunities

- (★) Solar water heating systems are typically deployed on a residential scale, but their viability for larger sites, such as commercial or industrial developments, could be explored as an innovation.

A.4.4 Process Heat and District Heating

Overview

A number of industries rely on heat for their processes, mainly by the industrial and commercial sectors for industrial processes, manufacturing, and warming spaces. This is often in the form of steam, hot water or hot gases.[55] According to ARENA, Australian industry accounts for 44% of the nation's end use energy and 52% of that is process heat, mostly provided by gas combustion with coal the second biggest source.[56]

---

[53] https://www.energyrating.gov.au/products/solar-water-heaters#:~:text=Solar%20Water%20Heaters%20(SWHs)%20make,of%20your%20hot%20water%20needs
[54] https://www.cleanenergycouncil.org.au/resources/technologies/solar-water-heating
[55] Process Heat – Current state fact sheet (mbie.govt.nz)
[56] ARENA, *Renewable Energy Options for Industrial Process Heat*, available at https://arena.gov.au/knowledge-bank/renewable-energy-options-for-industrial-process-heat/#:~:text=Australian%20industry%20accounts%20for%2044,coal%20the%20second%20biggest%20source

Another approach to supplying process heat (and cooling) is construction of a district heating network. This is a system where heat is produced from a central location using gas, renewable energy or waste heat. Underground pipes then deliver hot water or steam to the heating and hot water systems in buildings in a closed loop. The water is returned to the plant to be heated and returned again and again.

Design Considerations

- (−) The key challenge in considering process heat and district heating is that it is unclear at this stage what process heat reliant businesses will locate to the precinct or even when they might locate. Typically, coordinated heat requirements at a precinct level are achieved through knowing in advance the businesses that need heat. In Europe, district heating is common as any excess heat is used to defrost frozen roads, which makes the business case far easier to justify.
- (−) Heating from grid electricity cannot achieve very high temperatures, so typically gas is used.[57] However the use of gas represents a challenge in achieving a zero-carbon precinct.
- (+) Hydrogen could be used as a gas substitute for CHP plants if it is available. Combined-heat-and-Power engines normally use natural gas to fire the engine that generates heat and power. This of course generates carbon emissions, so the use of hydrogen resolves this problem.

Potential Williamtown SAP Application

Within the SAP, the most significant problem with developing a whole of precinct approach to process heat is having a reasonable expectation of a need for this resource. Given that the precinct will be progressively developed, and the planning of the precinct is also at such an early stage, it is recommended that the suitable way forward is to require each business to manage their own process hear requirements. A district heating development is therefore not recommended.

The simplest approach is to use electricity from the grid to power heat pumps for heat production. The use of combined heat and power is worth considering if hydrogen is available and affordable as a fuel source for CHP engines. Hydrogen fueled CHP engines are already commercially available. However, this should only be considered if the business case is viable against the use of grid electricity. This is because the hydrogen being used will already have been created from processes that have expended energy to create the hydrogen in the first place. Therefore, transforming it through another energy conversion step would only make sense if there is no green electricity available off the grid or sufficient temperatures cannot be achieved through hear pumps.

- (★) Green grid electricity should be used as a first option for process heat requirements, then the use of hydrogen should be considered, but only at a site by site basis.

Top Developmental Risks

- (−) Uncertainty whether the power off the grid will be green. Green grid power depends on establishing a PPA for the whole precinct or requiring each business to procure green power as part of their obligations when setting up their business within the SAP.

Innovation Opportunities

- (★) The use of hydrogen in a CHP engine would be innovative, and also provide an opportunity for businesses to reduce their energy demand through behind-the-meter energy production on top of heat production.

[57] ITP Thermal, Report for ARENA - Renewable energy options for process heat, November 2019, xii., available at https://arena.gov.au/assets/2019/11/renewable-energy-options-for-industrial-process-heat.pdf

A.5 Baseline Assessment Conclusions

- Local strategic plans and policies, in particular state-wide policies for New South Wales, are supportive of the uptake of renewable energy technologies within the state, particularly in the Hunter Region.
- The scope to construct sources of renewable energy within the precinct are limited. Key constraints include resource availability, land and geography constraints and height restrictions.
- The use of rooftop solar should be maximised as much as possible, and locations for grid scale PV should also be explored as a next step.
- There are potential value streams from use of batteries in soaking up excess large or small-scale solar generation from within the SAP to shift peak demand, as well as generating demand response opportunities.
- Enabling DER capability within the SAP will prepare the SAP to take advantage of the demand response market that will come into play in the national electricity market within the next 5 years. The extent of value to be driven from such markets depends largely on the flexibility of the demand profile of customers within the SAP and this will require further investigation at a later stage to determine commercial and technical feasibility.
- An energy system based on a DER platform could be considered, including rooftop PV, large-scale battery systems and perhaps a small dispatchable generation plant. Such a system may have commercial benefits and introduce the opportunity to drive value from emerging markets and NER changes.
- In addition, chemical energy sources such as biomass and waste might be supplied into the precinct and have the potential to contribute to a circular economy. A Waste to Energy or bioenergy facility should be considered further, noting potential considerable constraints in design at the site due to the nature of these facilities.
- Demand could also be supplied from a large-scale renewable generator, or portfolio of generators, located off-site via PPA contracts. This arrangement could be used in conjunction with small-scale solar PV and storage to provide some resilience for key energy users. This should be explored further.
- Considered technologies which are not deemed to have good potential at the Williamtown SAP site are large-scale wind, small-scale wind, geothermal, large-scale solar thermal, and pumped hydro energy storage.
- In all cases, the capacity of the electricity generation assets could be calculated to ensure more generation is supplied than is needed within the SAP. In this situation, the additional renewable energy could be exported to the grid and/or traded in the wholesale electricity market.
- The need for process heat by businesses within the precinct should be managed by each individual business through the use of green grid energy. Where green grid energy is not available or higher temperatures are required, the use of hydrogen as a fuel source through a CHP engine should be considered. Given the piecemeal nature of development of the precinct, construction of district heating infrastructure is difficult to justify and is not recommended.
- The viability of green fuel technologies such as hydrogen and biofuels at the Williamtown SAP site is uncertain with the level of information available at this stage in the process but should be considered in further studies. In particular a hydrogen production facility should be considered in alignment with state and federal policy aims, though it must be noted that hydrogen export opportunities require scales of production orders of magnitude larger than the SAP, and will likely not be driven by SAP considerations.

Appendix B Energy Strategy Testing

B.1 Land Use Scenarios

Section 4 of this report provides a summary of the scenario development during the first Enquiry by Design workshop held on 10 and 11 February 2021 which involved implementing visions and concepts, identifying challenges and developing innovative solutions at a precinct-wide level across all technical streams. A range of scenarios were developed and refined by Roberts Day for the Williamtown SAP Structure Plan boundary. They considered land use, transport, infrastructure, PFAS, environmental, social, aboriginal heritage and economic matters in conjunction with the SAP vision.

Each of the scenarios tested identifies the development limitations, constraints management and required infrastructure that would be required to support the respective structure plan's proposed development. This information was subsequently used at the second Enquiry by Design workshop to inform the preferred structure plan.

B.1.1 Proposed Renewable Energy Strategies

A range of potential guiding visions for renewable energy were developed as laid out in Table B-1. These visions have been used to guide development of a range of possible energy strategies.

Table B-1 Design philosophies for each strategy

Option	Vision for renewable energy
Option 1	▪ Renewable energy used to offset SAP energy demand and engage SAP community in sustainability initiatives. ▪ Well established technologies used to minimise capital cost and development risks. Strong focus on community support and involvement.
Option 2	▪ Renewable energy used to offset SAP energy demand and stimulate circular economy opportunities. ▪ Combination of mature and emerging technology applied to mitigate risk while stimulating economic growth and local jobs.
Option 3	▪ Renewable energy and future fuels opportunities used to offset energy demand and facilitate innovation in the SAP. ▪ Advanced and innovative technologies such as hydrogen and biofuels manufacturing employed to support the aviation precinct and other regional economic activity.

In support of these visions for renewable energy futures in the SAP, the design principles outlined in Figure B-1 were developed. These were used to drive technology selection in each strategy.

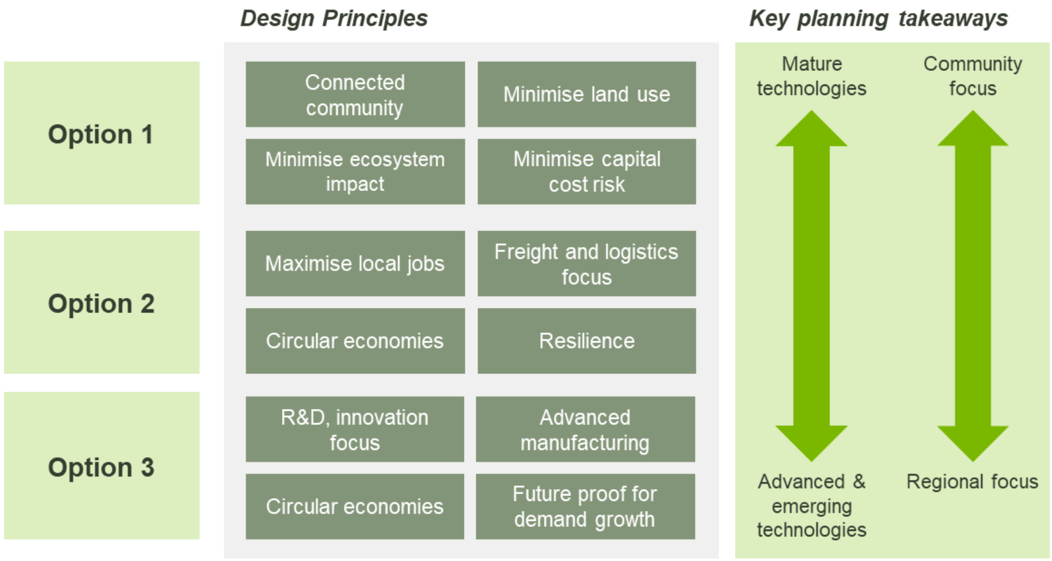


Figure B-1 **Design principles and key planning factors for renewable energy strategy**

B.2 Energy Strategy Formulation

The main driver for the difference in energy strategies is the appetite for innovation and economic growth. We therefore suggest a common baseline technology mix for each strategy supported by supplementary technologies which will stimulate economic growth and industry activity.

This Section lays out our approach to defining a range of potential energy strategies for which could be adopted in Williamtown SAP and was the basis for scenario testing.

B.2.1 Opportunities and Constraints

Location and space

Within the SAP, there are two key locations for possible renewable energy integration:

- **The Energy Corridor:** A designated land area within the SAP which can be considered for large-scale renewables development, as well as any advanced fuels manufacturing or related activities.
- **Rooftop Space:** The majority of new building development proposed for the SAP will include rooftop space which can be utilised for DER such as rooftop solar PV. This is typically connected 'behind the meter' to the building on which it is installed and used to directly offset energy demand.

With the airport approximately centrally located in the SAP, it is important to also consider the height restrictions on structures in the surrounding area. Across the energy corridor, planning and development of structures greater than 7.5 m in height may be restricted. This is unlikely to present an issue for technology such as large-scale solar PV but will need to be considered for technology such as wind turbines or generators with tall chimneys (e.g. direct-fired bioenergy plant).

SAP Demand

Understanding the demand profile for the precinct informs key considerations relating to supply. Key considerations are:

- Peak demand and the periods over which the demand will come online, given the precinct will most likely develop in stages.
- The demand profile, i.e. the shape of the demand and level of flexibility the customer has in altering this profile.
- The level of reliability required by the customer. Higher reliability comes at a cost, and there is usually an economic tipping point at which the cost of increasing reliability exceeds the benefits.

Table B-2 outlines some indicative characteristics of end users in the Williamtown SAP.

Table B-2 Indicative Energy User Requirements within Williamtown SAP

SAP Customer Group	Indicative demand profile	Potential interest in demand response	Indicative Electricity Supply Priorities	Other Energy Requirements
Defence Contractors/ Aerospace	24-hour level demand every day	-	▪ Reliability ▪ Cost	Aviation 'fuel'
Research and Development	24-hour level demand for periods of several days, otherwise day-time demand	-	▪ Cost ▪ Reliability	'Fuel' for heat
Advanced manufacturing	24-hour level demand every day	~	▪ Cost ▪ Reliability	'Fuel' for heat or processing
Defence Commercial Centre	Daytime demand every day	-	▪ Cost ▪ Reliability	
Light industrial	Daytime demand every day	-	▪ Cost ▪ Emissions	
Commercial Centre	Daytime demand every day	-	▪ Cost ▪ Emissions	
Freight and Logistics	24-hour level demand every day	✓	▪ Cost ▪ Reliability	Transport 'fuel'
Multi-modal Hub	Morning and evening peaks, 24-hour residual demand level	✓	▪ Reliability ▪ Emissions	Transport 'fuel'

B.2.1 Conclusions and Approach

Based on the above constraints and opportunities, we have drawn the following key conclusions:

- We do not expect land use to change dramatically between scenarios
- We do not expect demand profiles to change dramatically between scenarios
- The main difference driving planning between scenarios is the appetite for innovation and economic growth, along with some potential considerations for reliability

We are therefore suggesting a baseline **technology mix** for each scenario to provide SAP electricity supply, supported by supplementary technologies which will stimulate economic growth and industrial activity in the SAP in alignment with each scenario vision.

B.2.2 Gas demand alternatives

To develop a fully carbon-neutral precinct, opportunities to replace or offset gas use must be considered. Four options are considered for the Williamtown SAP, as in Table B-3.

At present for the SAP, an expansion of the gas network is planned as described in the Utilities Infrastructure Report. Thus, a gas connection will be available for customers in the SAP. It has been assumed that carbon offsets will be used to account for any gas use in the SAP under all scenarios.

Of total energy demand, it is estimated that 28% is related to gas consumption.

Table B-3 Options for gas demand alternatives

Option	Description	Application
Electrification	Thermal energy via the grid and/or renewable energy source. Producing heat from electricity is technologically mature in the commercial and residential sector. However, for industries with high gas demand, high temperature requirements and/or advanced equipment (i.e. Industrial, healthcare, commercial kitchens), electrification may not be feasible.	▪ Space heating ▪ Domestic hot water ▪ Household cooking
Renewable Gas	Renewable gas such as biomethane is a natural gas substitute. It can be injected into the natural gas network to provide thermal energy. This is a potential long-term solution to decarbonising the precinct as biogas is not currently available to accommodate the needs of the precinct. Jemena is undertaking a trial to inject biomethane into the natural gas network in New South Wales.	▪ Industrial processes ▪ Space heating ▪ Domestic hot water ▪ Commercial and residential cooking
Hydrogen Distribution Network	A parallel hydrogen distribution network can be used to supply energy to industrial customers that require high heating outputs. Hydrogen supply could be imported from facilities around the area.	▪ Industrial processes
Carbon Offsets	The SAP purchases carbon credits to offset the emissions from gas use.	▪ All

For consideration: Hydrogen-gas blend opportunities

Delivering green hydrogen through the SAP gas pipeline network as a hydrogen and natural gas mixture will reduce the emissions associated with heating energy. A review completed by COAG (2019) found that the addition of 10% hydrogen (by volume) to a typical gas blend has no significant impacts of implications on gas quality, safety and risk aspects, materials, network capacity and blending (providing the mixture is homogeneous). The potential of this solution is further described in the Utilities Infrastructure Report.

B.3 Energy Strategies

B.3.1 Overview

This Section presents the potential energy strategies developed for Williamtown SAP. Figure B-2 shows a summary of the energy strategies proposed in alignment with the design principles presented in Section B.1.1.

We are suggesting a **baseline technology mix** for each energy strategy to provide SAP electricity supply. Around this baseline technology mix, additional generation or advanced fuels technologies have been suggested in each strategy to align with the vision for renewable energy and development for the SAP.

- For Option 1, key design principles were a focus on sustainability, community, and low land impact. A community battery and VPP aggregation program have been proposed, as these involve strong community engagement and create value streams for the SAP while involving minimal land development.
- For Option 2, supplementary technologies which stimulate local economic activity and resonate with a 'movement economy' focus have been selected. Hydrogen could be produced for use in a local transport fuel trial, growing this emerging market in the region and responding to state goals for hydrogen. A bioenergy waste to energy plant could make use of local waste outputs to produce electricity, responding to circular economy principles.
- For Option 3, a focus on innovation and economic activity on a regional and wider scale was taken. Hydrogen production was again considered, but with a look to future expansion and regional markets. A biofuels pilot plant for aviation fuels has been proposed to engage with the local aerospace industry.

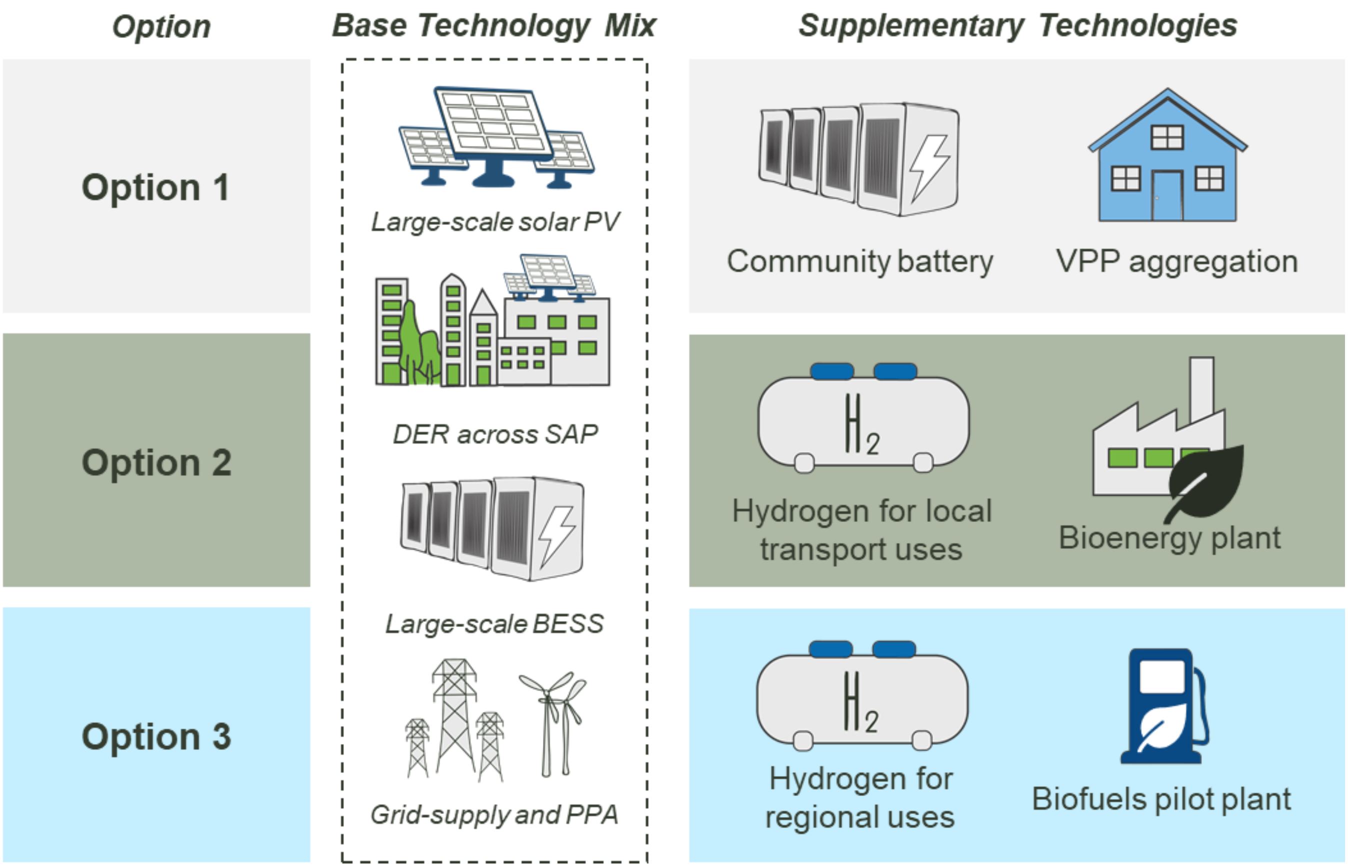


Figure B-2 Overview of Energy Strategies

B.3.2 Base technology mix

The base technology mix for each energy strategy will consist of:

- Large-scale solar PV in a potential energy corridor;
- Rooftop solar (DER) on the majority of applicable new SAP developments;

- A large-scale battery energy storage system (BESS) located a potential energy corridor; and
- Grid supply and PPA contracts.

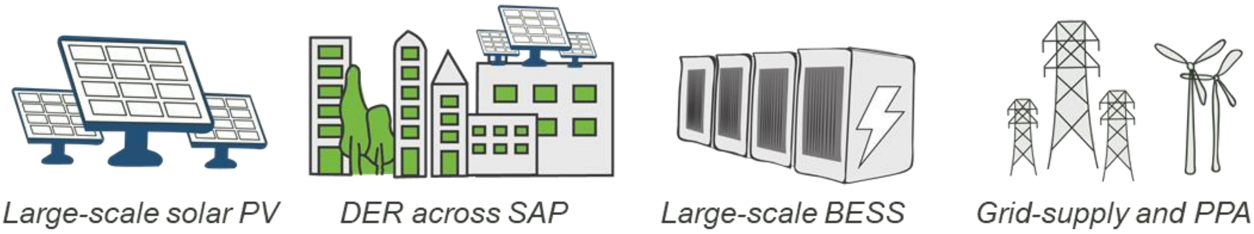


Figure B-3 Baseline technology mix

The sizing for each technology or contract type has should be optimised for the SAP based on power systems studies and economic analysis.

Table B-4 presents a high-level SWOT analysis of the base technology mix, as it applies to all strategies.

Table B-4 SWOT analysis of the base technology mix

Strengths	Weaknesses
▪ **Net Zero Emissions:** The baseline strategy has the potential to achieve net-zero/net-positive outcomes for the SAP via PPAs and or carbon credits. ▪ **Technology Maturity:** Solar and BESS technologies are technologically and commercially mature, presenting few risks for planning or cost estimation for the project. ▪ **Grid connection:** Connection to the grid facilitates potential revenue streams via VPP and solar export and also provides a high level of reliability compared to an off-grid solution.	▪ **Technical complexity:** Difficulties associated with orchestrating battery, solar and demand behind the meter to achieve net-zero while maintaining commercial viability ▪ **Capital intensive:** Ownership of energy assets and the operating costs/risks that go with energy asset ownership.
Opportunities	**Threats**
▪ **Capex deferral opportunities:** The modular nature of solar and BESS assets will allow for staging of development in line with SAP progression. ▪ **Potential value stream through wholesale market participation via a VPP:** Small-scale renewables can be integrated and controlled through a VPP network. This will allow the DER owners to indirectly participate in the wholesale electricity market. ▪ **Potential value streams from BESS:** The BESS has the potential to generate revenue through customer demand management, demand management for DNSP, arbitrage from the spot market, FCAS and network support.	▪ **Grid connection risk:** Large-scale solar may face risks in the grid connection process depending on the strength of the local grid - This risk should be mitigated by beginning engagement with TransGrid and AEMO early in the planning process - If required, technology such as a synchronous condenser could be installed at the SAP.

B.3.3 Option 1

Along with the base technology mix, a community battery and VPP aggregation model have been proposed.

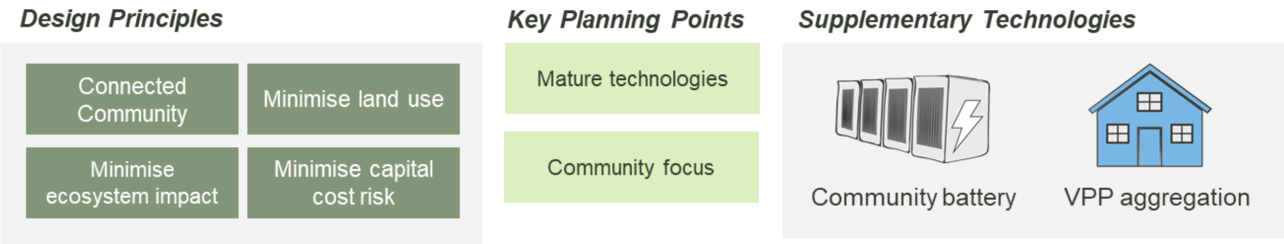


Figure B-4 Scenario 1 Design Principles and Technology Summary

Along with the base technology mix, a community battery and VPP aggregation model have been proposed.

Community Battery

A 'community battery' is a medium to large-scale (100 kW-1 MW) battery owned and maintained by an external provider, in which businesses and residents can own a share by contributing equity. This supports the design principle Connected Community. This approach allows the SAP to take advantage of community battery storage, without having to pay any up-front costs as the battery is owned and maintained by an external provider. There a number of community storage trials being undertaken in Australia.

Large-scale batteries can generate multiple potential revenue streams through participation in wholesale markets, including arbitrage, FCAS services, and peak demand management services for DNSPs. Additional potential benefits include reduced energy costs for customers, improved solar energy self-consumption, peak shaving, and increased network hosting capacity for non-dispatchable energy generation such as rooftop solar.

There are a number of commercial and regulatory barriers limiting the uptake of this ownership model. First, battery storage is expensive and capital intensive. A battery's operating profile must be designed to ensure that the optimal mix of revenue streams is being targeted. It is not economically efficient to consider large-scale battery application simply as a means of energy shifting and decarbonisation purposes. In addition, complex commercial arrangements may be required to implement and operate a community battery. For this reason, in the current market community battery trials are typically led by government agencies, or with grant funding.[58]

Considerations for next stage analysis:

- **Detailed load assessment** should be conducted to gain a better understanding of the energy end uses and demand profile within the SAP. By understanding the loads, the SAP should be able to determine the demand profile and estimate the flexible loads within the SAP. The outputs of this exercise, along with a solar analysis, should help size the community batteries.
- **Commercial Arrangement:** There are a number of commercial pathways available for the implementation and operation of a community-scale energy system. The SAP should consider different ownership models to determine a suitable arrangement that is beneficial for the community.
- **Operating model:** The operating model for the battery must be designed to optimise potential revenue streams, taking into account investor risk appetite and market trends.

Virtual Power Plant

By interconnecting and aggregating behind-the-meter resources, including the community-scale battery, into the grid, participating solar customers can "virtually" store excess energy generated from their solar panels and then utilise that stored energy during the afternoon and evening peak when their systems are no longer generating electricity. This is managed via a virtual power plant (VPP) platform. VPPs can provide an opportunity to increase energy equity, providing an opportunity for a wider range of individuals to access the benefits of renewable resources.

The VPP can open up several revenue streams for the SAP and the BESS operator, potentially making the battery system more economically feasible. Although one of the strengths of storage and VPP is the range of potential

[58] For example, the Queensland Government will fund five large-scale community batteries with a combined capacity of 40MWh: https://statements.qld.gov.au/statements/91787

sources of revenue open to it, this is also one of its weaknesses as those revenue streams are not easily aligned and the commercial and operational models are complex.

Considerations for the next stage analysis:

- **Economic assessment:** Although one of the strengths of storage and VPP is the range of potential sources of revenue open to it, this is also one of its weaknesses as those revenue streams are not easily aligned. An economic feasibility study should be completed to determine the viability of the community battery and VPP. The study should take into account costs, different commercial models, and revenue streams.
- **Regulatory Framework:** The regulatory framework to enable community battery participation is being developed. There are a number of issues such as how customers can participate regardless of their retailer.

Table B-5 presents a SWOT (Strengths, Weaknesses, Opportunities, Threats) assessment of Option 1

Table B-5 SWOT assessment of Option 1

<table>
<tr><th>Strengths</th><th>Weaknesses</th></tr>
<tr><td>Mature Technology: Community-scale BESS are technologically mature and used successfully internationally
Scale-efficient cost: Larger batteries tend to be more cost-efficient than household systems on a per MW basis
Wholesale market participation: Community ownership model allows residents/businesses to participate in the wholesale market, generating revenue streams
DER hosting capacity: Increase ability to integrate more solar PV energy generation into the distribution network</td><td>Complex commercial arrangements may be required to implement and operate the VPP. Using an aggregator service can help to access some of the ancillary services and reserve services available.
Capital intensive: Battery storage is still expensive compared to other power generation/grid balancing services
Difficulty aligning revenue streams: Although one of the strengths of storage and VPP is the range of potential sources of revenue open to it, this is also one of its weaknesses as those revenue streams are not easily aligned.
Community equity stake: Relies on willing to invest from local residents or businesses.</td></tr>
<tr><th>Opportunities</th><th>Threats</th></tr>
<tr><td>Energy equity: Community batteries and VPPs may provide an opportunity to increase energy equity, providing an opportunity for a wider range of individuals and businesses to access and invest in renewable resources.
Electric vehicle uptake: As electric vehicles uptake increases, they will introduce an additional controllable load source to the SAP, and can potentially be included in VPP aggregation. They will increase local electricity demand but introduce new opportunities for load shifting.</td><td>Evolving regulation: The regulatory framework to enable VPP participation is being developed. There are some issues such as how customers can participate regardless of their retailer.</td></tr>
</table>

B.3.4 Option 2

Along with the base technology mix, hydrogen manufacturing and waste to energy plants have been proposed for further investigation.

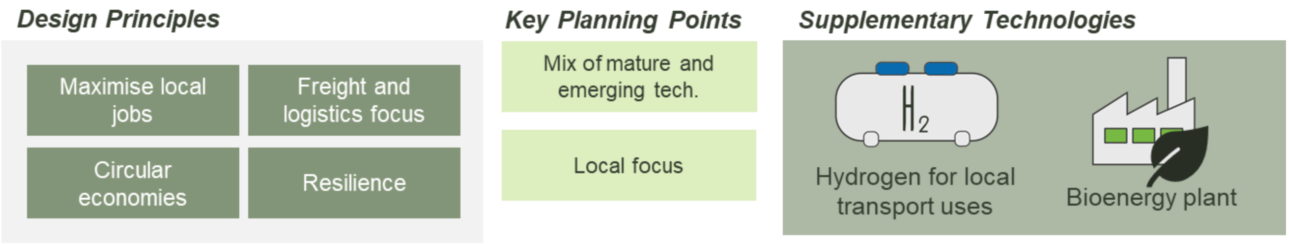


Figure B-5 Option 2 Design Principles and Technology Summary

Along with the base technology mix, hydrogen manufacturing and waste to energy plants have been proposed for further investigation.

Hydrogen production

Hydrogen could be manufactured in a pilot-scale plant in the energy corridor using electrolysis, to be used as a fuel source in local or regional transport applications, or as an alternative for natural gas. The development of hydrogen technology in the SAP would align with NSW Government objectives to build a hydrogen hub in the Hunter Region (as announced in March 2021), with the potential for additional grant funding from this objective to support development of the technology in the SAP. Hydrogen for transport fuels would stimulate the local economy and create opportunities for skilled labour, as well as supporting NSW Government goals to be the largest national consumer of hydrogen.

This technology is relatively well demonstrated in pilot plants worldwide, and the SAP could be well suited to 'back-to-base' refuelling infrastructure, with a hydrogen refuelling infrastructure co-located at the electrolyser site, for a captive market of vehicles, such as buses, council vehicles, airport ground support vehicles, or a hydrogen car-share program within the local or regional area.

Economics of hydrogen at this scale are very poor, as a result of the high cost and low utilisation of the electrolyser and refuelling station. The design of the refuelling station would need to be carefully matched to the vehicle fuelling patterns (incorporating potential future growth), and electricity consumption profiles carefully considered and matched to the most economic electricity source.

A potentially comparable pilot-plant is the Engie-Yara hydrogen and ammonia project in the Pilbara region in Western Australia, which expects to produce hydrogen and ammonia using renewable-powered electrolysis. This plant aims to produce approximately 2 tonnes of hydrogen per day using a 10 MW electrolyser, on 15.4 hectares of land. The water requirement for this facility in the SAP would be approximately 15.4kL/day.

Considerations for next stage analysis:

- **Demand assessment** should be carried out as part of a business case for hydrogen in the region, to test the local appetite for hydrogen fuels. Market sounding should determine local businesses interest in trialling hydrogen fuels in their vehicles.
- **Testing supply chain options:** Currently a centralised 'back to base' refuelling operation based in the energy corridor has been suggested, which would require vehicles to return to the energy corridor for fuel. Alternative supply chain models such as pipelines or tanker storage distributed throughout the SAP or wider Hunter Region should be considered and hydrogen infrastructure carefully matched to the demand profile.
- **Water supply:** Hydrogen production via electrolysis can require a relatively significant volume of water. A water supply for production in the SAP will need to be established, including consideration of the use of treated water waste streams.

Waste to energy

A waste-to-energy plant could be implemented to make use of municipal solid waste (MSW) produced by the SAP, as well as waste streams from the greater Hunter Region. This technology makes use of circular economy principles and is moderately 'dispatchable' as fuel intake and burn rates can be controlled.

Typical installations worldwide suggest that as a rough rule-of-thumb a typical 100,000 t/yr plant will export around 7 MW[59].

Considerations for next stage analysis:

- **Feedstocks from the wider Hunter region:** The availability of MSW from the SAP and other potential valuable waste streams within the wider Hunter region (e.g. viticulture wastes) must be considered, taking advantage of circular economy principles. Transport and logistics implications of using these waste streams must be considered in any cost or feasibility analysis considered.
- **Synergies with SAP manufacturing:** Waste to energy produces steam as a by-product, and the commercial viability of this technology is greatly improved when it can be coupled with an industrial process requiring steam.
- **Anaerobic digestion:** Community perceptions to waste to energy can be negative, due to perceived risks from combustion emissions. Anaerobic digestion, which uses organic wastes to produce methane for use in electricity production or industrial processes, could be considered as an alternative to waste to energy. This would be particularly suitable if a high-quality organic waste stream from Hunter regional agricultural processes could be secured.

Table B-6 presents a SWOT assessment of Option 2.

Table B-6 SWOT assessment of Option 2

Strengths	Weaknesses
▪ **Strategic alignment:** Hydrogen production aligns with several national and state-level strategies, including Australia's National Hydrogen Strategy and the NSW Electricity Infrastructure Roadmap. ▪ **Circular economies:** Waste to energy will take advantage of locally produced waste streams, aligning with circular economy principles.	▪ **Uncertain market:** Hydrogen markets are still emerging in Australia, and demand for hydrogen in the short-term may be limited. ▪ **Availability of hydrogen vehicles:** A transport fuel trial requires specific hydrogen vehicles, of which supply is limited in Australia. ▪ **Community perceptions** to waste to energy can be negative, due to perceived risks from combustion emissions. Engagement and mitigation will likely be required early in the planning process.
Opportunities	**Threats**
▪ **Steam by-product:** Steam produced through waste to energy generation could potentially be used for heating or industrial processes in the SAP, or even potentially as part of the hydrogen manufacturing process. ▪ **Using excess solar:** Excess daytime solar generation at the SAP could be used to power hydrogen production behind the meter, reducing operating costs (will need to be confirmed through load flow analysis). ▪ **Scale-up production:** Land space could be made available in the energy corridor for hydrogen production to be scaled up in the SAP in the medium to long-term if regional demand can be established.	▪ **Water supply** must be secured for hydrogen production via electrolysis. - Begin discussions on water supply early with Hunter Water to assess potential sources and volumes. - There is the potential to use water treated for PFAS contamination in this process. However, the viability of this as well as the local water supply levels must be assessed. ▪ Safety and exclusion zone considerations for production of hydrogen.

[59] Energy Technology, O.P. Gupta, page 770

B.3.5 Option 3

Along with the base technology mix, hydrogen and biofuels manufacturing have been proposed for further investigation.

Figure B-6 Option 3 Design Principles and Technology Summary

Along with the base technology mix, hydrogen and biofuels manufacturing have been proposed for further investigation.

Hydrogen production

As outlined in Option 2, hydrogen could be manufactured in the energy corridor using electrolysis, to be used as a fuel source in transport applications or for use in local gas networks. It is suggested that in Option 3 production be scaled up to that of a full-scale plant rather than a pilot operation, and demand sources outside the sub-precinct area of the SAP be targeted. A full-scale plant could produce approximately 17t/day of hydrogen and require approximately 154 kL/day of water.

A more regional focus for demand assessment is suggested for Option 3, along with consideration of a future potential use case for ammonia. Ammonia is gaining interest on the world stage as a potential alternative to renewable hydrogen as a transport fuel, particularly in shipping applications, as it is cheaper and easier to store than hydrogen. It must be noted that ammonia production is typically only commercially feasible on a large scale, and would have additional safety and environmental considerations which must be considered.

Considerations for next stage analysis:

- Same as for Option 2, but with larger and more regional market sounding.
- Additionally, test local and regional industry demand for ammonia, either as a transport fuel or potential feedstock.

Biofuels (or synthetic fuels) pilot plant

To support innovation in the aerospace precinct, a pilot-scale biofuels plant could be developed in the energy corridor. Blend or pure aviation fuels must be compatible with commercial Jet A-1 fuels and compliant to ASTM D1655 and DefStan 91-91 international fuel standards. There are many potential methods for jet fuel production, with feedstocks for synthetic fuels being developed worldwide from a vast range of source materials such as biomass to liquid fuels, gas to liquid fuels, coal to liquid fuels and fuels from algae.

There have been several trials of biofuels and synthetic fuels in Australia, including at Brisbane and Wellcamp Airports in Queensland. Establishing a pilot plant and research and development in the SAP, potentially in coordination with the Defence/Aerospace contractors, would stimulate economic activity in the region and allow for trials in NSW.

A pilot plant targeting 1 ML/yr production could be established in the energy corridor, with potential applications of municipal solid waste or local biomass waste for feedstock.

Considerations for next stage analysis:

- **Assessment of regional supply chain:** There may be more valuable feedstock options outside the SAP in the surrounding Hunter region (e.g. sugarcane or other agricultural products). While this may carry additional costs including consideration of transport requirements, feedstock purity and sugar content is often key to bio or synthetic fuel success.
- **Demand assessment** for biofuels and appetite for trial and innovation at Williamtown Airport and by RAAF. Assess the potential desired volumes of fuels, any specific regulations beyond ASTM fuel compliance standards, distribution and supply needs, etc.

Table B-7 presents a SWOT assessment of Option 3.

Table B-7 SWOT assessment of Option 3

Strengths	Weaknesses
▪ Strategic alignment for hydrogen ▪ **Strong R&D opportunity:** The SAP presents a uniquely strong opportunity for R&D in the aviation sector, and may be able to secure trial opportunities at Williamtown airport.	▪ Uncertain hydrogen market ▪ Availability of hydrogen vehicles ▪ **Feedstock supply chain:** the availability of suitable feedstock in the Hunter region and the nature of existing supply chains requires investigation.
Opportunities	**Threats**
▪ Utilising excess solar ▪ Scale-up hydrogen production	▪ Water supply for hydrogen ▪ Commercial feasibility of large-scale hydrogen production ▪ Safety and exclusion zone considerations for production of hydrogen or ammonia. ▪ **Commercial feasibility:** Biofuels have been historically uncompetitive with standard fossil-fuel based jet fuels due to cost. ▪ Potential site emissions could have land use or aeronautical impacts which must be accounted for.

For consideration: Future Fuels

There is growing interest in bio and synthetic base fuels manufacturing to serve a range of use cases, including transport fuels, chemical feedstocks, and even for injection into gas supply networks. If the customer and local/regional industry demand for innovation in this space proved to be high, Williamtown SAP could consider the development of a 'future fuels' hub, focusing on novel and emerging fuel production methods.

B.4 Summary of Strategy Testing

Table B-8 presents a comparison of each of the energy strategies developed.

Table B-8 Comparison of Energy Strategy Options

Category	Factor	Option 1	Option 2	Option 3
Key values	Alignment to SAP vision	Promotes sustainability through renewable uptake with low land impact. Focus on community involvement.	Promotes local industry and movement economy through transport fuel trial, and circular economy making use of waste.	Promotes regional growth and innovation through advanced technologies. Synergies with local aviation capability.
	Alignment to strategic plans and policies	In line with overall	Supports NSW Electricity Infrastructure Roadmap	Supports NSW Electricity Infrastructure Roadmap
	Environmental / sustainability outcomes	Very minimal land impact. Main land use for large-scale solar PV.	Active use of waste streams. Potential concerns regarding emissions. Relatively significant water use.	Active use of waste or biomass streams for biofuels. Very significant water use.
	Community outcomes	Strong community involvement	Hydrogen transport trial will engage local industry. Potential negative opinion on waste to energy.	Hydrogen transport trial will engage local industry. Possible negative visual or emission impacts from biofuel plant.
Implementation strategy	Capex Risk[1] ($, $$, $$$) *Less $ is better*	$ - Mature technologies, relatively capital intensive.	$$$ - Risks associated with the cost of hydrogen and biofuels plant due to limited market size. Capital intensive.	$$$ - Risks associated with the cost of hydrogen and biofuels plant due to limited market size. Capital intensive.
	Asset Opex[2] ($, $$, $$$) *Less $ is better*	$ - Low O&M costs associated with BESS and solar.	$$ - Hydrogen and bioenergy relatively significant O&M, with potential for cogeneration.	$$$ - Hydrogen and biofuels will have significant O&M.
	Stimulus potential ($, $$, $$$) *More $ is better*	$ - Will support SAP and community, but limited external stimulus potential	$$ - Hydrogen industry stimulus.	$$ - Hydrogen industry stimulus. Will promote biofuels sector, but larger external limits to industry growth.
	Overall commercial readiness	Minor barriers to commercialisation, which can be resolved	Market for hydrogen will need sizing. Bioenergy emerging technology in Australia.	Market for hydrogen will need sizing Biofuels not commercially competitive.
	Overall technology readiness	Technical performance demonstrated through trials	Hydrogen capability demonstrated in pilot plants. International applications of bioenergy	Hydrogen capability demonstrated in pilot plants. Biofuels capability demonstrated in pilot plants
	Staging and scalability	All technology proposed is scalable and modular	Hydrogen capability can be tested through pilot plant	Hydrogen and biofuels capability can be tested through pilot plant

Legend: *Lower risk* — *Higher risk*

Table B-12 notes:

1. *Capital cost of each option is not an appropriate comparison metric at this time, due to substantial uncertainty around infrastructure type and sizing associated with each energy strategy.*
2. *A comparison of (on-site) Asset Opex is presented based on typical operating patterns and O&M costs associated with the infrastructure option selected. Actual Opex costs have not been estimated at this time. Note that reducing on-site infrastructure sizing (e.g. reducing large-scale solar capacity) would require additional electricity supply from grid/PPA sources, increasing this associated cost. Opex costs must be considered as part of the next phase of work.*

B.4.1 Potential Infrastructure Summary

Note on infrastructure sizing

This report has identified potential renewable energy infrastructure which could be used to fulfil the energy strategies defined. As part of the next phase of work, the generation mix, including electricity from grid supply and required PPA contracts, must be optimised to meet the electricity requirements of the SAP as well as DPE's sustainability, commercial, and economic goals for the SAP and greater Hunter Region.

Interaction with Utilities Infrastructure Report

As part of the next phase of work, potential renewable energy infrastructure selection and sizing must be considered alongside the constraints and opportunities raised in other Reports for the Williamtown SAP.

In particular, the infrastructure currently suggested in the Utilities Infrastructure Report represents the required assets to supply all SAP electricity demand with grid power. On-site renewable energy generation has the potential to offset the need for some electrical infrastructure upgrades; however, the scale of potential changes to the suggested utilities infrastructure scenarios will need to be determined following thorough assessment and sizing of potential renewable energy options as part of the next phase of work.

Table B-9 Potential Infrastructure Summary

Technology	Option 1	Option 2	Option 3
Large Scale Solar	Large-scale solar farm with up located in the Energy Corridor.	Large-scale solar farm with up located in the Energy Corridor.	Large-scale solar farm with up located in the Energy Corridor.
DER – Low rise buildings	Small-scale solar PV systems across the SAP	Small-scale solar PV systems across the SAP	Small-scale solar PV systems across the SAP
BESS	Grid-scale BESS located in the Energy Corridor	Grid-scale BESS located in the Energy Corridor	Grid-scale BESS located in the Energy Corridor
Waste		A waste-to-energy plant in the Energy Corridor.	
VPP	Communication infrastructure to aggregate and coordinate DER		
Community Battery	Community BESS located in either the Energy Corridor or near new electricity utility infrastructure.		
Hydrogen Production		Pilot hydrogen production plant with co-located refuelling infrastructure located in the Energy Corridor.	Full-scale hydrogen production plant with co-located refuelling infrastructure located in the Energy Corridor.
Biofuels pilot plant			A pilot plant for aviation biofuels located in the Energy Corridor.

B.5 Further considerations

This Section outlines recommendations on infrastructure development staging in line with SAP progressive development, and recommendations for the next stage of work.

Key recommendations common to each option:

- The SAP should encourage solar PV uptake by providing incentives to new and existing developments. Alternatively, solar PV could be mandated in the SAP SEPP and the delivery plan.
- The SAP should gain a better understanding of the loads and demand profiles to size the battery and optimise its operation. Having location-specific real data can improve the value proposition and attract investors.
- A PPA and/or Carbon Credits are required to achieve carbon-neutral targets.

Alongside asset development, a staging plan to achieve the SAP's carbon-neutral precinct goal should be considered as part of the development plan. The SAP will be particularly reliant on grid supply and carbon offsets in the short to medium term before large-scale generation can be installed on-site and PPA contracts established. In the medium to long-term, carbon neutrality will be possible through a balanced mix of large-scale and small-scale distributed generation and PPA contracts with renewable generators, with the potential for use of offsets for any small remaining portion of emissions which cannot otherwise be practically mitigated.

Further work required to assess the strategies proposed in this report should include:

- Detailed forecasting of likely customer load profiles, including obtaining estimated load profiles from prospective SAP customers where available, and trends in consumption and supply over a year.
- Modelling to consider an optimal mix of large-scale solar and BESS for the energy corridor, and commercial operating model and value streams to be generated by the BESS.
- Infrastructure ownership and planning requirements to be determined to ensure the SAP can achieve its operational carbon neutral targets.

For a community battery or VPP:

- Consider appropriate ownership and commercial models to maximise revenue streams from either technology and incentivise community involvement and DER uptake. Market sounding on VPP aggregation technology and providers.
- Assess relevant regulatory frameworks including potential registration, market integration and grid connection requirements for small-scale systems (<5 MW) operating in the wholesale market.
- Thorough assessment of commercial feasibility.

For hydrogen production:

- Demand assessment for hydrogen, considering local and regional markets, and the potential for future expansion into regional or international exports through ammonia.
- Consideration of optimal supply chain and refuelling infrastructure to suit the needs of the SAP. Where do vehicles refuel, how is fuel transported from the production site, is there demand for a dedicated pipeline? How much water will be required?
- Thorough assessment of commercial feasibility.

For biofuels and bioenergy:

- Supply chain assessment for waste products, biomass, and synthetic feedstocks in the region for application in biofuels, bioenergy, or future fuels manufacturing. This should consider the type, quality, and availability of feedstocks. Consideration should also be given to supply chain infrastructure and requirements for bioenergy or biofuels plants.
- High-level environmental impact assessment for both technology types to consider any potential negative impacts, including on surrounding community from emissions.
- Thorough assessment of commercial feasibility.

Appendix C Demand and Generation Estimation Methodology and Assumptions

To develop an approximate idea of the demand profile for each option, average high-level demand profiles were estimated for each land use based on typical patterns of operation seen from industry experience. Further work should involve a detailed demand assessment, including obtaining forecast load profiles from prospective SAP customers where available.

- In the absence of detailed load flow data, BESS generation and charging profiles have not been developed at this stage.
- Additionally, grid supply and PPA contracts will make up some portion of energy demand in the SAP which cannot be supplied by on-site or aggregated generation sources. In the absence of an annual hourly load and generation assessment, the amount of generation sourced from grid or PPA has been estimated at a very high-level average at this stage.
- The total area available for large-scale solar is dependent on the physical footprint of BESS and supplementary technologies, which were estimated based on similar projects. However, it must be noted that the size of biofuel plants is highly dependent on the type of feedstock and hydrogen plant is still an emerging technology and scaled-up numbers must be confirmed at later stages.
- The assumptions for large and small-scale solar PV are detailed below.

Table C.1 Large-scale Solar PV assumptions

	Unit	Assumption	Comment
Capacity factor	%	20	The capacity factor of a large-scale solar PV array in Australia is typically 20-25%
Power density of solar array	MW/ha	1	Typical value for solar farms with capacity above 10 MW that are usually equipped with trackers that go east-west to track the sun throughout the day. Assumes that the land is suitable for solar, i.e. relatively flat, clearable vegetation, etc.
Area	ha	Energy corridor land area - area for other technologies	Size for other technologies in the energy corridor: BESS, 0.5 ha; hydrogen, biofuels and waste to energy as per tables below

Table C.2 Small-scale Solar PV assumptions

	Unit	Assumption	Comment
Capacity factor	%	10	The capacity factor of a small-scale solar PV array in Australia is typically 10-15% due to the orientation and context of the panels
Power density of solar array	MW/ha	0.4	The density varies considerably on the location, orientation, and physical attributes of the surface it is installed upon as these are not typically optimised for solar irradiation
Proportion of roof used for panels	%	55	The usual range is between 25-75% and it depends on many variables such as shading, orientation, roof height, roof type etc.

For supplementary technologies proposed for further consideration in each option, the following key assumptions were made:

Table C.3 Hydrogen assumptions

	Unit	Assumption	Comment
Daily hydrogen production – Phase 1	t (H2)/day	1.71	Based on ENGIE-Yara's renewable hydrogen and ammonia project with a 10 MW electrolyser
Daily hydrogen production – Phase 2	t (H2)/day	17.1	Scaled-up production of trial by 10 times
Electricity required to produce hydrogen through electrolysis of water	kWh/kg (H2)	53.44	Based on ENGIE-Yara's renewable hydrogen and ammonia project with a 10 MW electrolyser
Plant size – Phase 1	ha	15.6	Based on ENGIE-Yara's renewable hydrogen and ammonia project with a 10 MW electrolyser
Plant size – Phase 2	ha	25	Estimated for a 100 MW electrolyser
Water requirement	L/kg (H2)	9	Source: National Hydrogen Roadmap, CSIRO

Table C.4 Waste to energy assumptions

	Unit	Assumption	Comment
Capacity factor	%	65	Source: US EIA monthly capacity factors for renewables, 2011-2013
Plant size	ha	1.2	Based on Waste Technologies: Waste To Energy Facilities, A Report for the Strategic Waste Infrastructure Planning Working Group – Figure 7
Waste-to-energy plant export capacity	MW/tpa	0.00007	As a rough rule-of-thumb a typical 100,000 tpa WtE plant will export around 7 MW. Source: Energy Technology, O.P. Gupta, page 770

Table C.5 Biofuels assumptions

	Unit	Assumption	Comment
Annual Production	Ml/yr	1	
Plant size	ha	10.4	Assumed the same size as WtE facility of the same waste capacity
Waste to biofuel yield	t/Ml	4403	Based on Sierra BioFuels Plant in Nevada, which plans to convert 175,000 tons of household garbage into 10.5 million gallons of fuel per year

Document prepared by

Aurecon Australasia Pty Ltd
ABN 54 005 139 873
23 Warabrook Boulevard
Warabrook NSW 2304
Australia

T +61 2 4941 5415
E newcastle@aurecongroup.com
W aurecongroup.com