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DEPARTMENT OF PLANNING,
INDUSTRY AND ENVIRONMENT

RENEWABLE ENERGY OPPORTUNITY AND CONSTRAINTS ANALYSIS - FINAL DRAFT MASTER PLAN

JULY 2020

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Renewable Energy Opportunity and Constraints Analysis - Final Draft Master Plan

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ABBREVIATIONS

AC	Alternating current
ADWF	Average Dry Weather Flow
AEMO	Australian Energy Market Operator
AUD	Australian Dollars
BESS	Battery Energy Storage System
ºC	Degrees Celsius
CAPEX	Capital expenditure
DC	Direct Current
DHI	Diffuse Horizontal Irradiance
DPC	NSW Department of Premier and Cabinet
DPIE	NSW Department of Planning, Industry and Environment
EbD	Enquiry by Design
ESD	Ecologically Sustainable Development
GE	General Electric (Company)
GHI	Global Horizontal Irradiance
Ha/HA	Hectare
HHV	Higher Heating Value
HV	High voltage
IEC	International Electrotechnical Commission
IPP	Independent Power Producer
KG/kg	Kilogram
km	Kilometer
kV	Kilovolt
kVA	Kilovolt-ampere
kW/KW_E/KWe	Kilowatt
kWh	Kilowatt Hour
LCOE	Levelised Cost Of Electricity
LEP	Wagga Wagga Local Environmental Plan
LGA	Local Government Area
LGC	Large-Scale Generation Certificates
LV	Low voltage
m	Metre

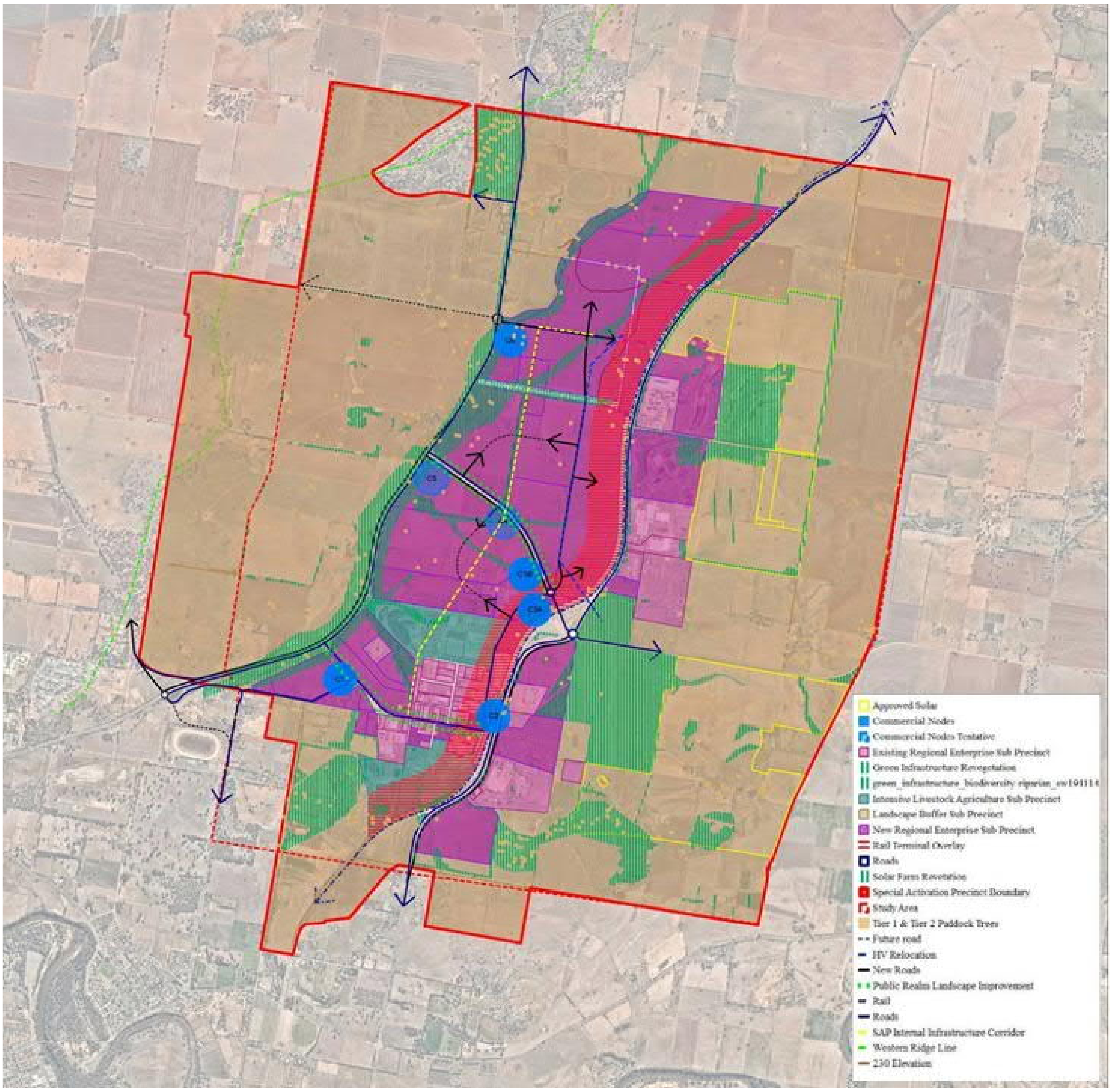
ML	Million Litres
MV	Medium voltage
MVA	Mega Volt Ampere
MW	Megawatt
MWh/MWH	Megawatt-hour
MWp	Megawatt-Peak
NA	Not Applicable
NSW	New South Wales
PPA	Power Purchase Agreement
PV	Photovoltaic
ROBE	Riverina Oil and Bio Energy Pty Ltd (Company)
RiFL	Riverina Intermodal Freight & Logistics
SAP	Special Activation Precinct
TPB	Theoretical Potential of Biogas
TS	Total Solid
UK	United Kingdom
V	Volt
VPP	Virtual Power Plant
W	Watt
WLEEH	Wagga Low Emission Energy Hub
Wp	Watt peak
WWTP	Waste Water Treatment Plant
Yr/YR	Year
ZS	Zone Substation

1 PROJECT BACKGROUND

1.1 STRUCTURE PLAN

The Full Enquiry by Design (EbD) workshop was organised in Wagga Wagga to present the testing results for the three scenarios developed during the Short Enquiry by Design Workshop and develop the project to the next and final level of: final structure plan. WSP, in conjunction with other consultants and stakeholders in the Full Enquiry by Design Workshop, developed and refined various precinct scenario options. These developed refined scenarios were then tested against the objective and constraints of the Wagga Wagga SAP and developed into a Structure Plan. The Wagga Wagga SAP refined Structure Plan is represented in Figure 1.1 below:

Figure 1.1 Wagga Wagga SAP Refined Structure Plan



Three indicative stages of development were developed:

— Stage-1: with growth percentage utilisation of 35% by 2030, 87% by 2040 and 95% by 2060

— Stage-2: with growth percentage utilisation of 80% by 2060

— Stage-3: to begin after 2060

WSP notes that the development timeframe for Stage-2 and Stage-3 are significantly far in the future, greater than 40 years in terms of power generation technology advancement. It is envisaged that by 2060, the technological landscape for power generation will be significantly different from relatively minor advancements, e.g. more efficient solar PV panels, to potentially large advancements e.g. presence of an established hydrogen economy in Australia. For the purposes of this report, WSP has based information on the current technology available however notes that the assumptions made in this report should be revised at suitable periodic times as recommended options and solutions may have changed at that time.

The land area assigned at each indicative Stage for the Regional Enterprise Sub-precinct along with Overlay areas is represented in Table 1.1 below:

Table 1.1 Land Area allocation

SUB-PRECINCT	STAGE-1 (HA)	STAGE-2 (HA)	STAGE-3 (HA)
Regional Enterprise (New + Existing)	483	595	800
Intensive Livestock Agriculture	106	106	106
Rail Terminal	149	149	179
Green Infrastructure	64	97	153

During the presentation of scenario testing results in the Full Enquiry by Design Workshop in Wagga Wagga, WSP was advised by DPIE that the aim for renewable energy generation is to meet 100% of the SAP annual electricity demand and options to achieve this should be investigated in this the final master plan development stage and incorporated into the Structure Plan.

WSP provided a high-level mix of technology options based on the iterative analysis of the resources and constraints available in the Wagga Wagga SAP. The shortlisted technology options to achieve 100% electrical energy demand through the SAP based on renewable energy are:

— Rooftop solar PV installation;

— Biogas based electricity generation from the Wagga Wagga Sale Yard (officially the Wagga Wagga Livestock Marketing Centre) and potential future Waste Water Treatment Plant (WWTP);

— Proposed 8MW Biomass project developed within the SAP for an existing business in the SAP;

— Teys Australia 8MW hybrid biogas Wagga Low Emission Energy Hub Project [1] [2];

— Adoption of existing under construction solar PV farms' capacities;

— Development of new solar PV project(s) in Landscape Buffer Sub Precinct;

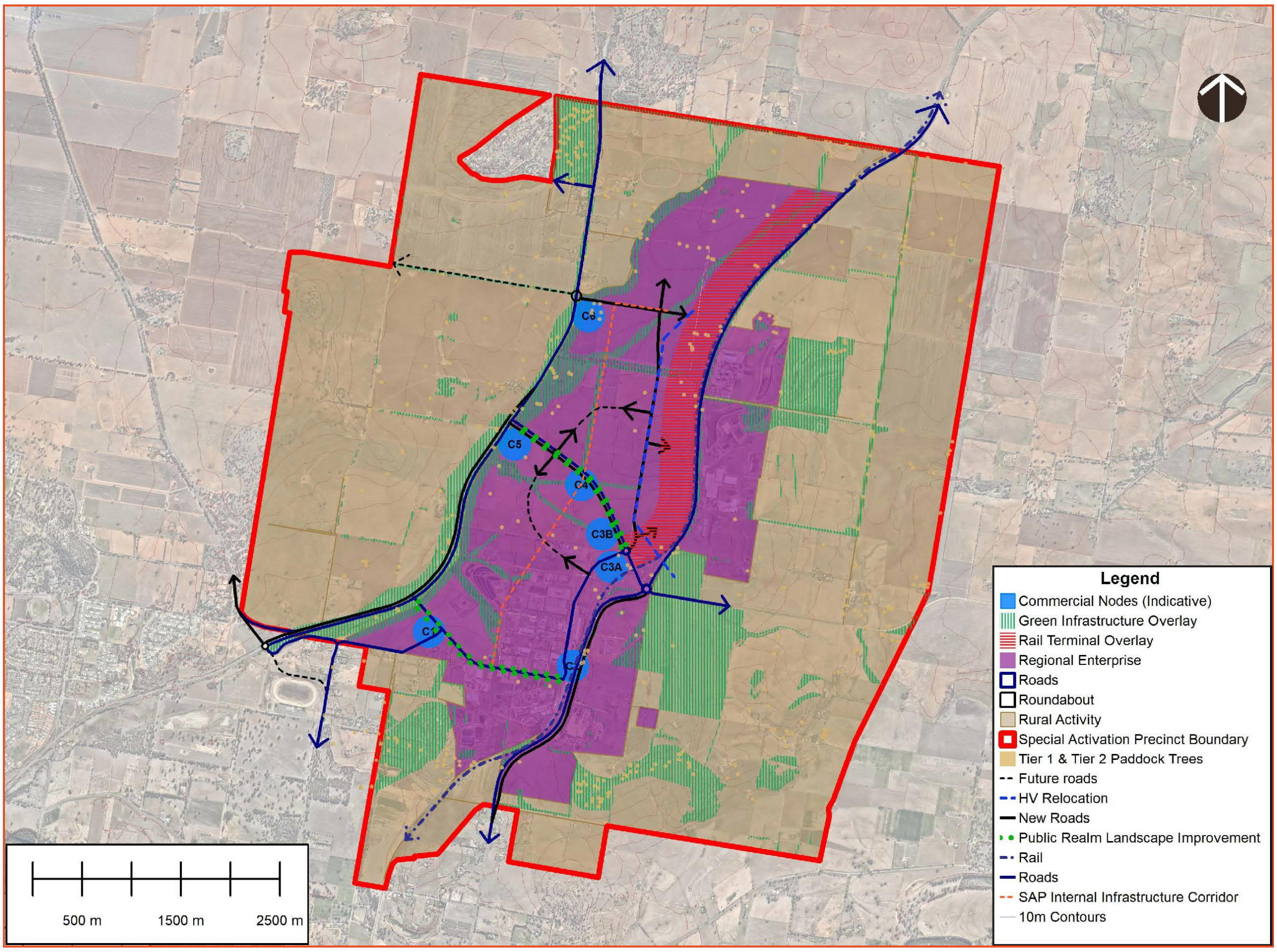
— Development of new small-scale biomass plant;

All the above renewable energy projects and opportunities need to be developed within an integrated and controlled Virtual Power Plant (VPP) network. Suitably sized energy storage facilities are also required for the efficient management of intermittent energy sources (i.e. solar) to meet the power demand of the SAP.

1.1.1 FINAL STRUCTURE PLAN

Following the Final Enquiry by Design workshop, the preferred Structure Plan was subject to further testing and refinement. At the time of this study, the Structure Plan showed indicative staging and land use sub-precincts, which were used as a basis for ongoing testing and analysis of the structure plan. Following this study, the Draft Master Plan and planning framework for the Wagga Wagga Special Activation Precinct was developed by the NSW Department of Industry, Planning and Environment. The draft planning framework proposes processes to determine staging (i.e. the Delivery Plan) and zoning controls and performance measures for noise, odour and air quality that would have a similar effect on controlling land use as the earlier sub-precincts approach. As such, the final Structure Plan in the draft planning framework no longer indicates staging and sub-precincts. The final structure plan, as included in the Draft Wagga Wagga Master Plan currently on exhibition is shown in Figure 1.2.

Figure 1.2 Wagga Wagga SAP Final Structure Plan



As the Final Structure Plan was developed after the Revision B of this report, the analysis and assessment undertaken in this report is based on the Refined Structure Plan.

2 ROOFTOP SOLAR PV

2.1 KEY ASSUMPTIONS AND CONSIDERATIONS

WSP has used the same assumptions and considerations for the calculation of energy generation from rooftop solar PV as those used in the scenario testing. The assumptions and considerations are presented in Section 2.2 of the Refined Scenario Options Report. Continuous improvement and innovation in the field of renewable energy technologies means that these assumptions, considerations and calculations should be re-evaluated at appropriate time periods (for instance, every 10 years).

2.2 ENERGY FROM ROOFTOP SOLAR PV

WSP has modelled the energy yield from rooftop solar PV with the assumptions that 75%[1] of the built area in each Stage will be installed with rooftop solar PV. WSP has undertaken basic modelling using the industry standard software PVsyst to assess the annual energy output from the various orientations, and to confirm the orientation to achieve the maximum capacity for a given area.

The annual electrical energy demand met through rooftop solar PV in each of the Stages is shown in Table 2.1 below:

Table 2.1 Annual Electrical Energy Demand vs Rooftop solar PV generation

STAGE	ANNUAL ELECTRICAL ENERGY DEMAND (MWH)[2]	ANNUAL ELECTRICITY GENERATION FROM ROOFTOP SOLAR PV (MWH)[3]	CUMULATIVE ROOFTOP SOLAR PV CAPACITY (MW)	ANNUAL DEMAND MET WITH ROOFTOP SOLAR PV
1	339,278	237,278	156	70%
2	394,425	285,324	188	72%
3	496,131	375,526	247	76%

Rooftop solar PV installations will contribute a major percentage to achieving 100% electrical energy self-sufficiency in the SAP from renewable energy sources. As shown in the table above, at the completion of stages 1, 2 and 3 of the SAP development, rooftop solar will provide 70%, 72% and 76% of the annual electricity demand of the SAP respectively.

It is recommended that all entities with rooftop solar PV installed also install an energy storage system (e.g. battery system) integrated with the rooftop solar PV system and VPP network in their premises to:

— Store excess energy, typically in peak generation hours;

— Store the energy during lower energy price hours and use the stored energy during periods of high energy prices;

[1] 75% of the built area to be considered for rooftop solar PV installation. The basis for this approach is explained in Section 3.1 and Section 3.3 of the Refined Scenario Options Report

[2] Source: Transport and Infrastructure's Final Draft Master Plan

[3] Evaluated energy yield – 1520MWh/MWp/Year with PVsyst modelling – Version 6.8.4

3 IDENTIFIED BIOENERGY PROJECTS

3.1 WAGGA WAGGA SALE YARD BIOGAS

Evaluation of the biogas-based electricity generation from the Wagga Wagga Sale Yard has been covered in Section 3.2 of the Refined Scenario Options Report. Per the evaluation, the biogas-based electricity generation has an estimated capacity of **1355 MWh/Year**. This is based on assumptions regarding the quantity of animals present during each sale, waste generated per animal, energy content of the waste and other factors. These assumptions are stated in the Refined Scenario Options Report. Any changes to these factors will alter the bioenergy potential from Sale Yard, primary being any future expansion capacity to the Sale Yard. For the purposes of this Final Draft Master Plan, WSP has considered the value estimated in the Refined Scenario Options Report in the overall energy coverage calculation.

3.2 WASTE WATER TREATMENT PLANT – BIOGAS

WSP has considered the potential wastewater generated from the entire SAP including from existing customers and assumed that the wastewater load will be directed to a new wastewater treatment plant (WWTP) for the SAP. The exception is wastewater from the intensive livestock industry areas where the wastewater will be used for onsite biogas generation. The estimated average dry weather flow (ADWF) in each stage of development of the SAP is shown below in Table 3.1.

Table 3.1. Estimated ADWF for the SAP WWTP

SAP PROGRESS	ADWF (ML/D)
Stage-1	3.08
Stage-2	3.8
Stage-3	4.98

Through the filtration and clarification processes, the WWTP will capture biosolids, which can be further processed through anaerobic digestion to produce biogas. The resulting biogas is then used to fuel an energy generating system such as a biogas reciprocating engine or microturbine to generate electricity for the SAP.

To determine the amount of electricity the WWTP can produce, the performance of several reference WWTPs was analysed and scaled for the SAP WWTP. The ADWFs and electric power generation of the reference plants analysed of similar scale to the SAP WWTP indicate a generation factor between 12 – 15 kWe per megalitre / day ADWF. A conservative estimate of 12 kWe per ML/D was used for WSP's estimation of the energy potential of a potential SAP WWTP with corresponding electrical output at each stage shown in Table 3.2.

Table 3.2. Electrical power generated from potential new WWTP

SAP PROGRESS	ELECTRICAL POWER (KW_E)
Stage-1	37
Stage-2	46
Stage-3	60

Considering the results of Table 3.2, a 60 kWe power generation system would be the likely largest system that could be installed. As an example, this output could be met with two 30 kW Capstone microturbines, or one 65 kW Capstone microturbine. To determine the amount of energy in megawatt hours generated by the WWTP, it was assumed that the WWTP would operate and produce biogas for 8,760 hours per year, however the power generation unit would only operate for 90% of the time – this allows approximately 36.5 days per year for maintenance. The load factor assumed was adjusted for the different flows during the different SAP stages. The assumed load factor in stages one, two and three was 56%, 72% and 90% respectively; corresponding to an overall capacity factor of 50%, 65% and 80% respectively. At these levels of operation, the electricity produced by digesting biosolids from the WWTP was estimated (see Table 3.3).

Table 3.3. Power generated from the WWTP

SAP PROGRESS	ELECTRICAL POWER (MWH / YEAR)
Stage-1	263
Stage-2	342
Stage-3	420

It was assumed that the WWTP would be constructed to treat an ADWF of 5 ML/d in order to meet the estimated ADWF for Stage-3. The estimated footprint of the WWTP including energy recovery equipment is approximately 50,000m^2.

A high-level indicative capital cost for this WWTP (including wastewater processing equipment and anaerobic digester) is approximately $40mil based on a reference plant data. The energy recovery equipment may be in the order of an additional $2mil. Based on the operating costs for several wastewater treatment plants in NSW, the annual operating cost for the WWTP may be approximately $700 per megalitre of wastewater processed [3]. Maintenance of the energy recovery equipment may be in the order of $50k - $100k per year.

3.3 PROPOSED 8MW BIOMASS PROJECT FOR AN EXISTING BUSINESS

WSP has been informed by the Ecologically Sustainable Development consultant for the Wagga Wagga SAP Master Plan project of an under-development 8MW Biomass power plant project in the SAP. The biomass power plant is being planned and developed by an Independent Power Producer (IPP), a developer of clean energy assets based on a "Build-Own-Operate" business model. Some of the key facts from the information provided is below:

— The proposed biomass project will provide behind the meter heat (steam) and electricity to an existing business in the Wagga Wagga SAP.

— The power plant will have 8MW output and use 40 tonnes of construction waste material per day (timber and organics) trucked in from western Sydney as feedstock. Using construction waste as feedstock was stated to 'stack up' financially because it is waste diverted from landfill and hence subject to landfill gate fee charges. As such, it was deemed more economical for the disposers to sell the waste as a fuel compared to disposing in landfill.

— The IPP also investigated the availability of agricultural residue to use as feedstock but observed that there is insufficient security of supply during times of drought in the region. Further, the available residue quantity is too expensive to make the business case viable due to other uses of the residue. For example, only 5,000 tonnes of rice husks is available presently in the region against the normal year production of 80,000 tonnes which resulted in the price for the available quantity of feedstock to be $200 per tonne and too high to be economically viable.

— The nearest viable feedstock the IPP could find was the construction waste from Western Sydney.

— Plant is scalable and could serve other businesses (of the SAP).

— The IPP preference is to supply behind the meter energy direct to customers, nevertheless, they can/are open to connect via a VPP network. They can typically retail energy at 30-35% lower than retail market rates.

— Footprint for the biomass plant will be approx. 50m x 50m in plant area, plus truck/waste holding area.

— The biomass plant is planned to be developed independently and it is not supported through any grants.

WSP has considered 70% as the capacity factor for the calculation of annual electricity generation capacity from this biomass project. The assumed capacity factor is a typical capacity factor of biomass plants in Australia [4].

Annual Electricity Generation from this project has been calculated using following formula:

$$Annual\ Electricity\ Generation\ (MWh) = Capacity\ Factor\ \times\ Plant\ Capacity\ (MW)\ \times\ 8760$$

Per the above assumptions, this 8MW Biomass project can generate approximately **48,922 MWh** of electricity per annum.

3.4 TEYS AUSTRALIA 8MW HYBRID PROJECT

WSP has identified the Teys Australia's project: Wagga Low Emission Energy Hub (WLEEH) project in the Section 3.8.3 of the Final Baseline Report. The media release of Teys Australia states that *"The hub will include baseload bio-generation, solid waste digestion, solar PV, energy storage and biomass boiler to produce steam"* [1].

Teys Australia's WLEEH project is also one of the 21 shortlisted projects for capital funding under stream two of the NSW Government's Capital Projects. The capacity of the project is identified to be 8MW of dispatchable electricity [2].

From the media release by Teys Australia and the NSW Government, WSP notes that the baseload generation of the 8MW project will be biogas-based electricity generation. From the case studies of electricity generation from biogas projects, a capacity factor of 78.8% [5] is considered for the calculation of annual electricity generation from this project.

Annual Electricity Generation from the WLEEH project has been calculated using following formula:

$$Annual\ Electricity\ Generation\ (MWh) = Capacity\ Factor\ \times\ Plant\ Capacity\ (MW)\ \times\ 8760$$

Per the above assumptions, the WLEEH project can generate approximately **54,662 MWh** per annum.

4 100% RENEWABLE ELECTRICAL ENERGY OPTIONS

From the analysis in section 3 of this report, it is concluded that 100% of the annual electricity demand of the SAP can be met via rooftop solar PV and the four identified bioenergy projects: Saleyard, WWTP, 8MW Biomass project and Teys; for Stage-1 of the SAP development. During Stage-2 and Stage-3, additional generation sources may be needed to achieve provision of 100% of the SAP electrical demand through renewable sources.

WSP along with the inputs from other stakeholders of the Project, have identified various energy options to achieve 100% electrical energy self-sufficiency in Stage-2 and Stage-3 of the SAP development. Table 4.1 shows a matrix of identified options and the capacity requirements to meet 100% annual electricity demand of the SAP at each stage of the SAP development through renewable energy sources.

Table 4.1 Generation options to meet 100% annual electricity consumption through renewable energy sources

	Energy Mixture	Stage-1		Stage-2		Stage-3	
		Capacity	Generation (MWh)	Capacity	Generation (MWh)	Capacity	Generation (MWh)
	Roof top Solar	156 MW	237278	188 MW	285324	247 MW	375526
	Wagga Sale Yard Biogas	378 kW	1355	378 kW	1355	378 kW	1355
	WWTP Biogas	60 kW	263	60 kW	342	60 kW	420
	8MW Biomass Power Plant	8 MW	48922	8 MW	48922	8 MW	48992
	Teys Australia Biogas Hybrid Plant	8 MW	54662	8 MW	54662	8 MW	54662
Option-1	Adopt Existing Solar Farm	0	0	2	3820	7	15176
Option-2	Development of New Solar Farm	0	0	2	3820	7	15176
Option-3	New Biomass project	0	0	1	3820	3	15176
	Total Annual Electricity Generation (MWh)		342480		394425		496131
	Annual Electricity Demand (MWh)		339278		394425		496131

At any stage of the SAP development (including Stage-1), the identified options (as described in this Section) can be pursued in place of any of the identified projects (as described in Section 3), if any of the projects identified in Section 2 and Section 3 of this report will not be realised.

WSP notes that the above assessment does not factor in time-series analysis i.e. the assessment does not account for differences in electrical demand and generation potential throughout the day and daily differences. In other words, the assessment does not account for differences in electrical demand and generation potential for example at 9am compared to 9pm or demand and generation potential during a day in January compared to a day in July. The assessment has assumed that one kWh of demand is equivalent to one kWh of generation. This will not necessarily be true as 100 kWh of demand may be required at night however 100 kWh may only be capable of being generated around midday (as is typical for solar). The impact of these differences can be smoothed with the use of energy storage (and this is assumed for the Master Plan) and as such should not materially alter conclusions for the Master Plan in regards to infrastructure requirements, however, further studies are recommended for more detailed assessment as necessary.

Each option from the above matrix is discussed below.

4.1 ADOPT EXISTING UNDER CONSTRUCTION SOLAR FARM(S)

As WSP has identified in Section 3.8.3 of the Baseline Analysis Report, the following two large scale solar farms are being developed in the Wagga Wagga SAP area.

1. Bomen Solar Farm (Capacity: ~120MW) – Approved and Under Construction
2. Terrain Solar Farm (Capacity: ~30MW) – Approved and construction is yet to commence

Based on the publicly available information, it is noted that both solar farms have Power Purchase Agreements (PPAs) for 10 years' tenure with businesses outside of the Wagga Wagga SAP area [6] [7].

When these existing PPA tenures are about to end, the SAP development corporation can approach the owners of these solar farms and negotiate to contract a certain capacity of their power output for the SAP based businesses through the corporate PPA mechanism.

This option is shown as Option-1 in Table 4.1, and at the end of Stage-1 development, there will not be a requirement for any capacity to be contracted with these solar PV farms. At Stage-2 and Stage-3, the required contracted capacity will be 2MW[4] and 7MW[4] respectively.

Although there will be no need for any capacity contract with these solar farms at the end of Stage-1, during the on-going development phase of Stage-1, an appropriate capacity contract (corporate PPAs) with these solar farms could be useful for interim renewable energy supply to the businesses.

WSP also notes that the Bomen Solar Farm is shortlisted for capital funding from the NSW government for a 10.3MW battery energy storage system [2] which can also provide support to the energy requirement on demand upon integration with a VPP network within the SAP.

4.2 DEVELOPMENT OF SMALL-SCALE SOLAR PV PROJECT

One of the options identified is to develop small scale ground mount solar PV panels in the Landscape Buffer Sub Precinct to achieve 100% electrical energy self-sufficiency through the SAP from renewable energy sources.

WSP calculated the potential capacity required to be developed as new small-scale ground mounted solar by using PVsyst modelling to evaluate the annual electrical energy production from ground mounted solar PV systems with single axis tracking located in the Wagga Wagga SAP[5].

This option is shown as Option-2 in Table 4.1, and at the end of Stage-1 development, there will not be a requirement for any additional capacity to be installed as new ground mounted solar PV. At Stage-2 and Stage-3, the required installed capacity will be 2MW and 7MW respectively.

The size of this development is typically referred to as commercial scale solar and typically attract different developers to small and large scale solar. These developers will however assess project economics similar to large scale solar developers e.g. solar yield, marginal load factor, and land costs but typically instigate lower capital investment solutions e.g. fixed ground mounted solar panels as opposed to tracking systems.

4.3 BIOMASS POWER PLANT

The estimated residual demand of the SAP after installation of rooftop solar and identified bioenergy projects may be met with the addition of an additional biomass plant. The estimated output of this plant would be 0 MWh, 3,820 MWh and 15,176 MWh per year respectively for Stages 1, 2 and 3 respectively.

It was assumed that the plant would operate approximately 90% of the year, allowing approximately 36.5 days per year for maintenance. Therefore, to generate enough electricity to fulfil the SAP's demand, a 3 MW Biomass Plant would be required. The additional following assumptions regarding the plant's design were made:

— Electrical efficiency (HHV) is 28%

4 WSP has not considered annual generation degradation of the solar PV systems for the calculation of required capacity to meet a certain percentage of energy demand, i.e. the required contracted capacity may be slightly higher than calculated in this report due to its reduction of generation capacity with time.

5 Evaluated energy yield – 2099kWh/kWp/Year with PVsyst modelling – Version 6.8.4

— Auxiliary power consumption is 2.5%

— Capacity factor is 60% [4]

A biomass plant of this size and performance would consume between approximately 4,000 - 6,100 tonnes of wood chips per year if firing only wood chips, or approximately 4,000 tonnes of straw per year if firing only on straw. WSP's high-level estimation of the footprint for this biomass plant is shown in Table 4.2 which is based on the reference plant Rothes Corde in the UK, which has a fuel input of 34 MWth. This reference plant is similar in size to the biomass plant suggested for the Wagga Wagga SAP, which will require a thermal input of circa 10MWth.

Table 4.2. Estimated footprints for the biomass plant and major components

AREA	LENGTH (M)	WIDTH (M)	AREA (M^2)
Overall Plant	130	60	11,700

The estimated capital expenditure for a biomass-fired plant of this size based on the findings of the ACIL Allen Fuel and Technology report for AEMO is approximately $18 million. A high-level indicative maintenance cost for this plant was taken to be in the range of $20/MWh - $25/MWh based on WSP's previous experience[6]. In addition to this, the cost of the fuel and its delivery to the site should be considered. The delivered costs of these biomass fuels are outlined in Table 4.3.

Table 4.3. Indicative Wagga Wagga region biomass economics

BIOMASS SOURCE	APPROXIMATE DELIVERED COST ($/T)	APPROXIMATE DELIVERED COST ($/GJ)
Cereal Straw	80 – 100	6 – 8
Wood Chip	50	4 – 6

The annual operating cost for the biomass plant therefore depends on the number of megawatt hours that it generates, the fuel selection and the calorific value of the fuel. As a result, the total operating expenditure for the biomass plant may vary in each stage as shown in Table 4.4.

Table 4.4. Estimated operating cost per year for the Large-Scale Biomass Plant

SAP PROGRESS	ESTIMATED OPERATING COST PER YEAR
Stage-1	-
Stage-2	$390k – $490k
Stage-3	$1.55mil - $1.94mil

Table 4.4 does not have an operating cost for the biomass plant in Stage-1 because it would not be required to operate during this stage of the SAP development since the other power generation elements would satisfy the estimated electricity demand.

6 This estimation is based on a larger plant. For a 3 MW plant, these costs would need to be assessed in detail.

The viability of using a biomass plant to power the SAP may be limited by the costs related to its construction and operation. The availability of the fuel feedstock also needs to be considered in regards to the viability of a biomass plant in this region. In periods of drought, sourcing of the fuel feedstock may not be possible, or economically feasible as identified by the IPP for the 8MW Biomass project.

5 SUSTAINABILITY

One of the Wagga Wagga SAP aspirations is to *"Target secure affordable renewable energy to support Ecologically Sustainable Development and business investment"*

The identified renewable energy projects can support this aspiration of the Precinct. We have also targeted the aspiration of 100% electrical self-sufficiency through SAP based renewable energy generation resources. The identified renewable opportunities would automatically address the requirements of a sustainably developed Precinct from a broader perspective.

Through the master planning process, WSP has indicated the impacts of the identified renewable energy opportunities on various aspects of sustainable development. However, Table 5.1 represents the high-level impacts of each identified renewable opportunities on the three basic pillars of sustainability.

Table 5.1 Identified Renewable Opportunities and Sustainability

IDENTIFIED OPPORTUNITY	ECONOMIC	ENVIRONMENTAL	SOCIAL
Rooftop solar PV	**Positive:** — Cheaper electricity — Lower Levelised Cost of Electricity (LCOE) — Lower capital cost — Support circular economy	**Positive:** — No land requirement — No air pollution — No water pollution — No greenhouse gas emissions **Issues/Constraints:** — End of life disposal of PV modules	**Positive:** — Jobs creation — Affordability of electricity — Education encouragement **Issue/Constraints:** — Potential visual impact
Biogas Plant	**Positive:** — Reduction of waste disposal costs — Lower capital cost — By-product has economic value — Support circular economy	**Positive:** — Positive Climate change effect — Reduction of greenhouse gas emissions — Lower impact on air quality — Recirculation of organic waste — Lower water pollution — Lower land pollution	**Positive:** — Waste management — Jobs creation — Alternative to fossil fuel base load generators — Education encouragement

IDENTIFIED OPPORTUNITY	ECONOMIC	ENVIRONMENTAL	SOCIAL
Biomass Plant	**Positive** — Reduction of waste disposal costs (Construction wood waste) — Support agricultural economy — Support circular economy **Issues/Constraints:** — Higher capital investment — May have competing uses (straw) — Feedstock security especially during drought periods	**Positive:** — Reduction of greenhouse gas emissions — In the long term, positive climate change effect **Issues/Constraints:** — For the short term, additional carbon emission — Depending on where biomass is sourced, may increase vehicle emissions	**Positive:** — Jobs creation — Alternative to fossil fuel base load generators — Education encouragement **Issues/Constraints:** — Potential visual impact (due to stack)

Overall, it can be assessed from Table 5.1 above that the impacts of all identified renewable energy opportunities for the Wagga Wagga SAP will mainly have positive impacts on the economic, environmental and social pillars of sustainable development.

5.1 OFF-SITE IMPACTS OF THE IDENTIFIED OPPORTUNITIES

WSP has identified key offsite impacts from the delivery of the identified renewable energy opportunities. Table 5.2 below represents the offsite impacts from the identified renewable energy opportunities.

Table 5.2 Offsite impacts of the identified renewable energy opportunities

IDENTIFIED OPPORTUNITY	POSITIVE	NEGATIVE	TO BE ASSESSED
Rooftop solar PV	— Greenhouse gas emission reduction	— Potential visual impact (due to glare)	— PV module recycling at end of design life
Biogas Power Plant	— Greenhouse gas emission reduction — Lower water pollution — Lower land pollution	— No potential for major negative off-site impacts	— Quantified risk assessment would be required to assess the imposed risk on surrounding land uses

IDENTIFIED OPPORTUNITY	POSITIVE	NEGATIVE	TO BE ASSESSED
Biomass Power Plant	— Reduction of greenhouse gas emissions — Lower land pollution (by using construction waste as feedstock) — Reduced off-site	— For the short term, additional carbon emission — Potential visual impact (due to stack)	— Carbon neutral

6 LAND AND INFRASTRUCTURE

6.1 LAND LOCATION FOR IDENTIFIED OPPORTUNITIES

WSP has identified the strategic location for the types of renewable energy opportunities which can be delivered across the Precinct. Table 6.1 below represents the specific land requirements and co-existence opportunity for the identified renewable energy opportunities.

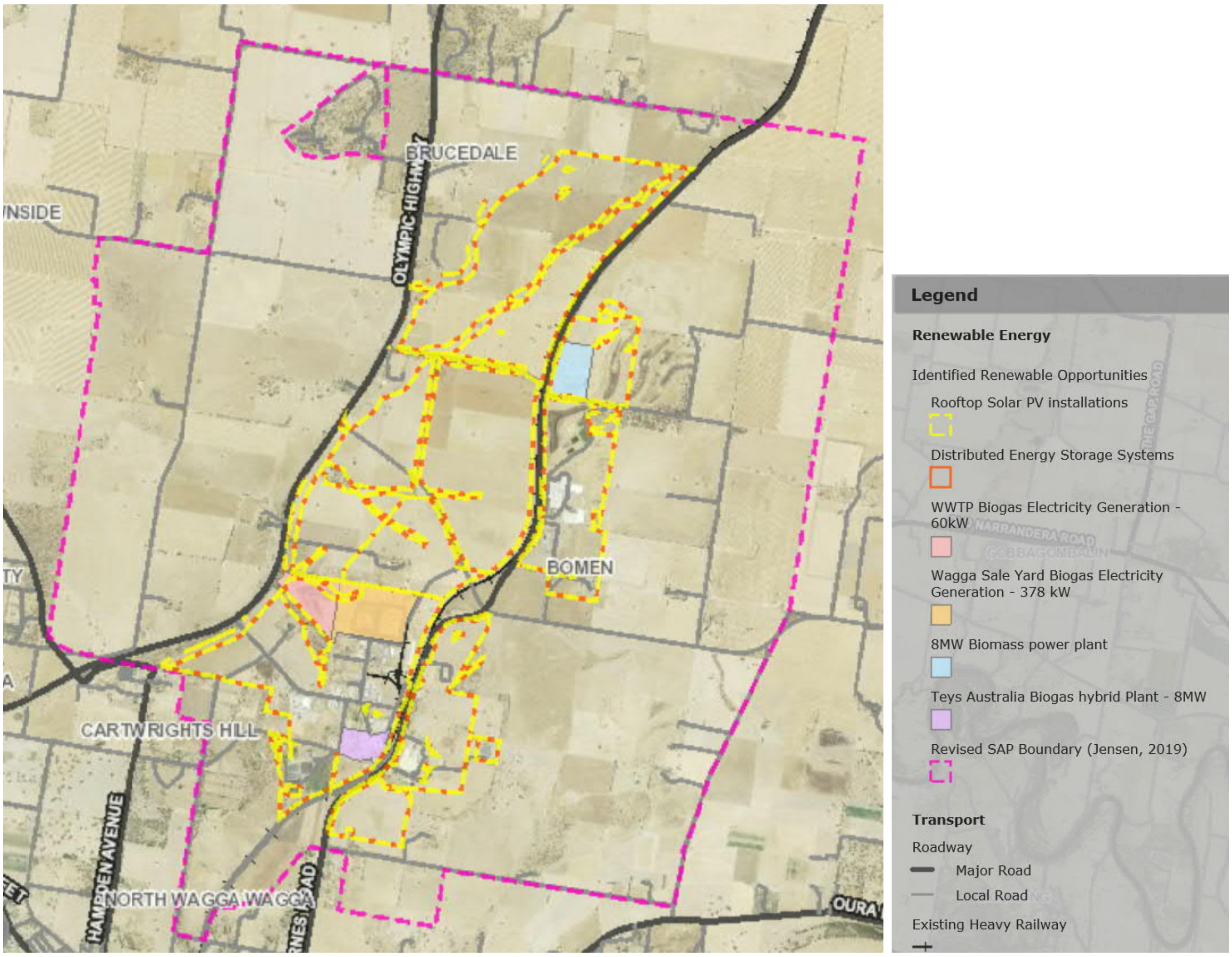
Table 6.1 Land area and location for identified opportunities

IDENTIFIED OPPORTUNITY	LAND REQUIREMENT	POTENTIAL STRATEGIC LOCATION
Rooftop solar PV installations	No additional land is needed as described in Section 3.3.1 of the Refined Scenario Options Report	Co-location with the businesses of the SAP
Wagga Wagga Sale Yard Biogas Electricity Generation Plant	Land requirement for Wagga Wagga Sale Yard biogas electricity plant is described in Section 3.3.1 of the Refined Scenario Options Report	Co-location within the premises of the Wagga Wagga Sale Yard in the Intensive Livestock Agriculture Sub-precinct
WWTP Biogas Electricity Generation Plant	Circa 50,000 m^2 for new WWTP for SAP generated wastewater. Area includes allowance for energy recovery equipment.	Co-location within the premises of WWTP in the Intensive Livestock Agriculture Sub-precinct
8MW Biomass Power Plant	Generation Unit: 50m x 50m Storage area would require additional space depending upon the feedstock storage plan.	Co-location within the premises of an existing business in the Existing Regional Enterprise Sub-Precinct
Teys Australia Biogas Hybrid Plant	It is assumed that this generation plant will be located within the Teys Australia premises, hence no additional land needed.	Co-location within the premises of Teys Australia Pty Ltd in the Intensive Livestock Agriculture Sub-precinct
Adoption of existing under construction solar farms	No new land needed.	Located within Approved Solar Site areas. Additionally, the land use will not need to change after the design life of these solar farms, as it can be re-built with the same or better solar PV panels using the latest technology available at that time (~25 year from the date of commissioning)
New Solar PV Farm	~ 2 hectares per MW as provided in Section 3.3.3 of the Baseline Analysis Report.	To be developed in the Landscape Buffer Sub Precinct.
Biomass Project	Circa 5,000 m^2 to circa 12000m^2. The largest land area requirement is for storage which will differ depending on biomass type and storage plan.	Near motorway or RiFL for transportation access. Within sector for industries with stack emissions.

IDENTIFIED OPPORTUNITY	LAND REQUIREMENT	POTENTIAL STRATEGIC LOCATION
Energy Storage Systems	No additional land is needed as the battery energy storage systems do not require significant space.	Energy storage systems would be located within the premises of the businesses and distributed across the Precinct.

Figure 6.1 below illustrates graphical representation of the identified renewable opportunities and locations within the SAP.

Figure 6.1 Wagga Wagga SAP - Identified Renewable Energy Opportunities



6.2 ELECTRICAL INFRASTRUCTURE

6.2.1 GENERATION CAPACITY AND LOAD

The potential generation capacity from different renewable sources as identified in the previous sections is summarised in Table 6.2 below. As the transformer rating is in MVA, the generation capacity (in MW) are converted to MVA by assuming a power factor of 0.90 (lag). The historical data from the Essential Energy report [8] shows the substation loading at 0.90 power factor and the same is considered while converting the MW values into MVA. This also gives the most onerous condition in terms of equipment loading.

Table 6.2 Summary of potential generation capacity at the end of each stage (MVA)

SOURCES OF GENERATION	APPROXIMATE PROPOSED INSTALLED CAPACITY OF GENERATION (MVA)		
	STAGE-1	STAGE-2	STAGE-3
Rooftop solar Plant	173.33	208.89	274.44
Wagga Sale Yard Biogas Plant	0.42	0.42	0.42
WWTP Biogas Plant	0.07	0.07	0.07
8MW Biomass Plant	8.90	8.89	8.89
TEYS Australia Biogas Hybrid Plant	8.90	8.89	8.89
Adopt Existing Solar Farm	--	2.22	7.78
Development of New Solar Farm	--	2.22	7.78
New Biomass Project	--	1.11	3.33
Total	**192.22 MVA**	**232.71 MVA**	**311.60 MVA**

WSP has estimated the average load demand for three stages of the SAP development. The summary of average electrical load demand for each stage is provided in Table 6.3 below. A power factor of 0.90 is considered for calculation purposes based on historical data from the Essential Energy report [8].

Table 6.3 Summary of average load demand estimates

STAGE	AVERAGE LOAD DEMAND ESTIMATE (MVA)
1	114.4
2	131.8
3	163.9

The following sections summarise the assessment and recommendation for the requirements of the electrical infrastructure to effectively manage the implementation of the identified renewable energy opportunities at each stage of development of the Wagga Wagga SAP.

WSP has also aligned its calculations and recommendations of the electrical infrastructure to support the growth of the renewable energy development with the draft Final Master Plan of the Transport and Infrastructure consultant.

6.2.2 STAGE-1 INFRASTRUCTURE REQUIREMENTS

As summarised in Table 6.2 above, the total peak generation capacity at the end of Stage-1 from the identified renewable energy projects is approximately 192.22 MVA during the peak hours of solar PV generation. From this peak generation capacity during peak generation hours, about 114.4 MVA will be utilised to meet the load demand within the SAP area and the surplus power of about 78 MVA will be utilised to charge Battery Energy Storage Systems (BESS). Upon optimal charging of the BESS, the surplus power would be fed to the Wagga North Substation through the distribution network. A summary of energy demand, generation capacity and additional infrastructure capacity requirement is provided in Table 6.4 below.

Table 6.4 Summary of Stage-1 infrastructure requirements

ITEMS	GENERATION/LOAD
Peak generation capacity at the end of Stage-1	192.22 MVA
Total calculated average load at the end of Stage-1	114.40 MVA
Maximum surplus power available to evacuate to the Grid (once the BESS is optimally charged)	77.82 MVA
Existing capacity available at Bomen and Cartwrights Distribution substations	44.5 MVA
Additional Distribution substation capacity required to evacuate the surplus power to Wagga North substation	34 MVA
Existing capacity available at Wagga North substation	60 MVA
Additional capacity upgrade required at Wagga North substation to accommodate surplus power	28 MVA

Table 6.4 above represent the infrastructure requirements to accommodate evacuation of the surplus power after meeting the load demand and BESS charging.

WSP notes that the Transport and infrastructure consultant's assessment of the power infrastructure requirements for Stage-1 are:

- New distribution substation of 70 MVA capacity within the SAP area; and
- Wagga North Substation extension with additional 60 MVA transformer capacity [9].

The preliminary power distribution lengths and source upgrades required for each stage are shown in Table 6.5.

Table 6.5 Summary of networks and source upgrades for Stage-1

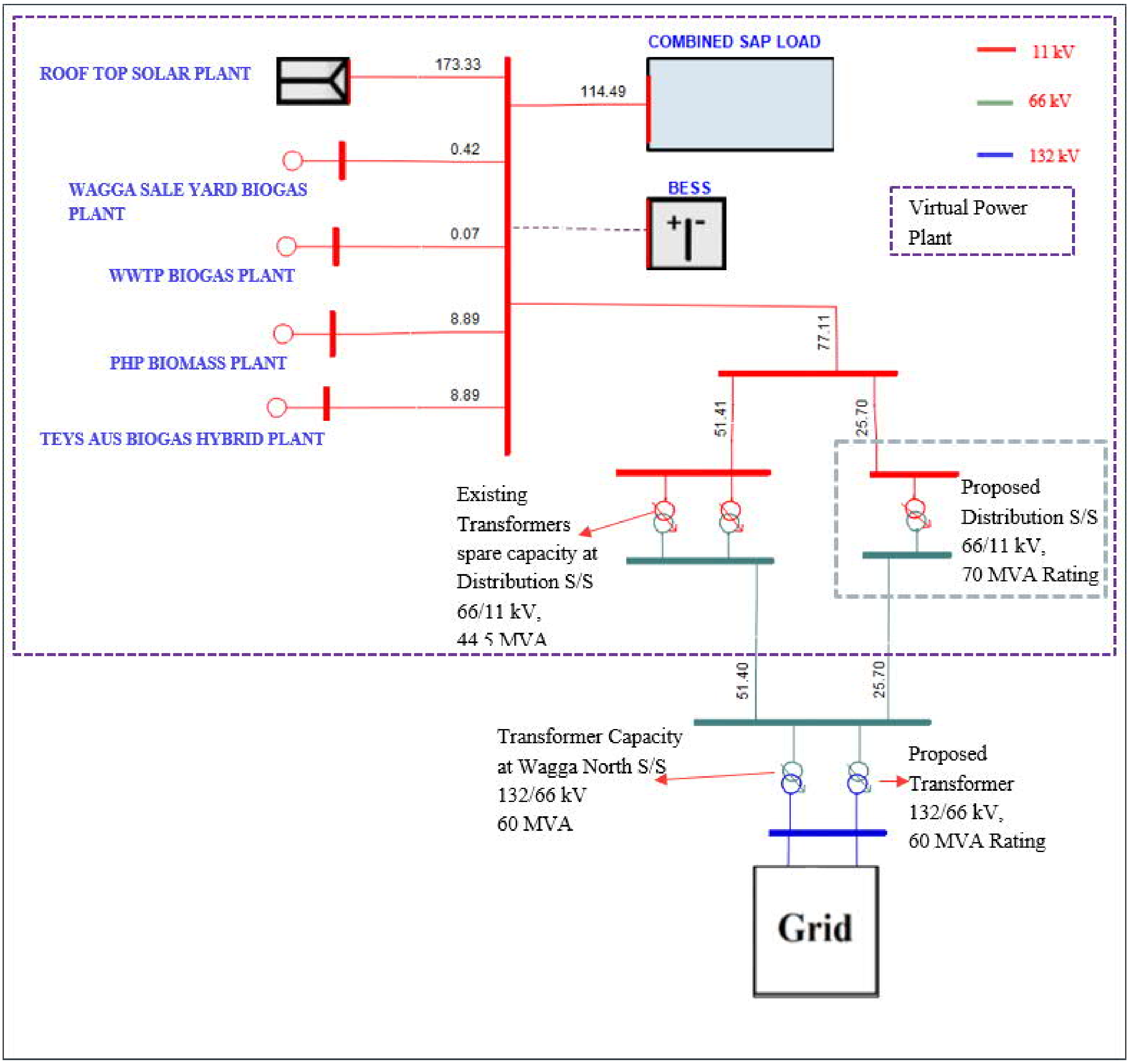
STAGE	NETWORK LENGTH (KM)	SOURCE UPGRADE REQUIRED
66kV feeder line from existing Wagga North Substation to Proposed Wagga SAP substation	2.80 km	Proposed 70-MVA distribution substation within SAP area.
Stage-1a	1.4292 km	Additional 60MVA substation capacity upgrade to existing Wagga North Substation.
Stage-1b	2.1077 km	
Stage-1c	2.7455 km	
Stage-1d	2.6477 km	
Stage-1e	2.1204 km	
Stage-1 (Sub-Total)	11.10 km	

WSP notes that the power infrastructure requirements recommended by the Transport and Infrastructure consultant already cover the infrastructure required to implement and rollout identified renewable energy opportunities by the end of Stage-1.

Following the upgrade of substations and the network, the surplus generation of about 78 MVA can be evacuated using this electrical infrastructure without any separate upgrade as shown in Figure 6.2. It is to be noted that the power flows shown in the diagram are in MVA and only for indicative purposes. The actual topology and the actual power flow depends on the detailed design of the network, the transformer rating, and cable reticulation.

For the electrical infrastructure requirement assessment, WSP has assumed that all the power generation systems will be interconnected via a Virtual Power Plant network and battery energy storage systems.

Figure 6.2 Preliminary connection diagram for Stage-1



6.2.3 STAGE-2 INFRASTRUCTURE REQUIREMENTS

As summarised in Table 6.2 above, the total peak generation capacity at the end of Stage-2 from the identified renewable energy projects and renewable energy generation options is approximately 227.16 MVA during the peak hours of solar PV generation. From this peak generation capacity during peak generation hours, about 131.80 MVA will be utilised to meet the load demand within the SAP area and the surplus power of about 95.36 MVA will be utilised to charge Battery Energy Storage Systems (BESS). Upon optimal charging of the BESS, the surplus power would be fed to the Wagga North Substation through the distribution network. A summary of energy demand, generation capacity and additional infrastructure capacity requirement is provided in Table 6.6 below.

Table 6.6 Summary of Stage-2 infrastructure requirements

ITEMS	GENERATION/LOAD
Total generation from all sources during Stage-2	227.16 MVA
Total calculated load during Stage-2	131.80 MVA
Maximum Surplus Energy available to evacuate to the Grid (once the BESS is fully charged)	95.36 MVA
Combined existing capacity available at Bomen and Cartwrights Distribution substations + Stage-1 capacity addition	44.50 MVA + 70 MVA
Additional Distribution substation capacity required to evacuate the surplus power to Wagga North substation	0 MVA
Existing capacity available at Wagga North substation + Stage-1 capacity addition	60 MVA + 60 MVA
Additional capacity upgrade required at Wagga North substation to accommodate surplus power	0 MVA

Assuming that the electrical infrastructure upgrades recommended by the Transport and Infrastructure consultant for Stage-1 have been implemented before commencement of Stage-2, Table 6.6 above highlights that there will not be a need for further infrastructure upgrades to accommodate evacuation of the surplus power after meeting the load demand and BESS charging at Stage-2.

However, the preliminary power distribution lengths required for this stage in addition to Stage-1 is shown in Table 6.7.

Table 6.7 Summary of networks and source upgrades for Stage-2

STAGE	NETWORK LENGTH (KM)
Stage-2	0.780 km

Additionally, WSP notes that the Transport and Infrastructure consultant's assessment of the power infrastructure requirements for Stage-2 are:

— New distribution substation of 20 MVA capacity within the SAP area; and

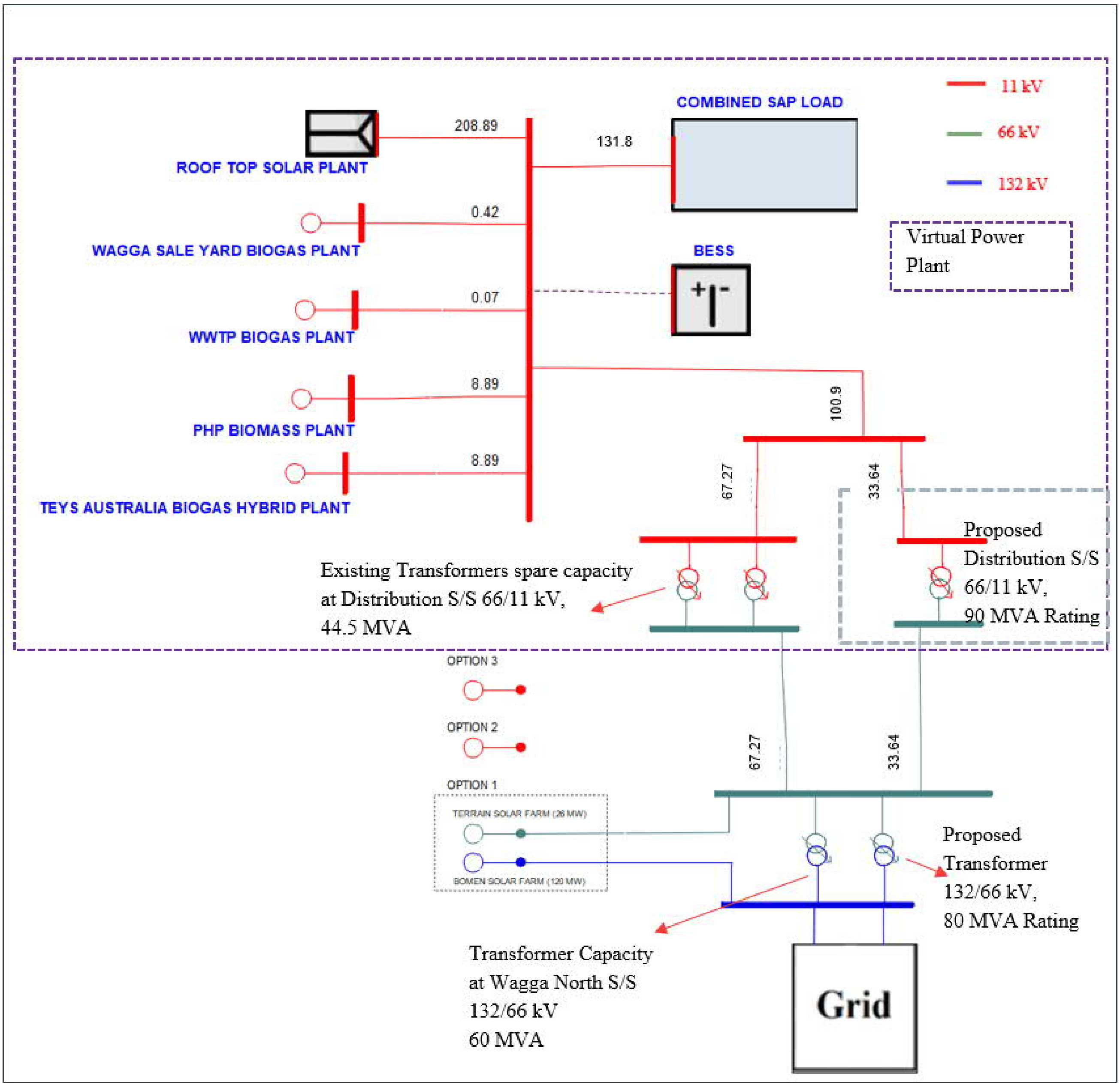
— Wagga North Substation extension with additional 20 MVA transformer capacity [9].

WSP notes that the power infrastructure requirements recommended by the Transport and Infrastructure consultant for Stage-1 already cover the infrastructure required to implement and rollout identified renewable energy opportunities by the end of Stage-2.

Following the upgrade of substations and the network for Stage-1, the surplus generation of about 95.36 MVA in Stage-2 can be evacuated using this electrical infrastructure without any separate upgrade as shown in Figure 6.3. It is to be noted that the power flows shown in the diagram are in MVA and only for indicative purposes. The actual topology and the actual power flow depends on the detailed design of the network, the transformer rating, and cable reticulation.

For the electrical infrastructure requirement assessment, WSP has assumed that all the power generation systems will be interconnected via a Virtual Power Plant network and battery energy storage systems.

Figure 6.3 Preliminary connection diagram for Stage-2



6.2.4 STAGE-3 INFRASTRUCTURE REQUIREMENTS

As summarised in Table 6.2 above, the total peak generation capacity at the end of Stage-3 from the identified renewable energy opportunities will be approximately 292.71 MVA during the peak hours of solar PV generation. From this peak generation capacity during peak generation hours, about 170 MVA will be utilised to meet the load demand within the SAP area and the surplus power of about 122.71 MVA will be utilised to charge Battery Energy Storage Systems (BESS). Upon optimal charging of the BESS, the surplus power would be fed to the Wagga North Substation through the distribution network. A summary of energy demand, generation capacity and additional infrastructure capacity requirement is provided in Table 6.8 below.

Table 6.8 Summary of Stage-3 infrastructure requirements

ITEMS	GENERATION/LOAD
Peak generation capacity at the end of Stage-3	292.71 MVA

ITEMS	GENERATION/LOAD
Total calculated average load at the end of Stage-3	170 MVA
Maximum surplus power available to evacuate to the Grid (once the BESS is optimally charged)	122.71 MVA
Combined existing capacity available at Bomen and Cartwrights Distribution substations + Stage -1 capacity addition + Stage-2 capacity addition	44.50 MVA + 70 MVA + 20 MVA
Additional Distribution substation capacity required to evacuate the surplus power to Wagga North substation	0 MVA
Existing capacity available at Wagga North substation + Stage -1 capacity addition + Stage-2 capacity addition	60 MVA + 60 MVA + 20 MVA
Additional capacity upgrade required at Wagga North substation to accommodate surplus power	0 MVA

Considering that the electrical infrastructure upgrades recommended by the Transport and Infrastructure consultant for Stage-1 and Stage-2 have been implemented before commencement of Stage-3,

Table 6.8 above highlights that there will be no infrastructure upgrade requirements to accommodate evacuation of the surplus power after meeting the load demand and BESS charging at Stage-3.

However, the preliminary power distribution lengths upgrades required for this stage in addition to Stage-1 and Stage-2 is shown in Table 6.9.

Table 6.9 Summary of networks and source upgrades for Stage-3

STAGE	NETWORK LENGTH (KM)
Stage-3	4.78 km

Additionally, WSP notes that the Transport and infrastructure consultant's assessment of the power infrastructure requirements for Stage-3 are:

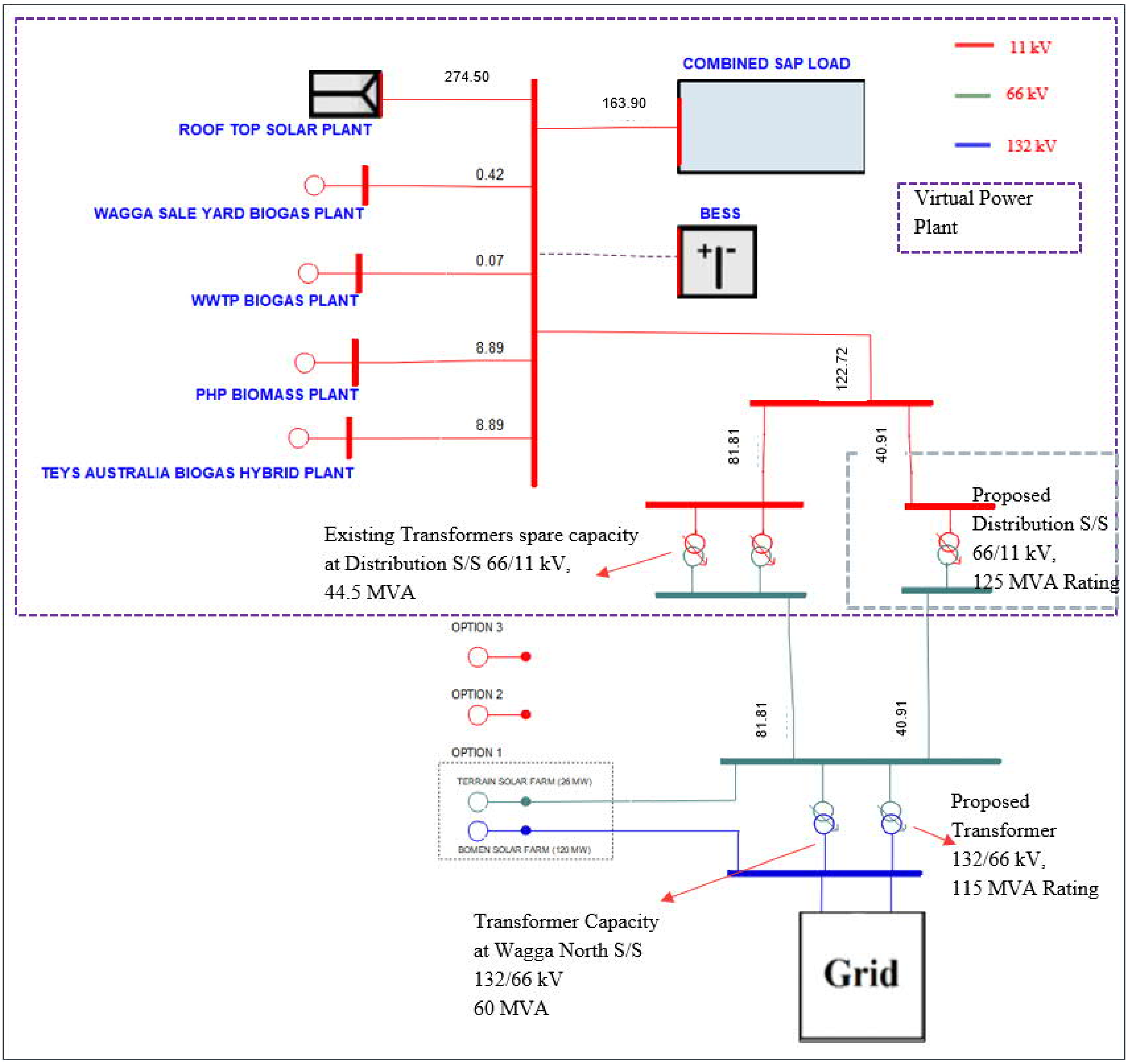
- New distribution substation of 79 MVA capacity within the SAP area; and
- Wagga North Substation extension with additional 63 MVA transformer capacity [9].

WSP notes that the power infrastructure requirements recommended by the Transport and Infrastructure consultant for Stage -1 and Stage-2 already cover the infrastructure required to implement and rollout identified renewable energy opportunities by the end of Stage-3.

Following the upgrade of substations and the network for Stage-1 and Stage-2, the surplus generation of about 123 MVA can be evacuated using this electrical infrastructure without any separate upgrade as shown in Figure 6.4. It is to be noted that the power flows shown in the diagram are in MVA and only for indicative purposes. The actual topology and the actual power flow depends on the detailed design of the network, the transformer rating, and cable reticulation.

For the electrical infrastructure requirement assessment, WSP has assumed that all the power generation systems will be interconnected via a Virtual Power Plant network and battery energy storage systems.

Figure 6.4 Preliminary connection diagram for Stage-3



6.2.5 INFRASTRUCTURE FOR 100% RENEWABLE ELECTRICITY OPTION

The options to achieve 100% coverage of SAP annual electricity demand are outlined in Table 6.10.

Table 6.10 Options for 100% renewable energy

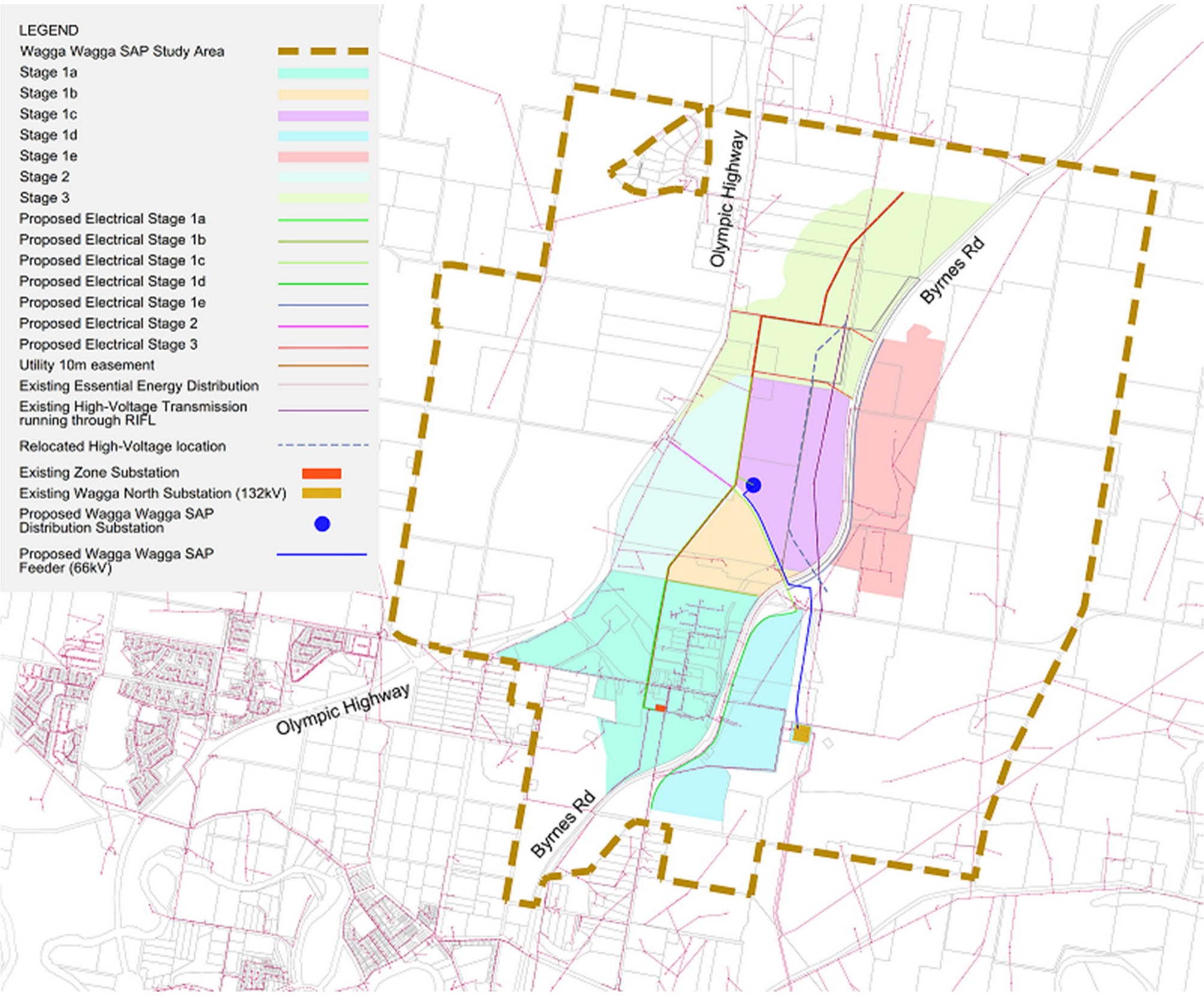
	STAGE-1	STAGE-2	STAGE-3
Option 1: Adopt Existing Solar Farm	--	2 MW	7 MW
Option 2: Development of New Solar Farm	--	2 MW	7 MW
Option 3: New Biomass project	--	1 MW	3 MW

WSP assess that to adopt any of the above options at Stage-2 and/or Stage-3 from Table 6.10 above, no additional electrical infrastructure would be required.

6.2.6 RECOMMENDED LOCATION FOR ELECTRICAL INFRASTRUCTURE

Data taken from Essential Energy assets shows that areas within the proposed SAP already have access to distribution networks which are overhead in nature. A summary of the proposed infrastructure location is provided in Figure 6.5. Further review and refinement of these locations, benchmarking against similar developments and consultation is required in the design stage.

Figure 6.5 Preliminary Network Infrastructure Location



The cost estimation for the above infrastructure is provided as a separate Schedule to this report. The strategic cost estimates shown are considered very conservative and were established based on multiple assumptions. This is for comparison purposes only. Further design development as well as refinement of assumptions is recommended before attempting to establish an estimated project cost/budget.

The total capacity of rooftop solar installation required was calculated in this study to be ~275MVA based on the assumption inherent in the report. WSP notes that we have not determined whether the installation of this quantity of solar PV or any renewable energy is feasible as it requires detailed network analysis to determine the technical feasibility of the individual project.

7 LIMITATIONS

This Report is provided by WSP Australia Pty Limited (*WSP*) for DPIE (*Client*) in response to specific instructions from the Client and in accordance with WSP's proposal dated 17th May 2019 and agreement with the Client dated 6th June 2019 (*Agreement*).

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