100% renewables

ROUS COUNTY COUNCIL

BULK WATER SUPPLY | WEED BIOSECURITY | FLOOD MITIGATION

Rous County Council

RENEWABLE ENERGY AND EMISSIONS REDUCTION PLAN

Final report

July 2023

www.100percentrenewables.com.au

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1 Executive Summary

Rous County Council (RCC) engaged 100% Renewables to develop a Renewable Energy and Emissions Reduction Plan (REERP) that aims to identify and assess various opportunities for reducing greenhouse gas (GHG) emissions originating from Council's operations, aligns with Council's adopted Business Activity Strategic Plan (BASP) 2022-2032, and builds upon RCC's Greenhouse Gas (GHG) Abatement Strategy from 2018, for which Council also engaged 100% Renewables.

The purpose of this REERP is to provide an update to Council's 2018 Greenhouse Gas Abatement Strategy and provide Council with an overview of current viable abatement opportunities available for its operations that in turn, can enable Council to align with NSW Government's objective of reaching state-wide net zero emissions by 2050.

1.1 Project context

In Australia, the commitment to addressing climate change is becoming more uniform and aligned towards international goals across all levels of government. This includes ambitious efforts towards decarbonisation by the middle of the century.

- The Federal Government has legislated emissions reduction of 43% by 2030 (from 2005 levels) and is committed to net zero by 2050
- NSW Government has a target of 70% emissions reduction by 2035 and net zero by 2050, as yet unlegislated
- A large number of regional local governments and communities representing more than two thirds of NSW population are committed to deep emissions cuts.

Over the next decades, coal-fired power stations in Australia, including NSW, will be replaced by renewable energy generation technologies such as solar, wind, pumped hydro, and grid-scale batteries. Electricity emissions for Rous County Council's operations will be significantly reduced as the grid transitions towards renewable energy sources.

1.2 Project scope

The scope of the current project is as follows:

- Provide an overview of progress to date, including a summary of relevant projects.
- Perform an energy and carbon footprint comparison of the current and 2016/17 baseline position.
- Develop an electronic questionnaire for acceptance by the project team for issue to Councillors and staff (to collect key information on strategic and operational considerations).
- Provide an overview of battery energy storage system (BESS) technology and feasibility.
- Provide target dates for replacement of light vehicle fleet with hybrid vehicles, followed by replacement with zero emissions vehicles.
- Assess a number of potential actions for site upgrades including advising on the current viability of use of BESS solutions, additional PV installations, and replacing combustion engine outdoor equipment with battery powered items.
- Cost estimates provided for their installation or implementation.
- The investigations are to have assessed lifecycle cost viability and site suitability.
- Review renewable energy targets for electricity use.

- Consider actions required for achieving overall net zero greenhouse gas emission for Council's operations.
- Undertake sequestration modelling for Council's tree planting activities and provide related advice.

1.3 Rous County Council's emissions footprint

Rous County Council's carbon footprint for the financial year 2021-22 (FY 2022) was **4,945 tonnes (t) of carbon dioxide-equivalent (CO2-e),** predicated upon Council's established emissions boundary. Grid-imported electricity remains to be the largest contributor to the inventory at 92%, followed by stationary and transport fuel use at 8%, for which the biggest share originates from diesel use for Council's fleet. Depicted in the following chart and table is the summary of Council's emissions for FY 2022. Emissions are categorised by Scopes 1, 2 and 3, referring to direct emissions from Council's operations, indirect emissions from consumed electricity, and all other indirect emissions within Council's value chain. More information about types of emissions is available in Section 3.1.

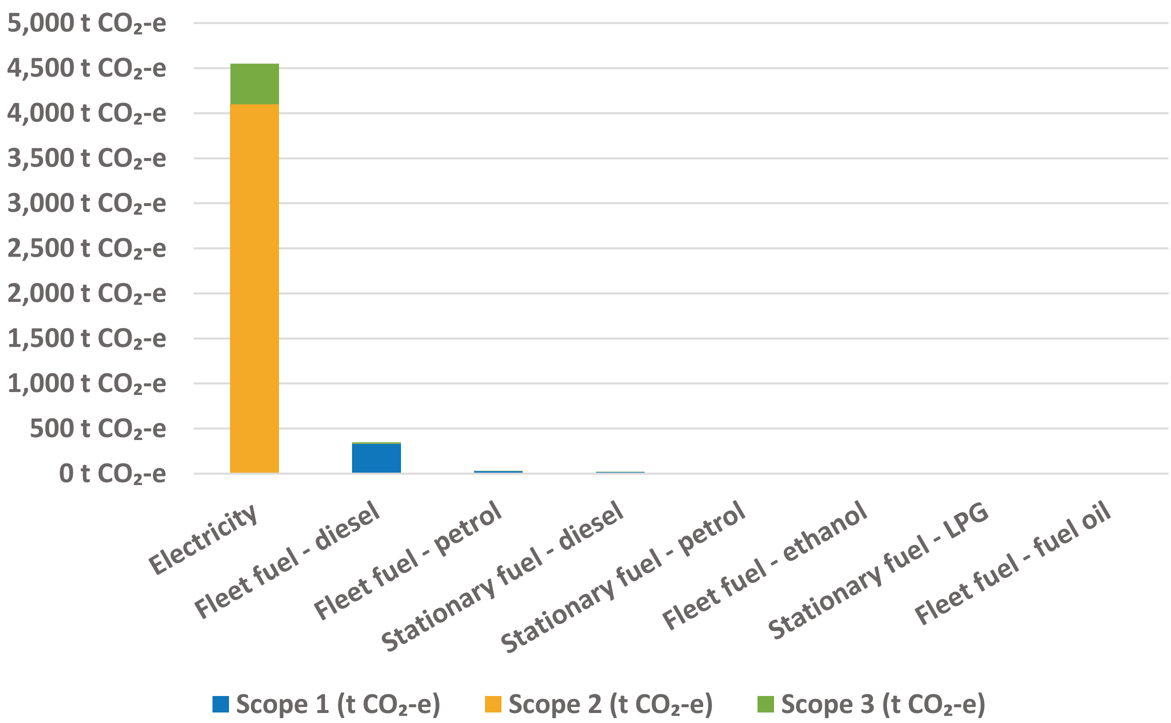


FIGURE 1: ROUS COUNTY COUNCIL'S FY 2022 CARBON FOOTPRINT BY EMISSION SOURCE AND SCOPE

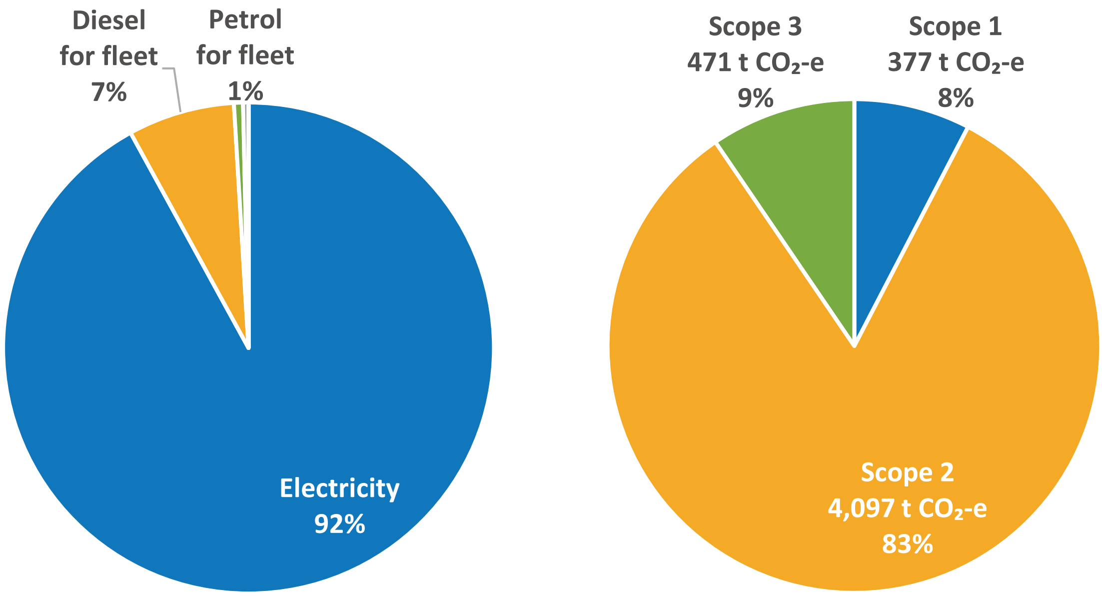


FIGURE 2: SPLIT OF ROUS COUNTY COUNCIL'S FY 2022 CARBON FOOTPRINT BY EMISSION SOURCE AND SCOPE

1.4 Year-on-year trends in Council's energy use and emissions

Council's data spanning financial years FY 2017-2022 indicates that electricity consumption across the assets remained steady, with major consumers being water treatment plants and pumping infrastructures. Solar PV installations have made modest contributions to offset electricity use and abate emissions. Fuel consumption, mainly from transport, accounts for approximately 8% of the carbon footprint and has varied moderately over the years. The following charts illustrate historical trends in energy use and carbon emissions:

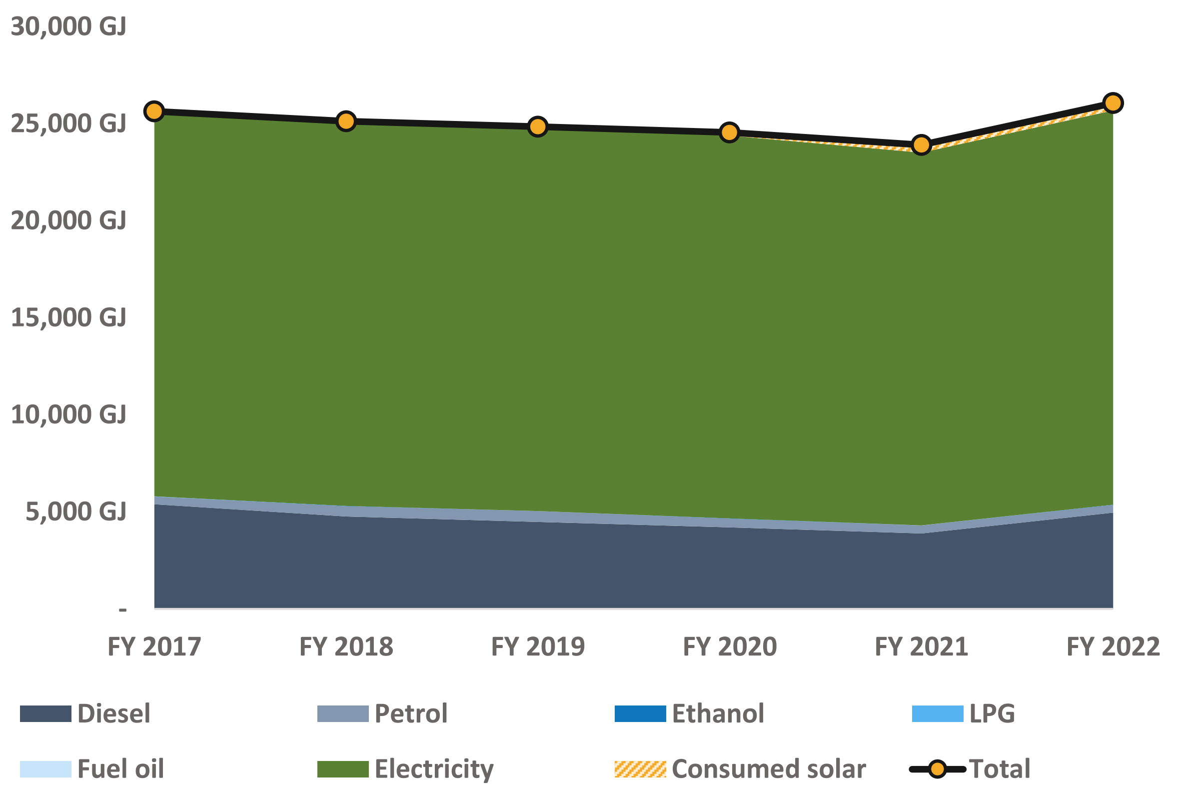


FIGURE 3: ROUS COUNTY COUNCIL'S HISTORICAL ENERGY CONSUMPTION TREND

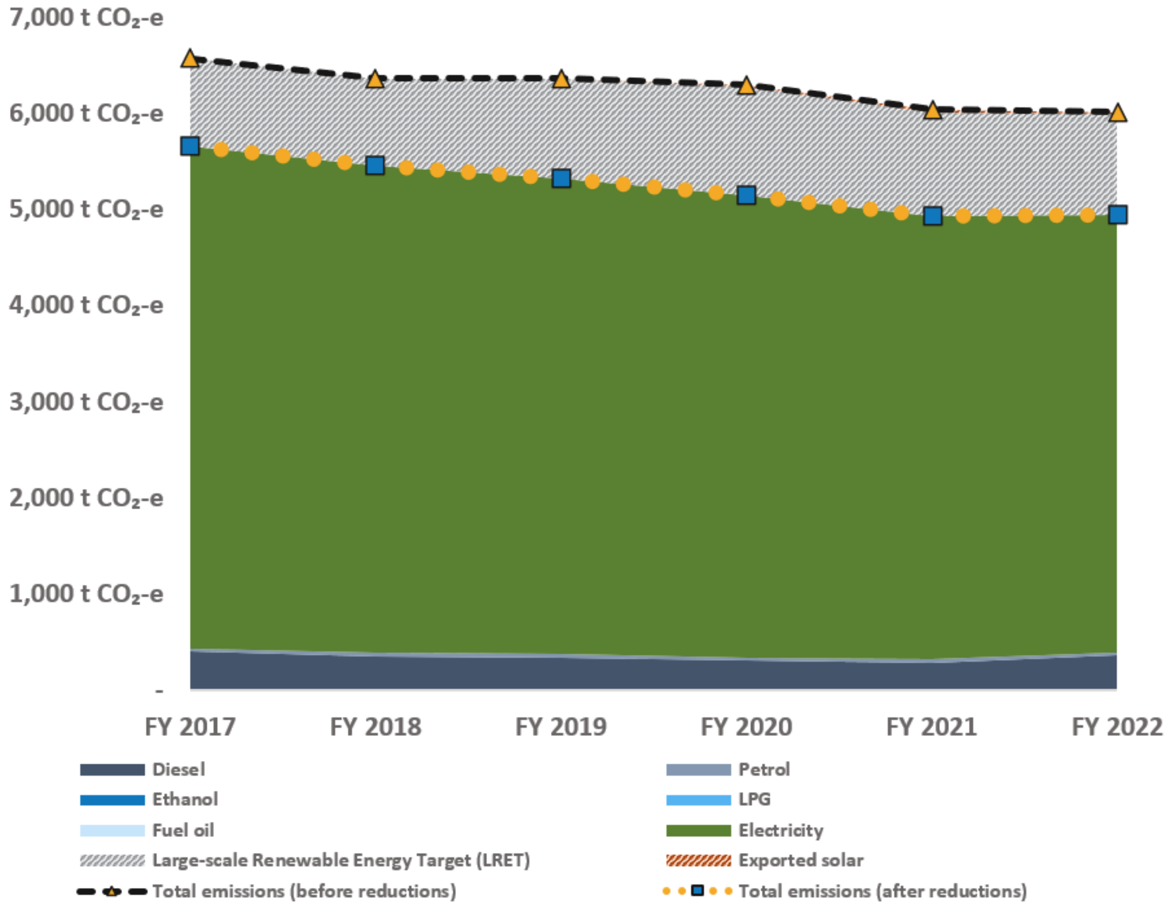
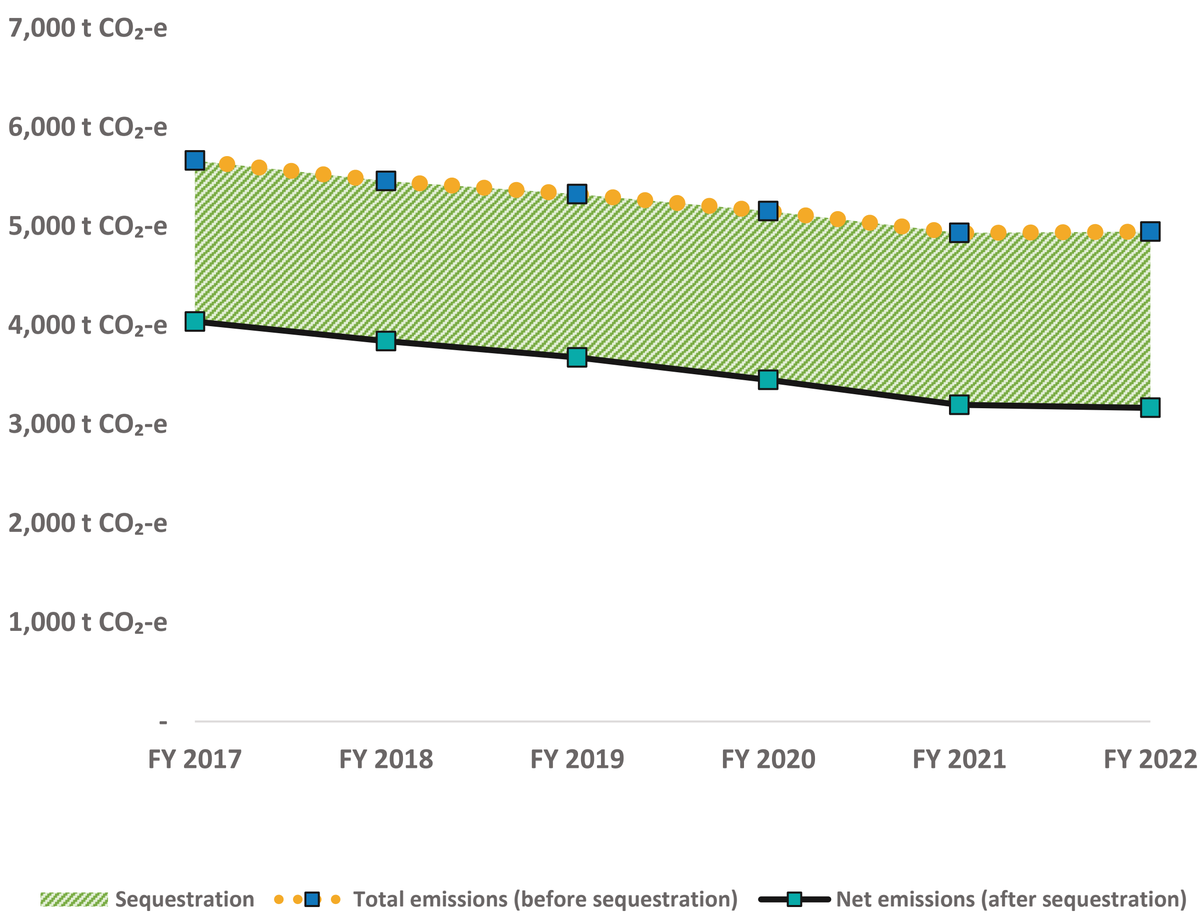


FIGURE 4: ROUS COUNTY COUNCIL'S HISTORICAL CARBON EMISSIONS TREND

1.5 Sequestration from tree planting

Subtracting sequestered carbon dioxide from the six-year trend of emissions estimates presented in Figure 4 above, Council's regeneration work at the four sites amounts to abatement of around 29-36% for each year. Provided below is an amended emissions trend graph that shows the emissions reduction due to Council's revegetation initiatives.



1.6 Survey of Councillors

A summary of strategic implications drawn from the survey results is outlined below:

- Secure water supply is of paramount importance.
- Act on more cost effective emission reduction measures in the short term where net financial benefit is likely.
- The transition to electric vehicles and equipment should be broadly supported, beginning with trials.
- Council should regularly monitor renewable electricity sourcing options for opportunities to purchase at prices similar or lower than grid energy offers.
- Council could reconsider capacity to absorb slightly higher electricity costs when cost of living pressures abate
- Savings / positive cashflow from measures should be accounted for and directed into the revolving energy fund. The Recurring Energy Fund should be better used to roll out projects while building financial capacity for consideration of renewable energy purchases and/or other emissions reduction measures in the future.

1.7 Battery technology viability

The project required assessment of a number of potential actions for site upgrades, additional PV installations, and replacing combustion engine outdoor equipment with battery-powered equipment.

Assessment of feasibility was conducted using a variety of approaches including undertaking review of current technology performance, site evaluation, appropriate system sizing, performance modelling, and financial cashflow forecasting. Cost estimates have been provided for equipment installation, and the methodologies adopted have assessed lifecycle cost viability including estimation of net present values (NPV).

Lithium-ion batteries can be considered a mature, reliable technology with clear advantages over other battery types. Although new battery types are under development, they cannot yet compete with lithium-ion for most applications. Beyond 2030, new battery types are likely to surpass lithium-ion for combined cost and performance, but this does not look likely before then. Most of the decline in lithium-ion battery prices has already occurred, and there is probably no financial benefit in waiting for further cost reductions, especially as electricity prices have been rising quickly, so any benefit gained by waiting would be more than offset by the need to pay more for electricity in the meantime.

Payback periods for BESS systems installed at water utilities are typically in the range of 6 to 10 years, depending on the specific circumstances of each installation.

1.8 Project feasibility assessments

The feasibility assessments undertaken for this project included the following steps:

- Review summary of sites' energy demand/import/export data
- Assess site energy demand and costs
- Consider site constraints and opportunities
- Determine appropriate system sizes for feasibility assessment
- Undertake cumulative cashflow analysis
- Provide data summary

A summary of results from feasibility assessments is provided in the table below

Table 1: Summary of solar PV & BESS opportunities at Rous County Council sites

Site name	Description of potential opportunity	Solar PV size	Battery capacity	Indicative capital costs ($)	Payback[1] (years)	IRR[1]	Year-1 savings ($)	NPV[1] ($)
Gallans Road Admin Offices	*Option 1:* Install a 35.9-kW roof-mounted solar PV at the north-facing roof to offset most of the site's daytime grid imports.	35.9 kW	-	~50,232	~3.7	30%	~12,636	~247,838
	Option 2: Alternatively, Council can consider utilising roof spaces in the middle portion and expand the solar PV capacity to 53.0 kW with 140 kWh of battery storage.	53.0 kW	140 kWh	~200,256	~7.9	13%	~21,827	253,404
Newrybar Pump Station	It is suggested to supplement the existing 30-kW solar PV system with a 45-kWh battery storage unit to reduce exports back to the grid.	-	45 kWh	~40,581	~8.0	12%	~4,609	~$ 33,869

[1] For estimation of payback period, internal rate of return & net-present values, escalation rate for electricity charges is set at 6% (average of 2-10% based on market ranges).

Site name	Description of potential opportunity	Solar PV size	Battery capacity	Indicative capital costs ($)	Payback[1] (years)	IRR[1]	Year-1 savings ($)	NPV[1] ($)
Emigrant Creek WTP	Investigate the potential to implement an additional 30-kWh battery storage unit to expand the existing 40-kW solar array.	-	30 kWh	~26,664	~7.6	12%	~3,185	~25,157
Rocky Creek Dam aerator	Council can consider installing a ground-mount 97.5-kW solar array in a small area south of the aerator. Additionally, it is suggested to transpose the site's operational hours forward to daytime to improve the system's economic viability amidst additional expenses for land clearing and extra cabling works.	97.5 kW	-	~212,673	~7.8	14%	~23,256	~324,714
Nightcap Raw Water Pumps	Council confirmed its plans of installing a further ~100-kW system on the roof of the water reservoir next to the Nightcap WTP. It is suggested to investigate the potential of augmenting the system with a battery storage unit for capturing exports during daytime.	~100 kW	68 kWh	~264,149	~8.2	13%	~26,710	~355,333

Site name	Description of potential opportunity	Solar PV size	Battery capacity	Indicative capital costs ($)	Payback[1] (years)	IRR[1]	Year-1 savings ($)	NPV[1] ($)
(Proposed) Russellton Estate Water Treatment Plant	Council affirmed that a new WTP will be situated at the Russellton Estate. Taking energy load profiles and structural configurations from the existing Emigrant Creek WTP as proxy, it is estimated that a roof-mounted solar PV system of 90-100 capacity with a ~200-kWh battery will be suitable to meet the proposed site's demand.	93.6 kW	210 kWh	~320,040	~8.3	12%	~33,276	~345,913

1.9 Fleet emissions

Fleet emissions currently represent 7.6% of RCC's carbon footprint. As shown in the table below, transport fuel use had been steadily dropping from 2017 to 2021, however 2022 saw a significant uptick in consumption with transport diesel use increasing 22%.

A review of key milestones in the evolution of the low emissions vehicle market is summarised below. The dates show a coalescing of key events in the 2026 to 2028 time period that, taken together, tip the scales in favour of seriously progressing the transition to EVs. Until then, hybrid vehicles will continue to have a lot of advantages over ICE-only vehicles both economically and environmentally. Beyond 2028, the case for electric vehicles becomes undeniable, just as model availability will be expanding rapidly. It would be wise to complete the transition to an all-electric fleet by 2035 in order to avoid both the risk of being impacted by an ICE vehicle ban as well as the likelihood of missing out on the substantial total cost of ownership and emissions savings offered by EVs by that time.

DC Fast Charging stations are far more expensive to install than Level 2 charging stations due to their higher electrical infrastructure requirements. Council may not require fast chargers to meet normal requirements, however, at least one or two fast chargers should be provided in the area for emergency situations and potentially be made available for public use (for example to support tourism at Rocky Creek Dam, and to enable community electric vehicle transition).

The most logical and convenient locations to begin trialling Level 2 charging infrastructure are at RCC's most used infrastructure locations, depots, offices, and at home for commuter use vehicles.

1.10Outdoor equipment

A requirement of the project is to consider RCC's outdoor equipment emissions and provide advice on the viability and timing of replacing outdoor equipment with electric alternatives

A review of RCC's outdoor equipment fuel consumption reveals the types of equipment responsible for most of the fuel consumption (and thus emissions).

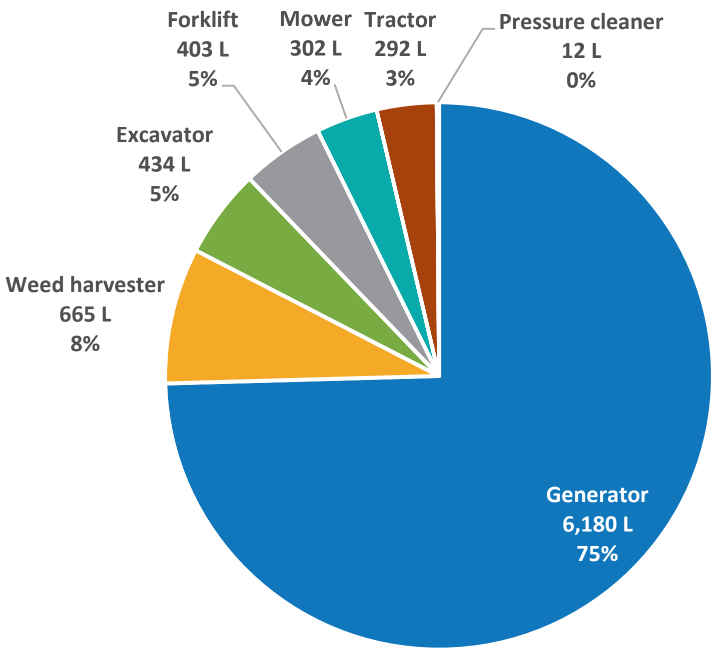


FIGURE 5: SPLIT OF OUTDOOR EQUIPMENT FUEL USE BY EQUIPMENT TYPE

As can be seen in the pie chart above, the generator used 75% of the outdoor equipment fuel. However this is due to its major refuelling in 2022 with 6.15 kL of diesel, which has had a small but significant impact on the carbon footprint for the 2022 FY.

Like electric vehicles, the availability of electric outdoor equipment is set to expand rapidly around the middle to the end of this decade. Desktop research was undertaken to assess the availability of electric alternatives built by high quality brand names. The review indicated that by 2026 there will be high quality electric alternatives for all equipment types with the possible exception of large scale weed harvesters.

Electric outdoor equipment shares similarities with EVs, for example in the potential total cost of ownership savings, and in the requirement for similar (type 2) charging infrastructure. For these reasons, it would be advisable to consider outdoor equipment transition and fleet transition as one process and undertake planning and technical trials accordingly, with a target date for 100% transition to be 2035 in both cases.

1.11 Recommendations

The recommended plan for RCC has considered a range of factors including:

- Progress on renewable energy and emissions reduction measures since 2018
- Views of RCC stakeholders including Councillors and operational staff
- Current global, state and local government policy context
- Outlook on technology maturity, costs and benefits
- Economic and practical feasibility of potential capital works projects
- Relevant trends, constraints, risks and opportunities

With these factors in mind, it is advised that RCC consider and adopt the following recommendations:

Emission reduction targets

- Council to target zero emissions by 2050 (in line with State and Federal targets).
- Council to target 70% emissions reduction by 2035 (in line with NSW Government target).
- **Grid decarbonisation will deliver the bulk, but not all, of these required reductions.**

Tree planting / revegetation

- Maintain or (if space allows) increase current rates of revegetation until at least 2035 in order to ensure significant rates of cumulative sequestration can be supported through to 2050.
- Consider measures to support the resilience of revegetated areas to possible future disturbance by fire to avoid any negative "step change" impacts on Council's carbon footprint.

Energy efficiency

- By 2025, review options for demand scheduling optimisation

PV & BESS Projects

- By 2028, implement prioritised projects. Prioritisation should be made with the following factors in mind:
    - Economic feasibility as indicated by payback period, Net Present Value (NPV), and other financial metrics. The ratio of capital cost to NPV can also be considered as a rough indicator of project return on investment.
    - Scale of additional renewable energy generation and emissions reductions
    - Potential for "bundling" or scheduling with other infrastructure projects, where clear synergies or efficiencies can be identified

Renewable electricity purchases

- From 2023, conduct market sounding ahead of contract cycle along with constituent councils and look to secure a PPA where there is no additional cost compared with a regular grid offer.

Fleet and outdoor equipment transition

- Implement trial program to run 2025 to 2028.
- Trial findings to inform full scale transition to be implemented 2028 to 2035.
- Target for all new vehicle and equipment purchases to be electric by 2035.

Residual emissions

- From 2028 to 2035, implement a strategy to reduce emissions from suppliers in order to address any of RCC's residual scope 3 emissions.
- From 2035 progressively build a quality carbon offset portfolio to offset any remaining emissions by 2050.

REERP Review

- Undertake a review of this Plan in 2028 to include at a minimum:

- Review of progress on implementing PV/BESS projects and assessment of additional opportunities in relation to new/planned infrastructure or building works
- Review progress on PPA implementation. In the absence of a PPA, and with consideration to positive cashflow forecasts from projects, agreements, and EV transition, revisit capacity for Greenpower purchases.
- A detailed business case assessment for a ground-mounted PV array at Gallans Road estate including a detailed business case assessment for 'virtual net metering' and a comparison to other potential larger-scale projects such as pumped hydro

The recommendations for getting to net zero emissions by 2050 have been presented in timeline form below:

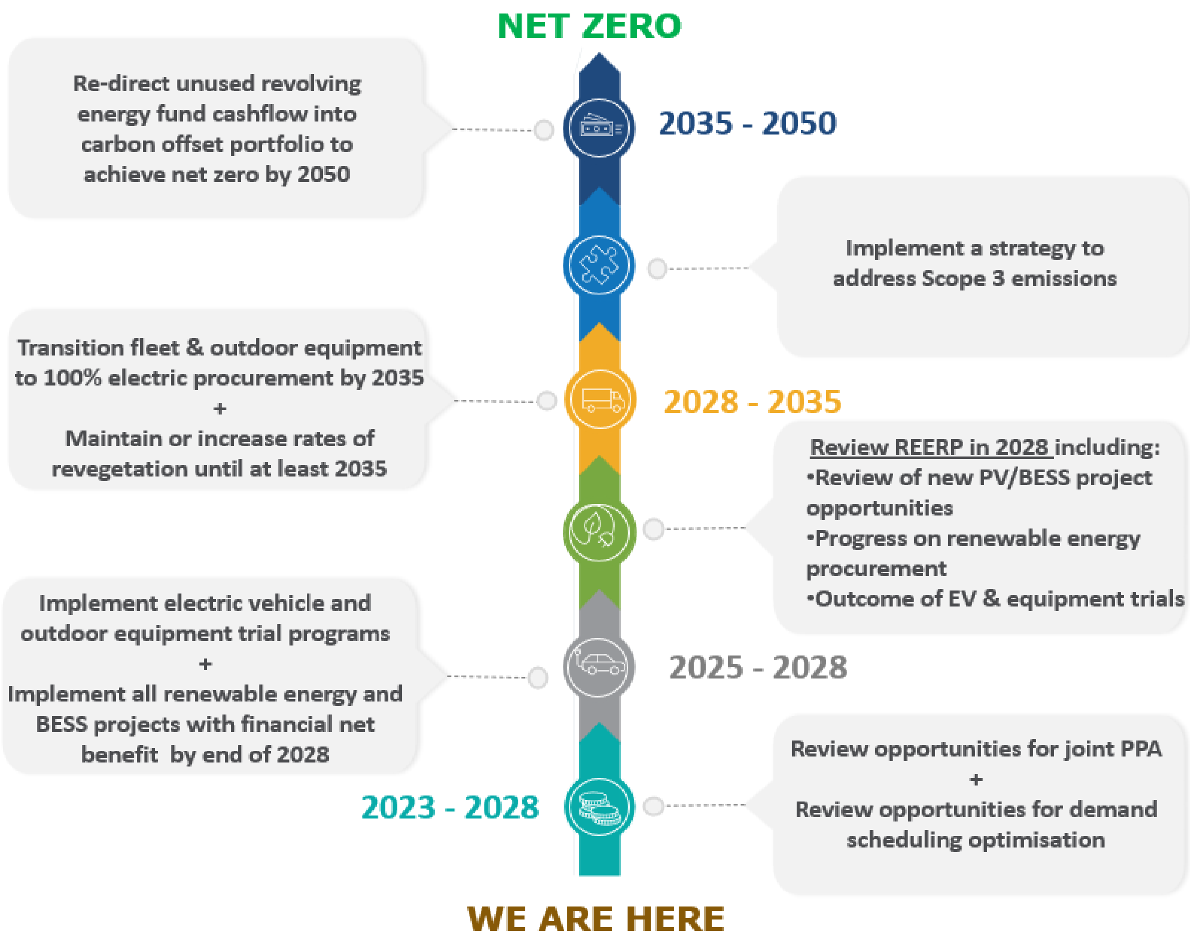


FIGURE 6: ROUS COUNTY COUNCIL'S TIMELINE OF ACTIONS TOWARDS NET ZERO BY 2050

2 Project scope and context

2.1 Purpose

Rous County Council (RCC) engaged 100% Renewables to develop a Renewable Energy and Emissions Reduction Plan (REERP) that aims to identify and assess various opportunities for reducing greenhouse gas (GHG) emissions originating from Council's operations, aligns with Council's adopted Business Activity Strategic Plan (BASP) 2022-2032, and builds upon RCC's Greenhouse Gas (GHG) Abatement Strategy from 2018.

The purpose of this REERP is to provide an update to Council's 2018 Greenhouse Gas Abatement Strategy and provide Council with an overview of current viable abatement opportunities available for its operations that in turn, can enable Council to align with NSW Government's objective of reaching state-wide net zero emissions by 2050.

2.2 Background to this project

In 2018 Rous County Council (RCC) engaged the services of 100% Renewables to assist in developing a Greenhouse Gas Abatement Strategy for its operations' carbon footprint.

The 2018 strategy recommendations are summarised below:

- Focus on operational energy use that is significant – i.e. electricity consumption.
- RCC will account for both electricity use and fleet fuel consumption in its carbon footprint reporting.
- Targets will initially be expressed in terms of renewable energy goals for operational electricity use.
- Carbon targets may be set at a later time and may include transport fleet and other sources.
- RCC will set ambitious renewable energy (RE) targets, including a 100% RE target for electricity use by 2030, where financially sustainable to do so.
- Short and medium term targets/actions will reflect opportunities identified within RCC operations.
- Long term targets will require further assessment of procurement and generation options, both by RCC and in conjunction with regional partners such as RCC's constituent councils.

Since 2018, Council has progressed a number of short and medium-term emissions abatement projects proposed in the Greenhouse Gas (GHG) Abatement Strategy, underpinning its commitment towards climate action. Presented below is an implementation timeline of these initiatives which include solar PV and battery installations at RCC operational sites, seed-funding of a Revolving Energy Fund (REF), and uptake of hybrid vehicles.

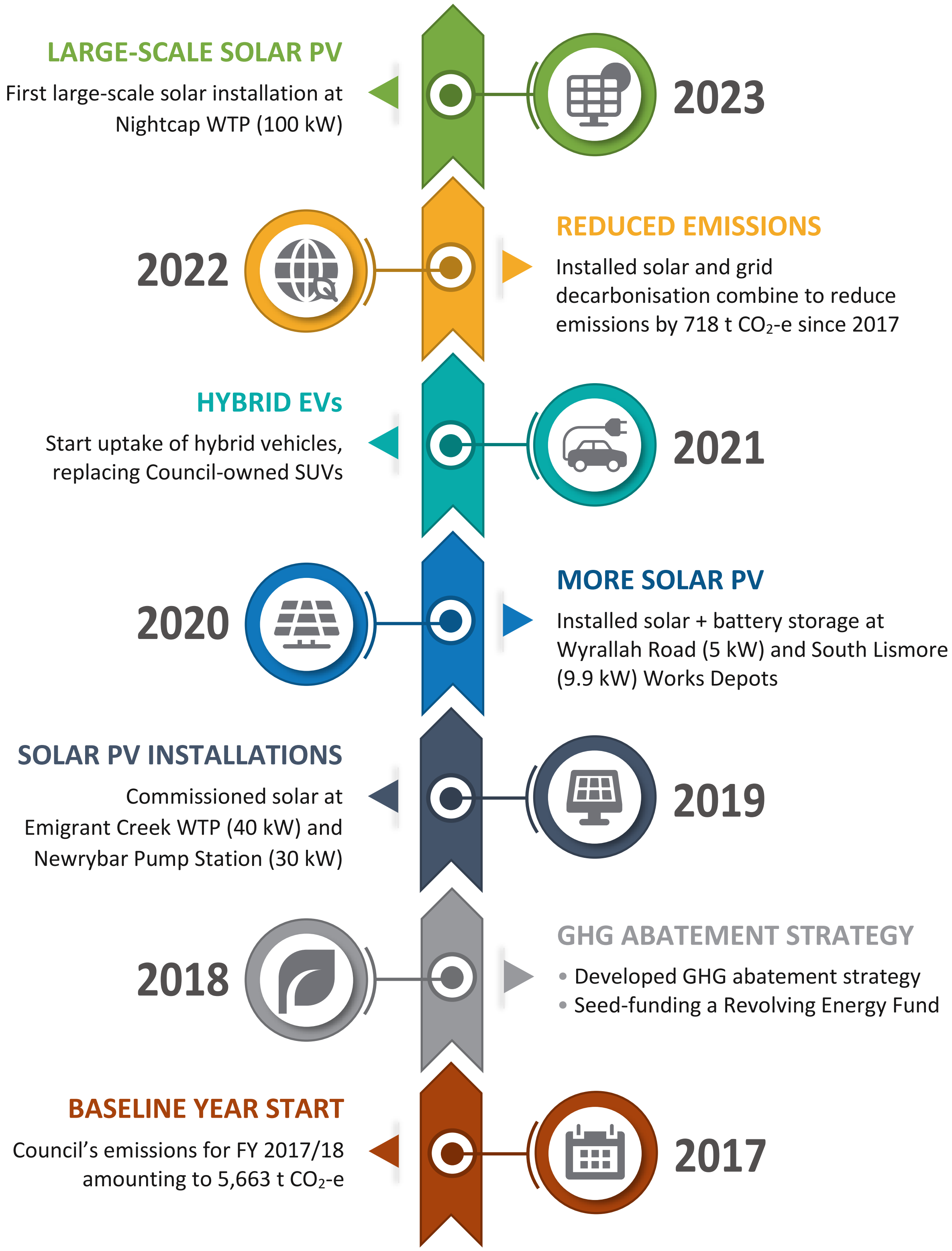


FIGURE 7: ROUS COUNTY COUNCIL'S TIMELINE OF ACHIEVEMENTS TOWARDS CLIMATE ACTION

2.3 Project scope and deliverables

The scope of the current project is as follows:

- Provide an overview of progress to date, including a summary of relevant projects.
- Perform an energy and carbon footprint comparison of the current and 2016/17 baseline position.
- Develop an electronic questionnaire for acceptance by the project team for issue to Councillors and staff (to collect key information on strategic and operational considerations).
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- Review renewable energy targets for electricity use.
- Consider actions required for achieving overall net zero greenhouse gas emission for Council's operations.
- Undertake sequestration modelling for Council's tree planting activities and provide related advice.

2.4 Global context

At a global level, the call to action for countries to act on climate change has been increasing for several years. According to the IPCC's report, *Climate Change 2021: the Physical Science Basis* we have emitted over 85% of all emissions we can emit if we are to have a chance of remaining within 1.5°C of warming in the long term. Key agreements and reports that underpin international consensus to act include:

1. Sustainable Development Goals (SDGs)[2]
2. Paris Agreement[3]
3. Special IPCC report on 1.5°C warming (SR15)[4], and
4. IPCC Sixth Assessment Reporting cycle (AR6)[5]

[2] Sourced from https://www.un.org/sustainabledevelopment/development-agenda/
[3] Sourced from https://www.un.org/sustainabledevelopment/climatechange/
[4] Sourced from https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Full_Report_HR.pdf
[5] Sourced from https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf

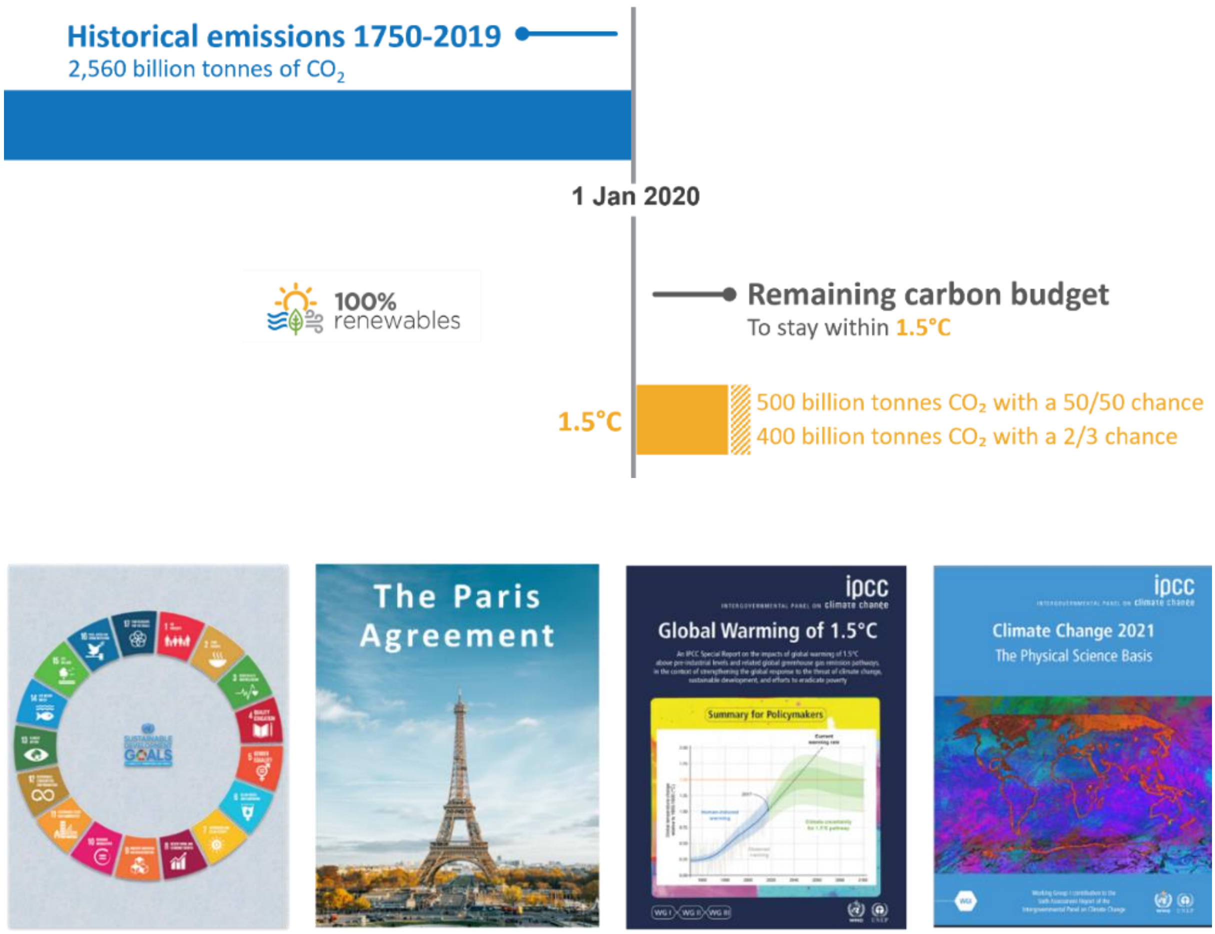


FIGURE 8: GLOBAL CONTEXT FOR ACTION ON CLIMATE

The pathway to follow if a safe future climate is a goal is to ***start today, make deep emissions cuts, and persist on this path for years to reach net zero emissions***. For RCC to align with global net zero goals and principles would require:

1. GHG emissions from stationary fuel combustion such as diesel are minimised, and
2. GHG emissions from electricity consumption are minimised, and
3. GHG emissions from transport fuel combustion are minimised, and
4. Supply chain (eg outsourced services) emissions are addressed, and
5. Remaining emissions are offset or removed through new sequestration measures

2.5 Changing national and local context

In Australia, the commitment to addressing climate change is becoming more uniform and aligned towards international goals across all levels of government. This includes ambitious efforts towards decarbonisation by the middle of the century.

- The Federal Government has legislated emissions reduction of 43% by 2030 (from 2005 levels) and is committed to net zero by 2050.
- NSW Government has a target of 70% emissions reduction by 2035 and net zero by 2050, as yet unlegislated.
- A large number of regional local governments and communities representing more than two thirds of NSW population are committed to deep emissions cuts.

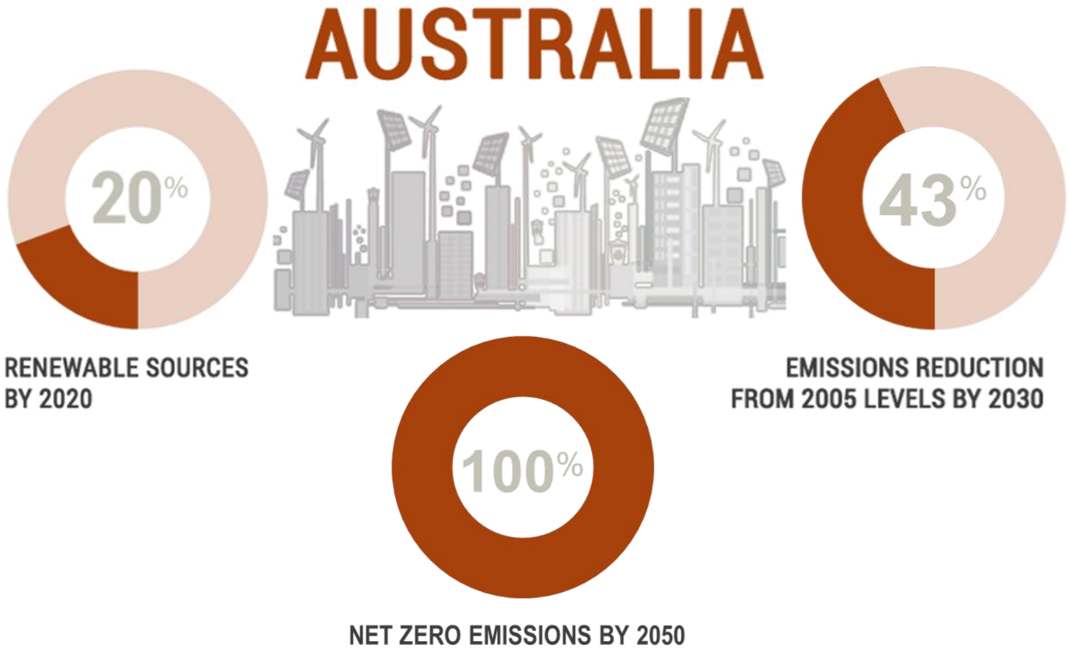


FIGURE 9: AUSTRALIA'S EMISSIONS REDUCTION GOALS AT A NATIONAL LEVEL

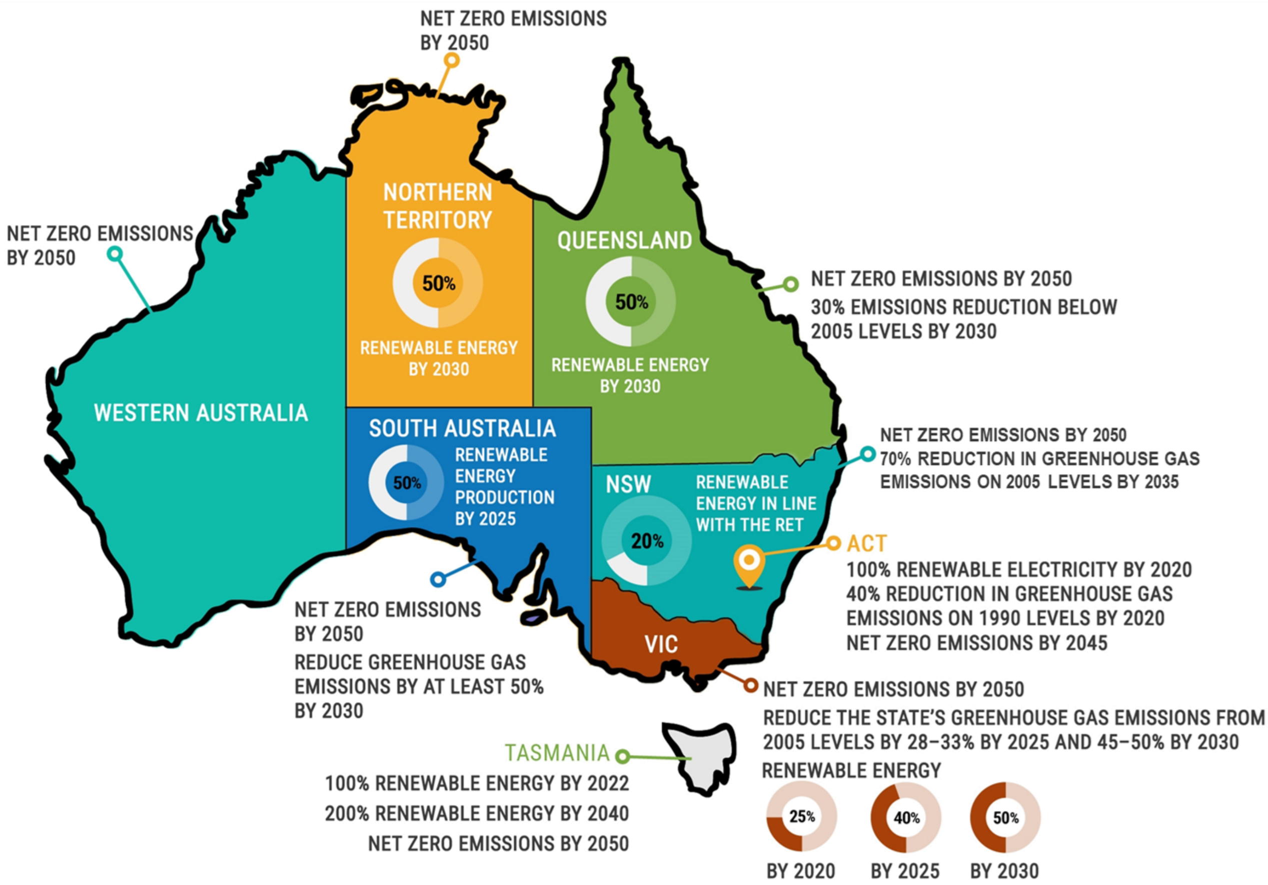


FIGURE 10: AUSTRALIA'S EMISSIONS REDUCTION GOALS AT STATES LEVEL

By the end of 2022, 40 out of 128 Councils in NSW have already declared a Climate Emergency[6]. This has led to some of the following outcomes across several councils:

- Increased focus and priority on reducing council carbon emissions and promoting sustainability.
- Development and implementation of a Climate Change Mitigation Plan or similar for Council and community emissions.
- Increased public engagement, education and literacy on climate change and opportunity.
- Better alignment with state and national climate goals and initiatives; and
- Potential for increased funding and support from state and federal governments for climate action

[6] Sourced from https://www.cedamia.org/ced-regions-in-australia/

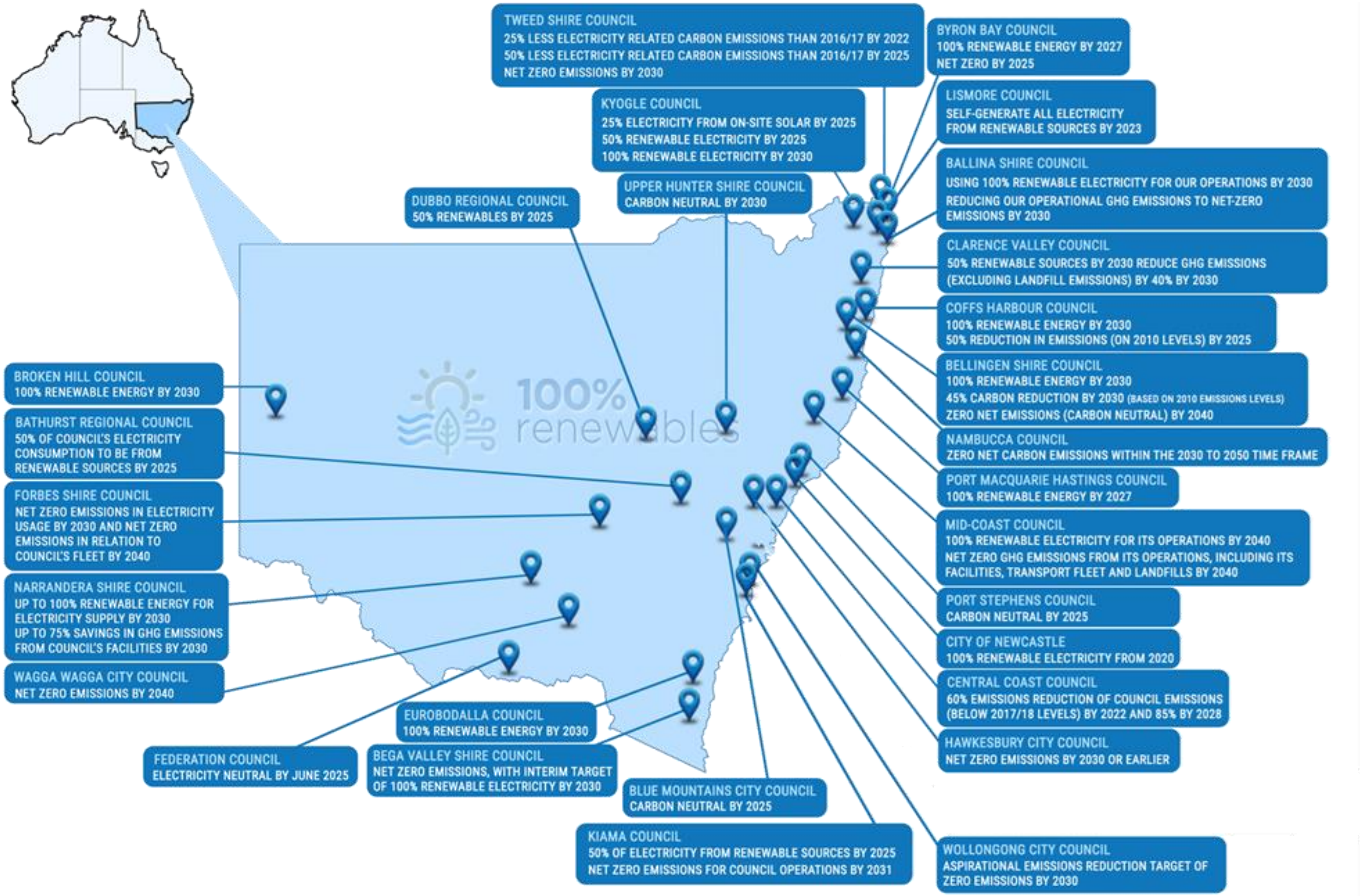


FIGURE 11: NSW LOCAL GOVERNMENTS EMISSIONS REDUCTION 2022

2.6 Grid decarbonisation

Over the next decades, coal-fired power stations in Australia, including NSW, will be replaced by renewable energy generation technologies such as solar, wind, pumped hydro, and grid-scale batteries.

In its Integrated System Plan 2022, the Australian Energy Market Operator (AEMO) considers different scenarios based on factors such as demand drivers, Distributed Energy Resources (DER) uptake, emissions, large-scale renewable build cost trajectories, investment and retirement considerations, gas market settings, coal price settings, policy settings, and transmission infrastructure development.

The resulting scenario outcomes for penetration of renewable energy in the National Electricity Market (NEM) are shown below, indicating a high probability of a rapid transition to renewables under the expected 'Step Change' scenario. The NSW Government's Electricity Infrastructure Investment Bill will facilitate the transition to renewables in NSW, as reflected in the ISP2022 forecasts.

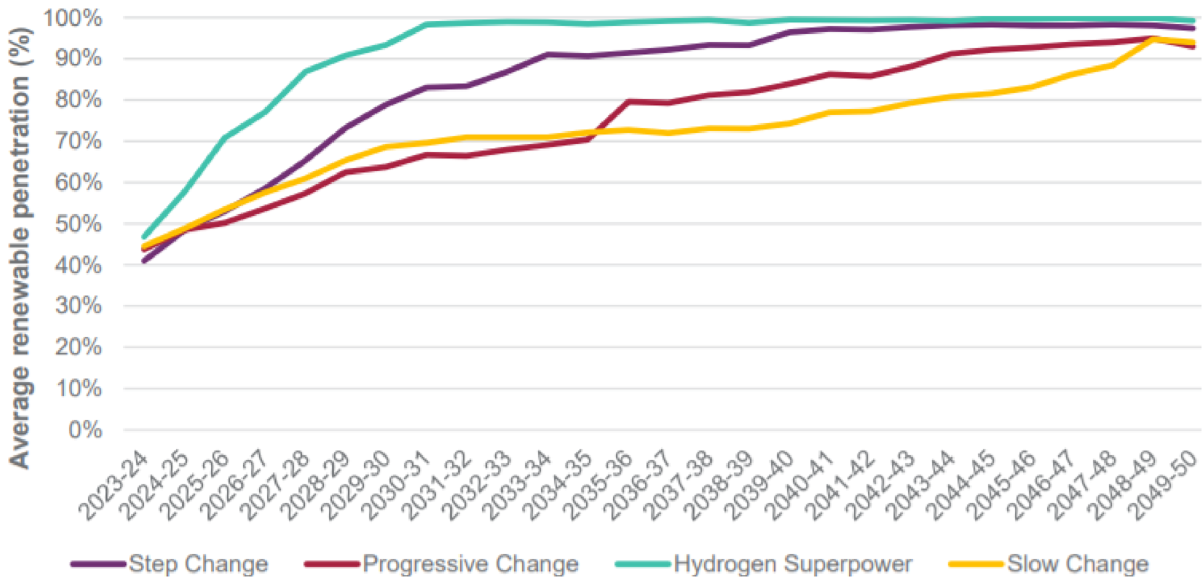


FIGURE 12: AEMO MODEL OF RENEWABLE ENERGY PENETRATION IN ISP2022 SCENARIOS[7]

Electricity emissions for Rous County Council's operations will be significantly reduced as the grid transitions towards renewable energy sources.

[7] AEMO: https://aemo.com.au/consultations/current-and-closed-consultations/2022-draft-isp-consultation

2.7 Survey of Councillors

To help establish parameters for development of RCC's emissions reduction strategy, strategic input was sought from RCC's Councillors regarding key issues and opportunities. A questionnaire was developed to gauge Councillor views on strategic goals and constraints, and to assess their level of support for a range of potential emission reduction measures and capital works projects. Results from the questionnaire were analysed and used to shape the development of this report and the recommendations contained therein.

100% renewables worked with RCC staff to develop a range of questions crafted to quickly gather input on key issues. Thought was given to the design of the survey in terms of being able to collect fixed quantitative information as well as allowing free text responses. Questions were refined through an iterative process in consultation with RCC staff. RCC then organised the distribution of the survey and provided several weeks for responses. Responses to the survey were discussed during a project meeting between RCC and 100% renewables and general interpretations and conclusions were drawn.

A detailed summary of the findings can be found in the Appendices.

2.7.1 Implications for REERP

The findings from the survey, including review of all "free text" responses, provided useful insights for informing the development of this REERP. Councillors generally felt that, because of the ongoing electricity price increases, cost of living pressures, interest rates, drought, fires, pandemic and floods, there is very limited short-term capacity to pass on additional costs of emission reduction measures, and that RCC should not pursue targets any more ambitious than the benchmarks set by the NSW and Commonwealth Governments.

The responses also indicated that operational reliability should not be compromised in pursuing emission reduction goals, and that projects needed to consider future likelihood of further natural disasters. Positive implications of the survey include the broad support to undertake cost effective emission reduction measures in the short term and medium term, and an openness to purchase renewable energy where it makes financial sense to do so.

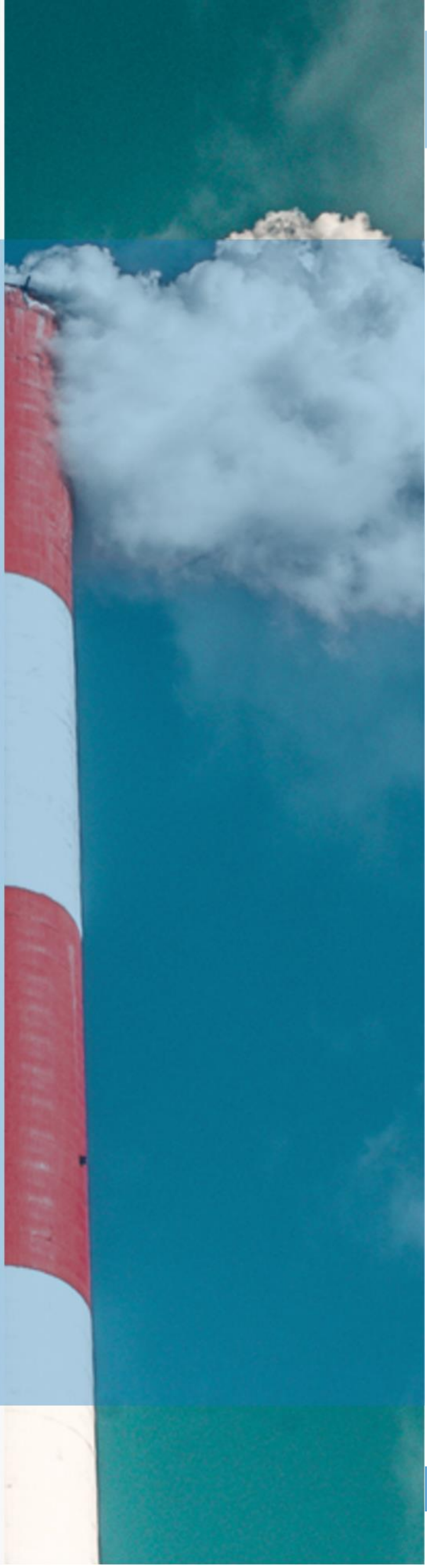
A summary of strategic implications drawn from the survey results is outlined below:

- Secure water supply is of paramount importance.
- Act on more cost effective emission reduction measures in the short term where net financial benefit is likely.
- The transition to electric vehicles and equipment should be broadly supported, beginning with trials.
- Council should regularly monitor renewable electricity sourcing options for opportunities to purchase at prices similar or lower than grid energy offers.
- Council could reconsider capacity to absorb slightly higher electricity costs when cost of living pressures abate
- Savings / positive cashflow from measures should be accounted for and directed into the revolving energy fund. The Recurring Energy Fund should be better used to roll out projects while building financial capacity for consideration of renewable energy purchases and/or other emissions reduction measures in the future.

100% renewables

Council Operations

Greenhouse Gas Emissions



3 Rous County Council emissions

This section of the report presents the results of calculations to quantify Council's carbon footprint and GHG emissions for the period 2017 to 2022. This chapter focuses exclusively on emission sources, omitting any discussion of sequestration, which is covered in Section 4.

3.1 Overview of emission scopes

To help differentiate between different greenhouse gas emission sources, emissions are classified into the following scopes according to the GHG Protocol[8] – Corporate Standard:

- **Scope 1 emissions** are emissions directly generated at your operations through the combustion of fuels, and fugitive emissions from refrigerant gases in your air conditioning equipment.
- **Scope 2 emissions** are caused indirectly by consuming electricity. These emissions are generated outside your organisation (in fossil fuel power plants), but you are indirectly responsible for them.
- **Scope 3 emissions** are also indirect emissions and happen upstream and downstream of your business. Typical examples are staff commute, air travel, the purchase of goods and services, contractor emissions, or leased assets. Emissions associated with the distribution of electricity from the power plant to your site are accounted for under scope 3.

FIGURE 13: SCOPE 1, SCOPE 2, AND SCOPE 3 EMISSIONS

[8] Sourced from https://ghgprotocol.org/

3.2 Scope of emissions assessed for Rous County Council

Illustrated below is a diagram depicting the operational boundary of Council's carbon footprint, covering scope 1 and scope 2 emissions. Consistent with the methodology adopted in RCC's 2018 GHG Abatement Strategy, scope 3 emissions (other than electricity supply) can be excluded due to their immateriality and can be reassessed by Council as it makes more substantial progress towards reducing scope 1 and 1 emissions. The measurement of current emissions coverage follows the Australian Government's Climate Active Standard, which aligns with GHG Protocol and enables the attainment of carbon neutrality through a reliable framework for quantifying greenhouse gas emissions. In addition, the standard provides a comprehensive guidance on how to measure, reduce, offset, validate and report emissions arising from an organisation's operations.

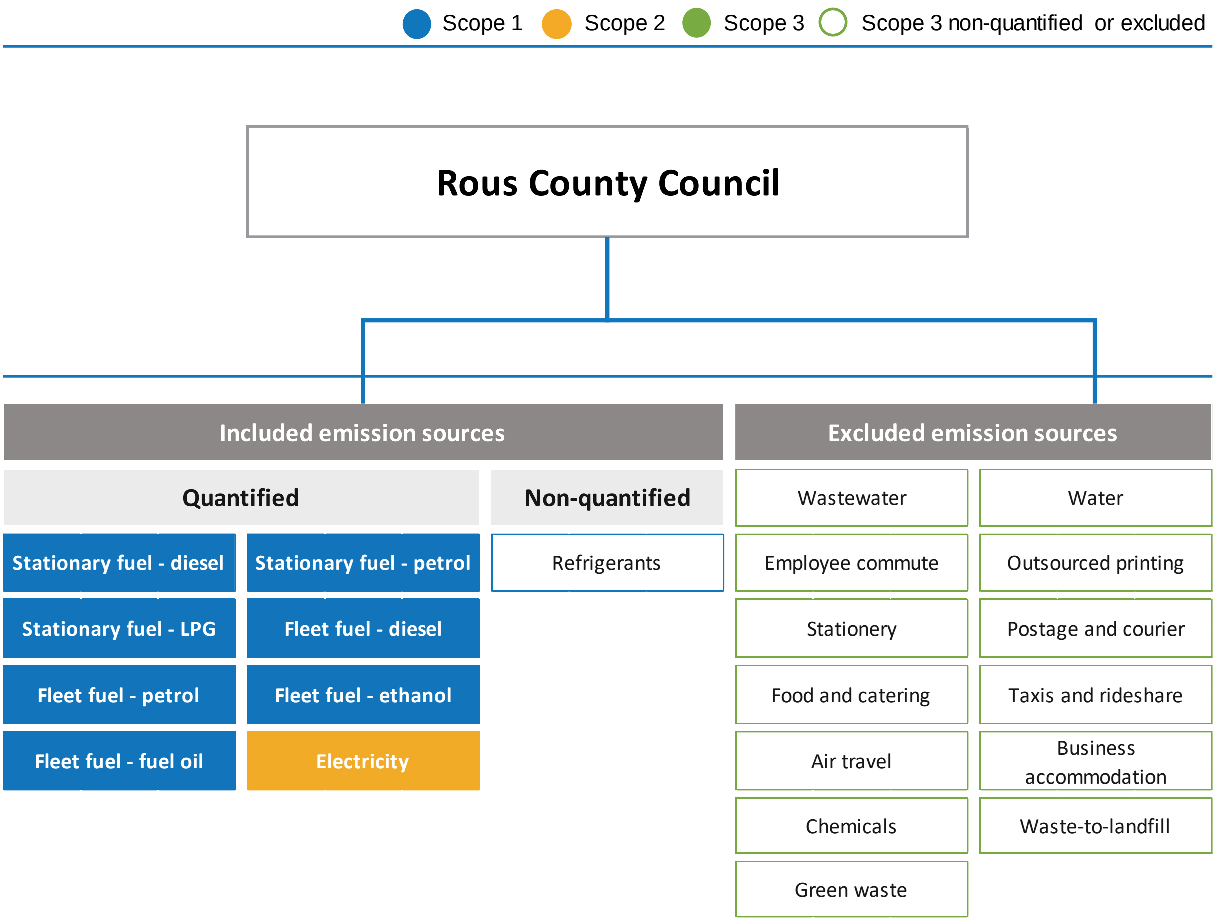


FIGURE 14: OPERATIONAL BOUNDARY OF ROUS COUNTY COUNCIL'S FY 2022 CARBON FOOTPRINT

As scope 3 emissions become more materially relevant over time, a comprehensive carbon footprint that is in accord with the Commonwealth Government's Climate Active Carbon Neutral Standard could in future potentially comprise a range of scope 3 emission sources including:

- Business travel such as flights
- Taxis and hire cars
- Detailed analysis of professional services (e.g. technical, accounting and legal services)
- Postal and courier services
- Refrigerant gas leakages from onsite air-conditioning and refrigeration systems
- Embodied emissions in building construction or alternation projects
- Telecommunications equipment and services
- Cleaning services
- Staff clothing expenses
- Office furniture and other purchased or replaced equipment

A detailed scope 3 analysis is usually created when an organisation plans to commit to carbon neutrality, or an organisation intends to better understand 'hot-spot' emission sources in the value chain and explore ways to collaborate with suppliers to reduce their emissions.

3.3 FY 2022 carbon footprint

The baseline year for RCC's 2018 Greenhouse Gas Abatement strategy is the 2016/17 financial year. For providing a "snapshot" comparison, RCC's carbon footprint was developed for FY 2021/22.

Rous County Council's carbon footprint for FY 2021/2022 was **4,945 t CO_2-e,** or around a ~13% decrease from the FY 2016/2017 footprint of 5,663 t CO_2-e. A detailed tabulation of the carbon inventory is provided below.

TABLE 2: ROUS COUNTY COUNCIL'S FY 2022 CARBON INVENTORY

Emission source	Activity data	Units	Scope 1 (t CO_2-e)	Scope 2 (t CO_2-e)	Scope 3 (t CO_2-e)	Total	%
Stationary fuel - diesel	6	kL	16.7		0.9	**17.5 t CO_2-e**	**0.35%**
Stationary fuel - petrol	0.02	kL	0.05		0.003	**0.05 t CO_2-e**	**0.00%**
Stationary fuel - LPG	0.01	kL	0.01		0.001	**0.01 t CO_2-e**	**0.00%**
Fleet fuel - diesel	122	kL	332.0		17.0	**349.0 t CO_2-e**	**7.06%**
Fleet fuel - petrol	12	kL	28.3		1.5	**29.8 t CO_2-e**	**0.60%**
Fleet fuel - ethanol	0.21	kL	0.01		-	**0.01 t CO_2-e**	**0.00%**
Fleet fuel - fuel oil	-	kL	-		-	-	-
Electricity	5,643,043	kWh		4,097	451	**4,549 t CO_2-e**	**91.98%**
TOTAL			377 t CO_2-e	4,097 t CO_2-e	471 t CO_2-e	4,945 t CO_2-e	100.00%

Greenhouse gas emissions from electricity consumption comprise the bulk of Council's total footprint, accounting for 92% of the whole. The remaining 8% of the total emissions originate from fuel consumption, with diesel use for Council fleet being the primary contributor. RCC's carbon inventory is presented visually through the following charts.

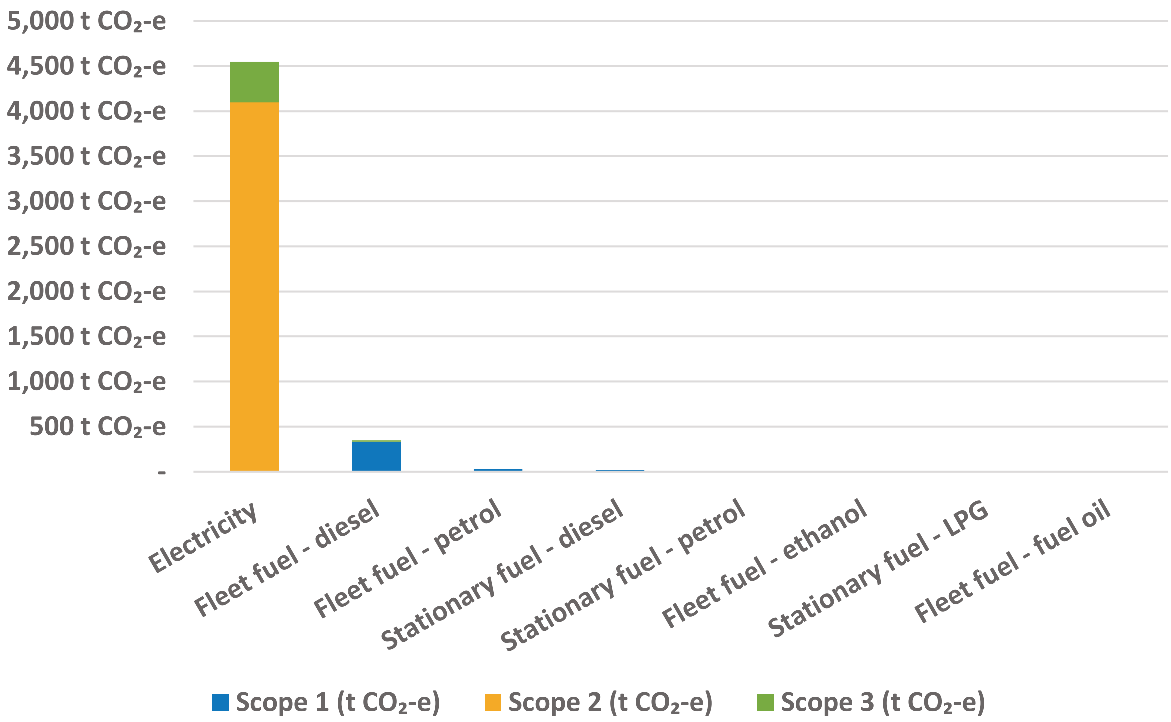


FIGURE 15: ROUS COUNTY COUNCIL'S FY 2022 CARBON FOOTPRINT BY EMISSION SOURCE AND SCOPE

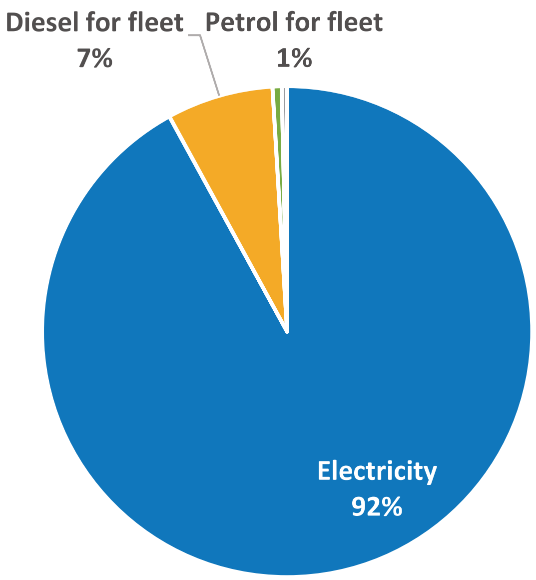


FIGURE 16: SPLIT OF ROUS COUNTY COUNCIL'S FY 2022 CARBON FOOTPRINT BY EMISSION SOURCE

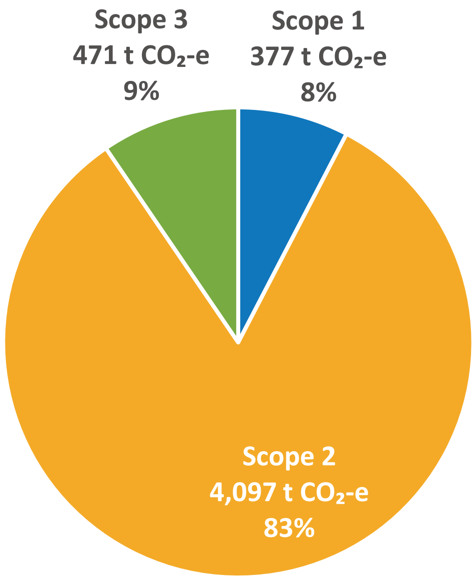


FIGURE 17: SPLIT OF ROUS COUNTY COUNCIL'S FY 2022 CARBON FOOTPRINT BY SCOPE

3.4 Year-on-year trends in Council's energy use and GHG emissions

The following section expands the analysis by comparing energy use and emissions across financial years FY 2017-2022.

TABLE 3: ROUS COUNTY COUNCIL'S FY 2017-2022 GRID ELECTRICITY CONSUMPTION FOR ASSETS

Site name	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
Nightcap Water Treatment Plant	2,211 MWh	1,702 MWh	1,855 MWh	2,013 MWh	2,010 MWh	1,890 MWh
Nightcap Raw Water Pumps	1,297 MWh	1,270 MWh	1,330 MWh	1,332 MWh	1,281 MWh	1,182 MWh
Wilson River - High Lift Pumps (x3)	658 MWh	758 MWh	859 MWh	705 MWh	675 MWh	883 MWh
Rocky Creek Dam Aerator	386 MWh	366 MWh	347 MWh	356 MWh	543 MWh	408 MWh
Emigrant Creek Water Treatment Plant	334 MWh	445 MWh	557 MWh	533 MWh	329 MWh	424 MWh
Rous County Council Administration Offices	190 MWh	154 MWh	184 MWh	178 MWh	175 MWh	145 MWh
Wilson River - Low Lift Pump	119 MWh	136 MWh	152 MWh	129 MWh	124 MWh	248 MWh
Lagoon Grass Pump Station	138 MWh	145 MWh	151 MWh	199 MWh	181 MWh	158 MWh
Gallans Rd Admin Offices	-					48 MWh
Knockrow Newrybar Pump Station	59 MWh	41 MWh	68 MWh	36 MWh	16 MWh	19 MWh
(Other Council sites)	121 MWh	-	-	-	-	237 MWh
Total	**5,512 MWh**	**5,017 MWh**	**5,502 MWh**	**5,481 MWh**	**5,334 MWh**	**5,643 MWh**

The relative electricity demand across RCC's assets has remained consistent over the years, with water treatment and pumping infrastructure being the largest consumers. Of interest is the doubling of demand between FY 2021 and 2022 at the Wilson River Low Lift Pump.

Council has commissioned solar PV at a number of its sites since the development of GHG Abatement Strategy in 2018. Cumulative values for self-consumed and exported solar for three financial years point to small but significant contributions to offset electricity use and abate emissions. A detailed breakdown of solar generation data is presented in Section 4 (Table 6).

Table 4: Rous County Council's FY 2017-2022 self-consumed and exported solar

Component	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
Solar self-consumed	-	-	-	46,201 kWh	112,095 kWh	105,910 kWh
Solar exports	-	-	-	17,071 kWh	32,644 kWh	30,408 kWh

Fuel constitutes roughly 8% of the carbon footprint, and absolute amounts consumed have varied significantly over the years. Transport fuel accounts for the majority of the total volume consumed. Ethanol consumption was extracted from fuel data pertaining to consumed E10 petrol, which contains about 10% of the compound.

Table 5: Rous County Council's FY 2017-2022 fuel consumption per fuel type

Fuel type	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
Diesel	140 kL	124 kL	116 kL	109 kL	101 kL	128 kL
Petrol	11 kL	15 kL	16 kL	13 kL	12 kL	12 kL
Ethanol	0.56 kL	0.29 kL	0.26 kL	0.27 kL	0.23 kL	0.21 kL
LPG	-	-	-	-	-	0.01 kL
Fuel oil	-	-	-	0.06 kL	0.03 kL	-
Total	**152 kL**	**139 kL**	**133 kL**	**122 kL**	**113 kL**	**140 kL**

3.5 Summary of Council's energy use and emissions since 2017

The graph below shows RCC's energy use dipped slightly in FY 2021, before increasing to its highest level in FY 2022. However, the overall increase since the baseline year has been insignificant and in line with expected demand increase due to population growth.

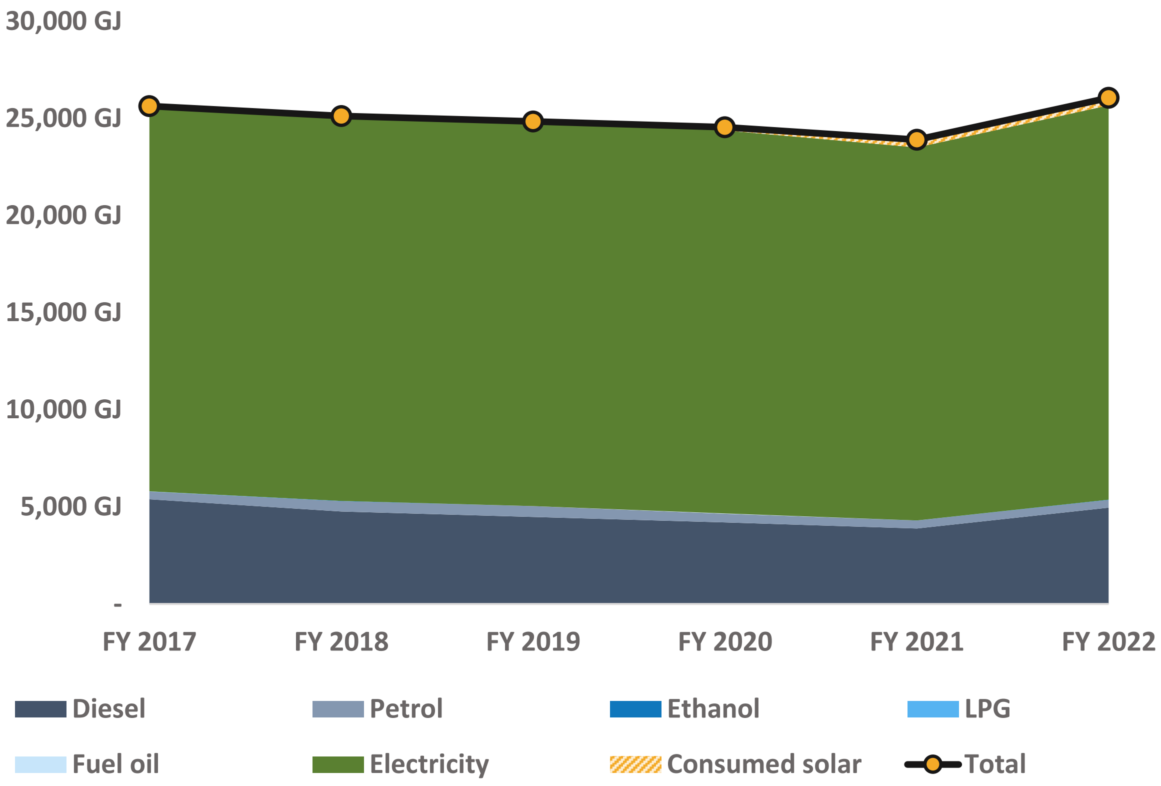


FIGURE 18: ROUS COUNTY COUNCIL'S HISTORICAL ENERGY CONSUMPTION TREND

The increasing amount of self-consumed solar, while only a few percent of total energy use, has been effective in minimising the need for increased consumption of grid electricity and thereby helping keep a cap on emissions, despite the significant uptick in energy use during FY 2022.

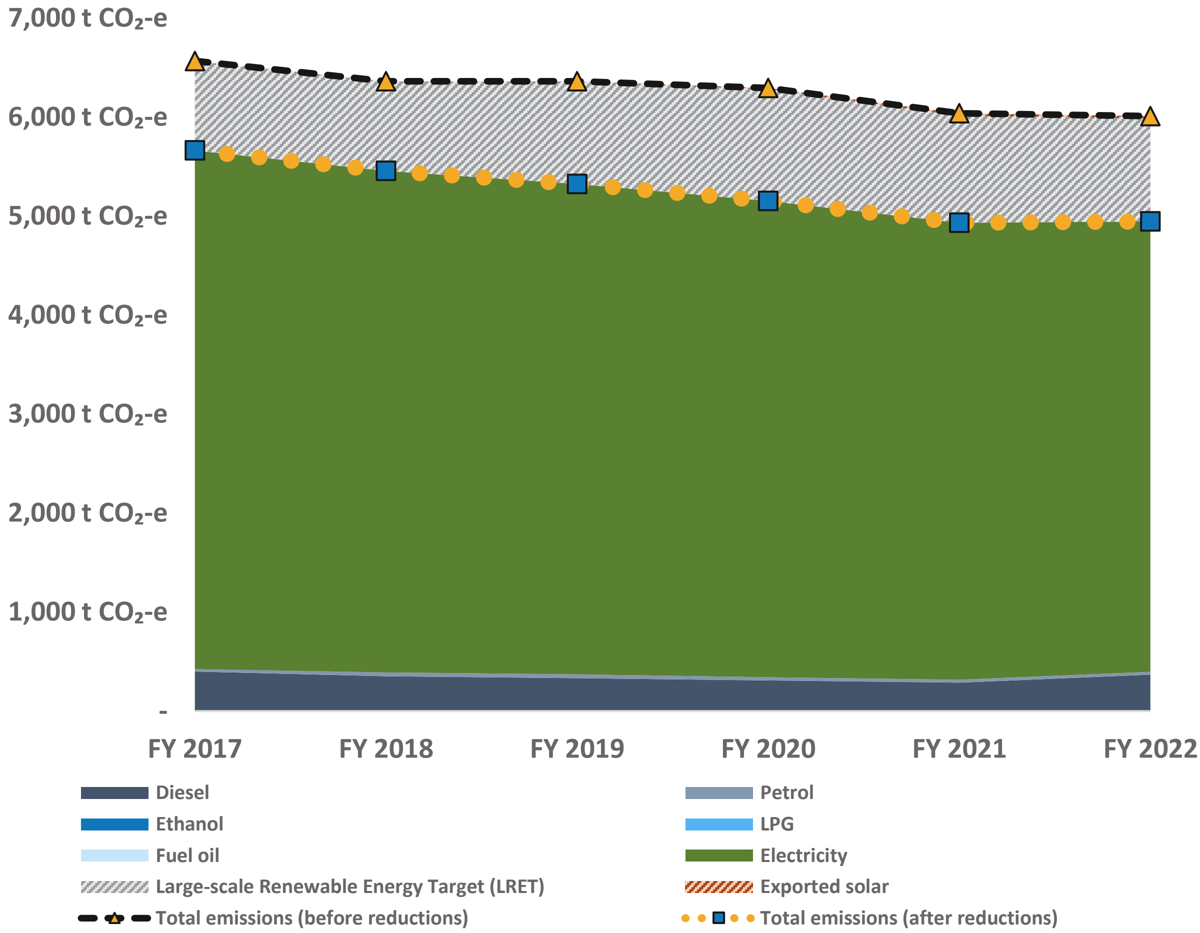


FIGURE 19: ROUS COUNTY COUNCIL'S HISTORICAL CARBON EMISSIONS TREND

As seen in Figure 19 above, there is a general downward trend in Council's emissions over the 6-year period under review. This downward trend reflects the general decline in Council's diesel energy use (with the exception of higher than usual consumption during the final year in the period), combined with the effects of ongoing grid decarbonisation and, to a lesser but still notable extent, Council's increasing use of onsite solar PV.

A large proportion of emissions reductions from grid decarbonisation are attributable to the Large-scale Renewable Energy Target (LRET), indicated by the grey shaded area in Figure 19. The LRET is a Commonwealth Government policy measure that sets a specific target for the proportion of electricity generation that must come from renewable energy sources. Electricity retailers purchase Renewable Energy Certificates (RECs) from renewable energy generators to meet their LRET obligations, but the cost of the LRET is ultimately passed on to consumers through their electricity bills. Therefore, abatement resulting from the LRET can be thought of as compulsorily purchased renewable energy.

4 Carbon sequestration from RCC's tree planting initiatives

Further to the analysis of emission sources and trends calculated in Section 3, Council requested further analysis and advice regarding the potential impact that tree planting activities, undertaken as part of Council's bush regeneration work program, has had on "net" emissions outcomes. This section outlines key methodological issues and considerations, describes the modelling process taken to estimate sequestration from tree planting activities, and calculates Council's net carbon footprint based on all the available data.

Climate Active are currently developing new rules and guidelines for "insetting" projects (specifically, tree planting activities) which will, eventually, become the main reference source for informing an acceptable sequestration accounting strategy.

Ideally, eligible sequestration should be properly accounted for in carbon footprint calculations, however the requirements for doing so are quite stringent in terms of data requirements. Working towards third-party recognition of sequestration quantification in the longer term is the ideal goal, and the work in this section of the report provides the necessary foundation and pathway to move towards that goal.

In addition to calculating the impact of sequestration on Council's carbon footprint, this section provides advice on the steps required to formalise the crediting of sequestration in a way that would allow for tree planting to contribute towards official Carbon Neutral certification in the future, should Council ever wish to pursue that ambition.

4.1 Approach

As specified in a variation to the original contract, the required services in regard to sequestration assessment are outlined below:

- Develop a spreadsheet model tailored to the available information provided by Council.
- Calculate sequestration outcomes based on appropriate methodology and tools.
- Calculate Council's net carbon footprint and post-sequestration emissions trends.
- Provide advice on relevant standards and requirements.

4.2 Overview of RCC tree planting activities

Revegetation projects conducted by Rous County Council are situated at four key Council sites, namely:

- Emigrant Creek Dam
- Rocky Creek Dam
- Wilson River
- Dunoon

Plantation activities have been undertaken since the 1990s, and methodologies vary from planting in an area with open grazing, to site restoration via weedy regrowth. Granular information on the vegetation work per zone across the four sites are provided in Table 6 and succeeding aerial photographs:

TABLE 6: DETAIL OF REGENERATION PROJECTS AT ROUS COUNTY COUNCIL SITES

Site & ID	Area (ha)	Plantation date	Existing vegetation prior to planting
Emigrant Creek Dam			
1	0.878	2006	Grazing
2	0.99	2003	Grazing
3	0.633	2003	Grazing
4	1.605	2007	Grazing
5	1.832	2007	Grazing
6	1.293	2008	Grazing
7	1.31	2008	Grazing
8	2.629	2009	Grazing
9	1.234	2008	Grazing
10	1.744	2005	Grazing
11	1.256	2005	Grazing
12	0.533	2006	Grazing
13	1.199	2006	Unused. Introduced weeds
14	2.776	2005	Grazing
15	0.549	2005	Grazing
16	0.821	2017	Unused. Introduced weeds
Rocky Creek Dam			
1	18.839	1990-2000, and 2000-2010.	Grazing in the 1950s. Introduced weeds recently
2	9.787	1990-2000, and 2000-2010.	Grazing in the 1950s. Introduced weeds recently
3	9.119	1990-2000, and 2000-2010.	Grazing in the 1950s. Introduced weeds recently
4	5.159	1980 – 1990	Grazing in the 1950s. Introduced weeds recently
5	40.923	2020 – present	Grazing in the 1950s. Introduced weeds recently
6	1.869	1990	Grazing in the 1950s. Introduced weeds recently
7	5.831	2010 - current	Grazing in the 1950s. Introduced weeds recently
8	1.258	2010 - current	Grazing in the 1950s. Introduced weeds recently
9	3.103	2000 - 2010	Grazing in the 1950s. Introduced weeds recently
10	4.153	2010 - current	Grazing in the 1950s. Introduced weeds recently
11	3.941	2010 - current	Grazing in the 1950s. Introduced weeds recently
12	1.241	2010 - current	Grazing in the 1950s. Introduced weeds recently
13	8.409	2010 - current	Grazing in the 1950s. Introduced weeds recently
14	7.626	2010 - current	Mixed forest

Site & ID	Area (ha)	Plantation date	Existing vegetation prior to planting
Wilson River			
1	0.569	2009	Grazing
2	1.737	2010	Grazing
3	1.26	2010	Grazing
4	1.721	2010	Grazing
5	2.285	2011	Grazing
6	3.932	2011	Grazing
7	3.202	2011	Grazing
8	1.281	2009	Grazing
Dunoon			
1	6.69	2002	Grazing
2	22.098	1990s	Grazing
3	3.814	1990s	Mixed forest
4	3.992	1990s	Grazing
5	7.028	1990s	Grazing
6	23.101	1990s	Grazing
7	2.174	1990s	Mixed forest
8	10.038	1990s	Grazing
9	9.097	2005	Grazing
10	12.656	1990s	Grazing
11	2.174	1990s	Grazing

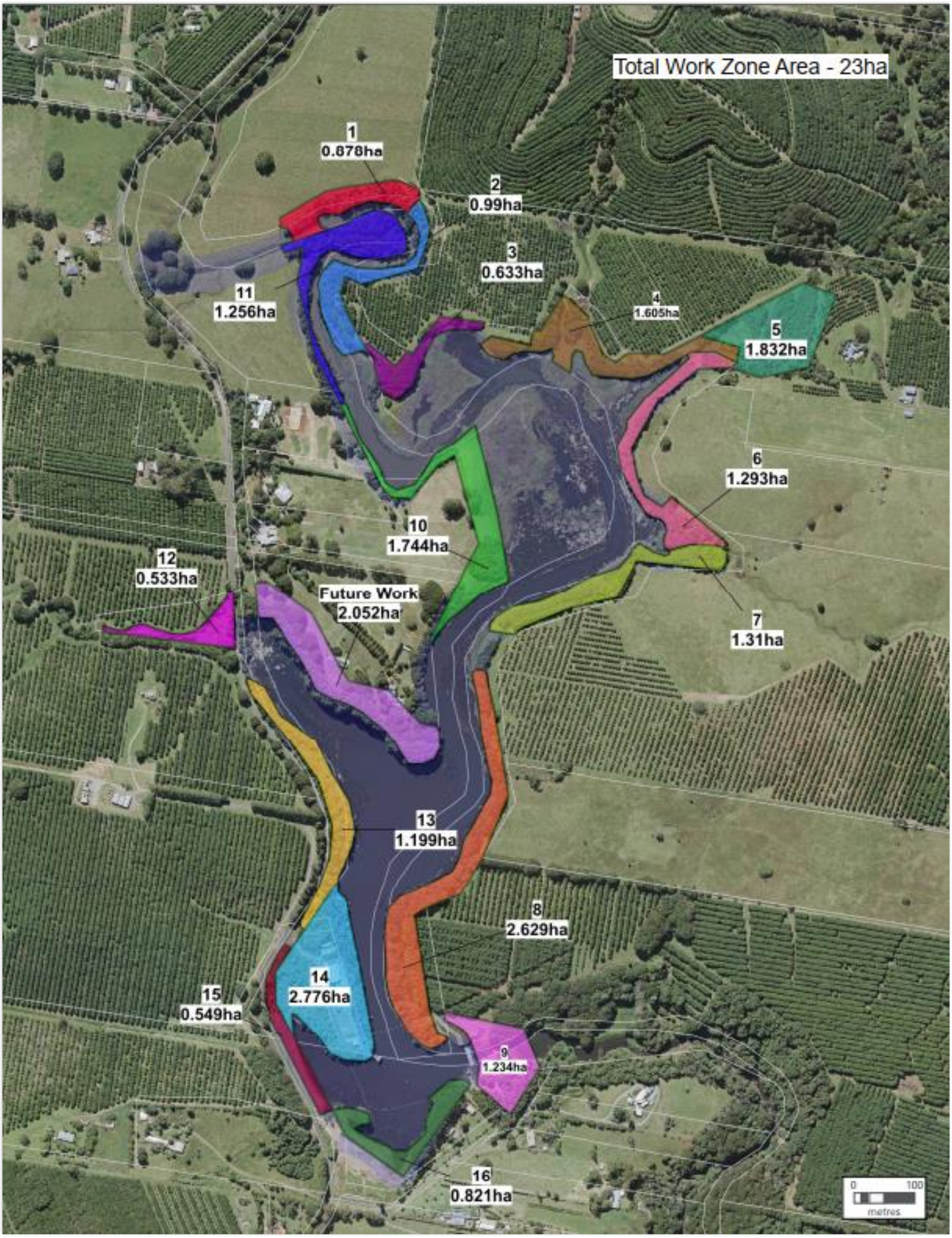


FIGURE 20: GEOGRAPHICAL LAYOUT OF REGENERATION WORK AT EMIGRANT CREEK DAM

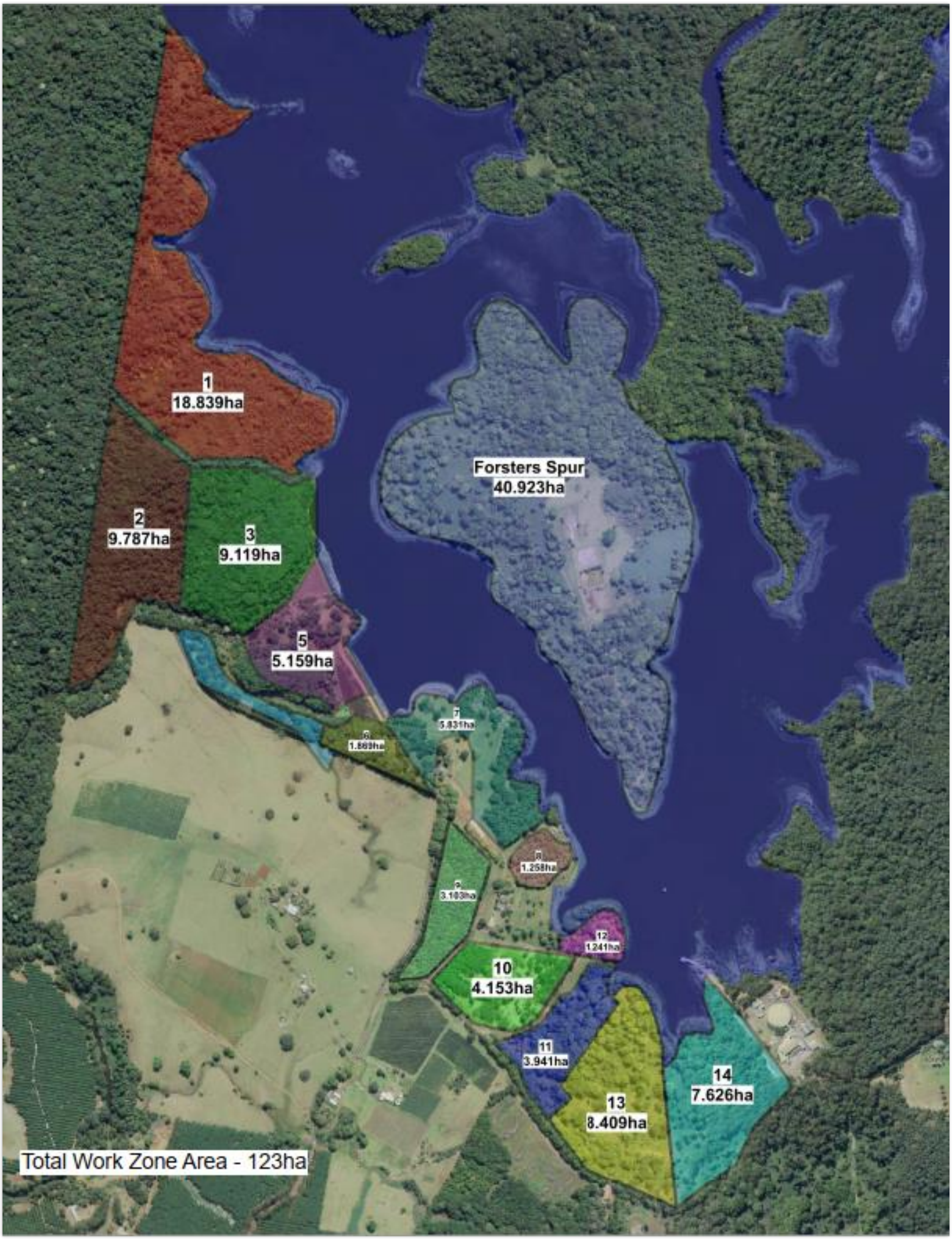


FIGURE 21: GEOGRAPHICAL LAYOUT OF REGENERATION WORK AT ROCKY CREEK DAM

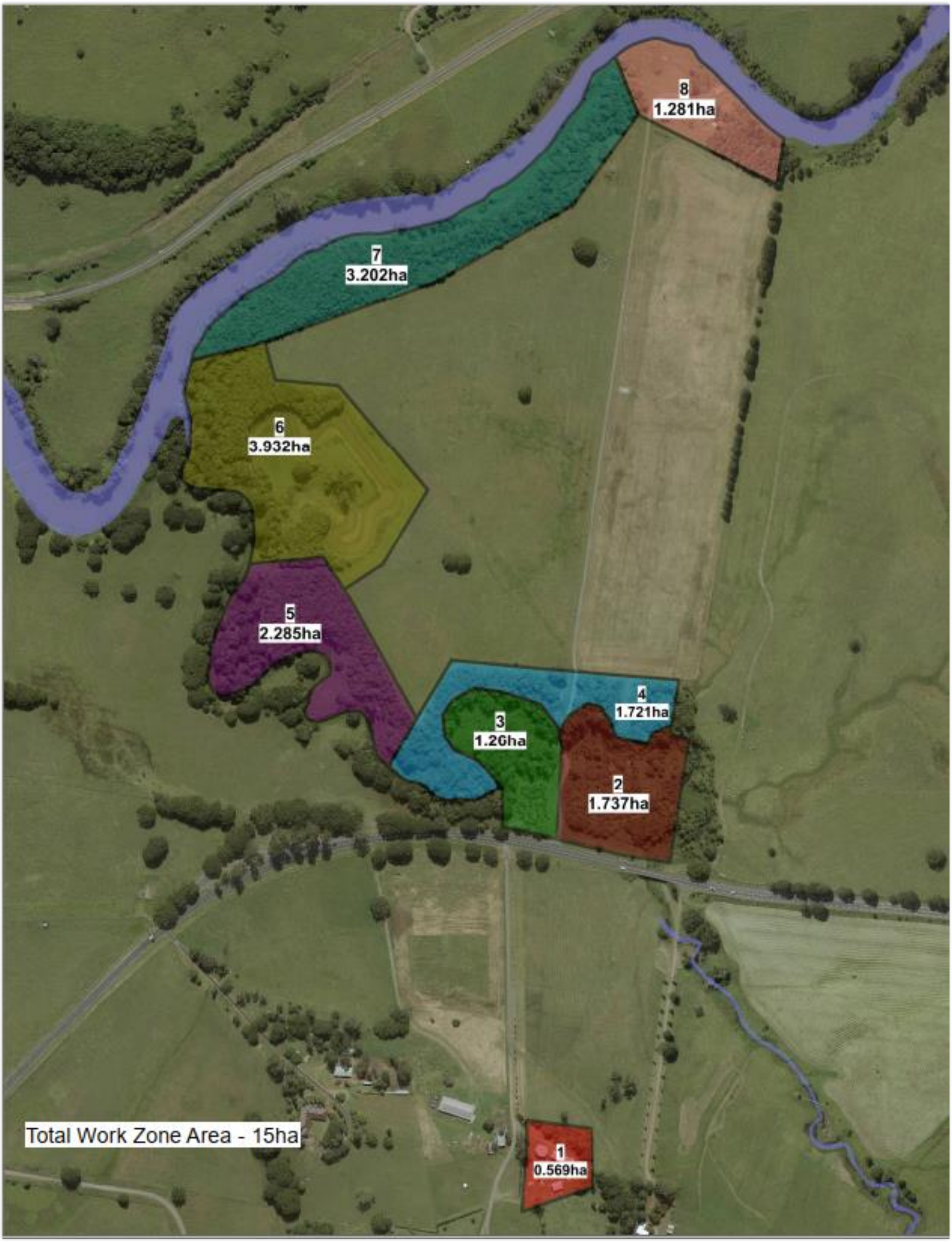


FIGURE 22: GEOGRAPHICAL LAYOUT OF REGENERATION WORK AT WILSON RIVER

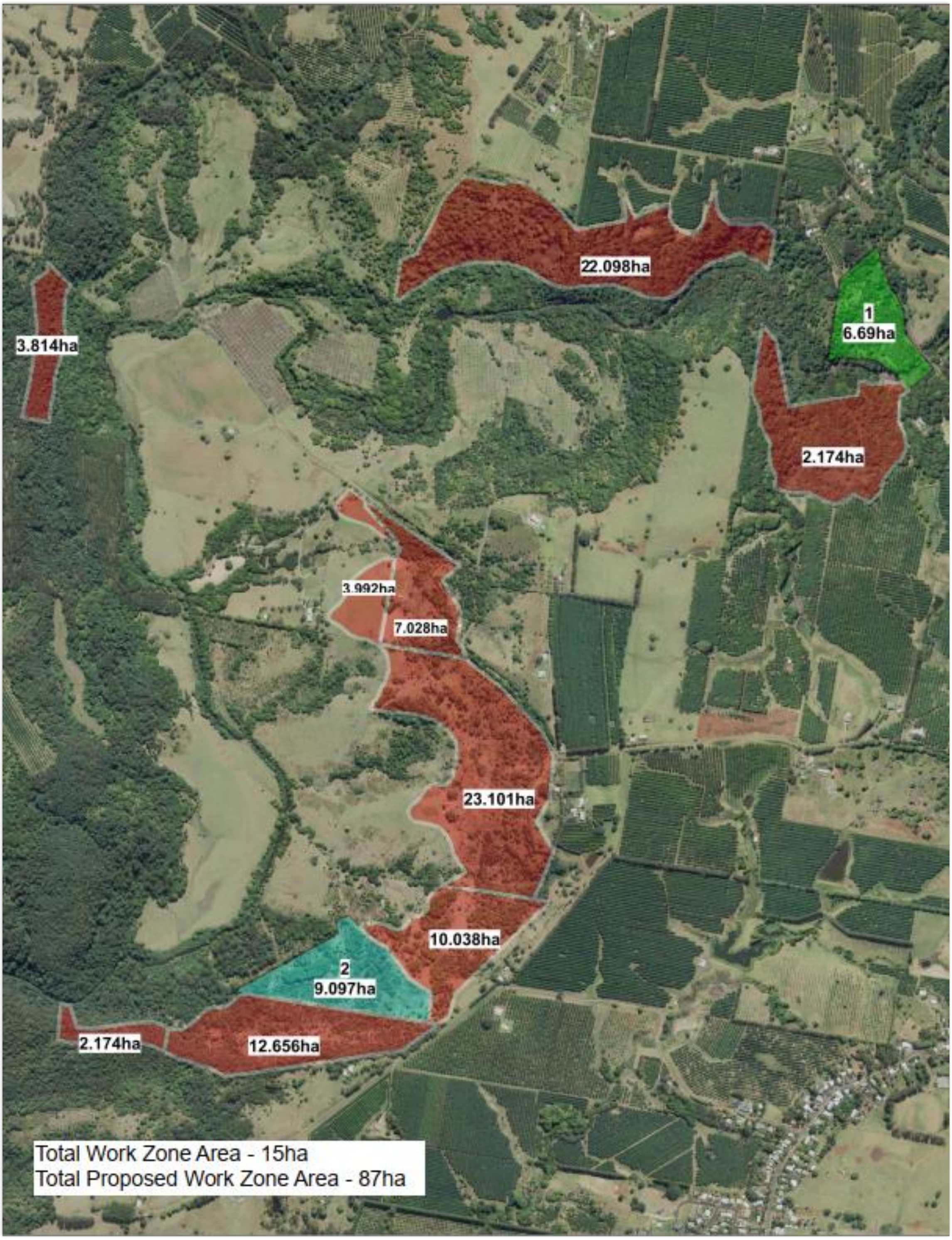


FIGURE 23: GEOGRAPHICAL LAYOUT OF REGENERATION WORK AT DUNOON

4.3 Draft Climate Active Guidelines

The guidelines for including carbon sequestration within a Climate Active carbon account are currently under development and expected to be finalised by the end of 2023. These guidelines are applicable to entities seeking to measure carbon sinks from trees and shrubs they have planted in addition to greenhouse gas emissions. The guidelines outline the five steps for achieving Climate Active carbon neutral certification: measure, reduce, offset, verify, and disclose.

The guidelines are distinct from the Emission Reduction Fund (ERF) methods, which have specific rules for carbon offsets projects.

- While there are some similarities between the guidelines and ERF methods, the main differences lie in the starting and ending points of the processes.
- Unlike ERF methods, the guidelines do not require the plantings to be new and do not generate Australian Carbon Credit Units (ACCUs) or any other tradeable carbon credit unit.
- If the plantings are included in an ERF project generating ACCUs, the sequestration cannot be accounted for using the Climate Active guidelines. However, voluntary cancellation of ACCUs can be used to offset emissions.

4.3.1 Eligibility requirements

The current draft eligibility requirements for inclusion of tree planting activities in carbon footprint calculations, and indication of whether or not Council's activities meet those requirements, are summarised below:

Table 7: Compliance of RCC projects with draft eligibility criteria of vegetation work

Relevant eligibility criteria	RCC activities
The trees and shrubs must be planted in an area that falls under the operational control or supply chain of the entity;	Yes
The planting event must have occurred in or after 1990;	Yes
The practical minimum plot area is 0.2 ha;	Yes
This area must be located in Australia in an area where FullCAM (Full Carbon Accounting Model) coverage exists;	Yes
The area must have been free of forest cover for at least 5 years before the trees are planted;	Yes
The area must not have been cleared over the 5 years prior to planting;	Yes
The entity must plant species of trees that has the potential to be at least 2 metres tall and reach a crown cover of at least 20% of the planting area, and either:	Yes
Consists of native species planted to match the structure and composition of local vegetation and is planted at a minimum of 200 stems per hectare (or higher if using specific calibrations);	Yes
Is a species-specific planting that matches the species, geometry and density conditions set out in the Emission Reduction Fund (ERF) environmental planting FullCAM guidelines.	Yes
The planting must not be part of an ERF project or any other carbon offset program.	Yes

4.4 Method overview

In brief, Climate Active's tree planting accounting guidelines require that the net abatement amount from tree planting activities for a reporting period be determined by calculating the change in total carbon stock across all plots within the project areas, considering emissions from fire and clearing events.

For modelling abatement outcomes from tree planting activities, Climate Active requires use of CSIRO's FullCAM software to assess the carbon neutrality claims of entities seeking Climate Neutral certification. By requiring the use of FullCAM, Climate Active can ensure annual estimates of the carbon sequestration (removal) and emissions associated with land-use activities, such as afforestation, reforestation, and forest management, can be accurately and consistently calculated across a wide range of different environments and management regimes.

To account for observed trends in forest permanence and to ensure abatement from tree planting activities is not overestimated, Climate Active applies a 70% "conservative multiplier" to abatement estimates to allow for a "reversal buffer". A reversal buffer serves as a precautionary measure to address uncertainties and potential changes in the carbon storage capacity of the project area.

4.4.1 Method application

The following worked example is taken from the draft Guidelines to help explain how the calculation method applies in practice:

> An Australian Capital Territory beef producer planted 2 hectares of a mixed environmental planting in 1990. In the 2022 financial year, the plot sequestered 1 t of carbon in above- and below-ground tree biomass, and 0.4 t of carbon in debris, making a total of 1.4 t of carbon. This is equivalent to 5.1 t of carbon dioxide (CO_2-e). The abatement, after applying a 70% conservative multiplier, is 3.6 t CO2-e. This last figure is included in the carbon account to 'inset' (rather than 'offset' via an external source of carbon credits) the supply chain emissions.

4.5 About FullCAM

FullCAM is a land-use and forestry model developed by the Australian government's Commonwealth Scientific and Industrial Research Organisation (CSIRO). FullCAM stands for "Full Carbon Accounting Model." It is a computer-based model designed to estimate greenhouse gas emissions and removals associated with land-use change, forestry activities, and natural disturbances.

FullCAM is a comprehensive tool for carbon accounting and modelling that considers various factors such as carbon stocks in different biomass pools (above-ground and below-ground), debris, and emissions from disturbances like fire events. It takes into account different gases, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), to provide a comprehensive assessment of carbon dynamics.

- Inventory data: FullCAM requires inventory data on the forest area, age, species composition, and other relevant parameters. This information is used to create a representation of the forest landscape.
- FullCAM classifies vegetation based on a system known as the "BiomePlus" classification. This classification combines both climatic and vegetation characteristics to define the main climatic vegetation classes in Australia.
- Growth and yield models: FullCAM uses growth and yield models to simulate the growth of forests over time. These models take into account factors like species characteristics, climate, and management practices. They estimate how much biomass (trees and vegetation) the forest will produce each year.
- Upper age limits: FullCAM has upper age limits for reliable estimates of sequestration. These limits are defined in the FullCAM Guidelines for plantation species and a publication related to environmental and mallee plantings. The age of maximum confidence is referred to as the upper age limit in the context of plantation forestry, and it is 30 years for environmental and mallee plantings.
- Biomass carbon: FullCAM calculates the amount of carbon stored in the forest's biomass based on the estimated biomass growth. Biomass carbon is the carbon stored in the living and dead organic matter of the forest, including above-ground and below-ground biomass.
- Soil carbon: FullCAM also estimates the change in soil carbon due to forest growth. Forests contribute to soil carbon through leaf litter, root systems, and other organic material. FullCAM

considers factors such as climate, soil type, and land management practices to estimate soil carbon changes.

- Decomposition: FullCAM accounts for the decomposition of dead organic material, such as fallen leaves and branches. It estimates how much carbon is released back into the atmosphere as these materials break down over time.
- Harvest and deforestation: If the forest is harvested or deforested, FullCAM calculates the carbon emissions resulting from the removal of biomass and the release of carbon stored in the forest.
- Net carbon sequestration: FullCAM calculates the net carbon sequestration by subtracting carbon emissions from carbon uptake due to forest growth. It provides an estimate of the total carbon sequestered or emitted by the forest over a given period.
- Reporting: The calculated carbon sequestration estimates can be used for reporting purposes, such as carbon accounting, reporting to emissions trading schemes, or monitoring the carbon balance of forests.

4.6 Modelling methodology

Consistent with Climate Active's draft guidelines for accounting carbon sequestration from tree plantings, the following steps were taken in order to estimate abatement from Council's regeneration activities:

4.6.1 Review of available data

Council provided data on land area (in hectares), year/s of plantation, and existing vegetation prior to plantation for each work zone at four (4) Council sites, namely:

- Dunoon
- Emigrant Creek Dam
- Rocky Creek Dam
- Wilsons River

Geographical layouts of the regeneration work were made available via aerial photographs, inclusive of plantation coverage and land area for the relevant work zones.

4.6.2 Clarification on data specifics relating to FullCAM's input requirements

Ensuring the accuracy of calculated stored carbon in the forest's biomass requires a comprehensive list of information in line with FullCAM's input requirements, including key parameters such as coordinates of representative point locations, species of tree or plantation, planting dates, stocking density of trees and shrubs, tree proportions, and data on management events (e.g. planting, thinning, harvest or fire). The following is a list of further questions sought from Council in order to ensure modelling could be undertaken using FullCAM:

a. Has fire affected any of the regeneration areas? If so, please provide year/date of occurrence and affected zone.
b. Is there any information as to what tree species were planted in each zone? If unavailable, is there information on the tree type (e.g. Eucalyptus, Acacia, or a mix of these)?

c. Are there records that indicate how many trees were planted in each zone?
d. For plantings done in dates indicated as ranges (e.g. 1990s, 2000-2010), were these spread over the period or undertaken in a particular year?
e. Has thinning been conducted in any of the regeneration areas since the date of plantation, or has the plantings been left to grow largely unmanaged?

4.6.3 Establishing input parameters and assumptions

Details on key parameters used for the estimation of carbon stocks at the start and end of each reporting period, and ultimately net abated emissions per period are as follows:

- Model point locations
  - Abatement modelling within FullCAM requires a single 'model point' location. It is not necessary to precisely delineate the geographical boundaries of the vegetation work within the tool, rather the coordinates for a single location of the boundary's approximate centre are sufficient. Latitude and longitude coordinates were retrieved for each of Council's work zone through the provided geographical layouts.
- Site conditions
  - Site-specific parameters such as historical amount of rainfall, evaporation and irrigation in millimetres (mm), historical air temperatures in degrees Celsius (°C), and productivity indices, as used for estimating growth rates of trees, can also be manually set within FullCAM, but per the Clean Energy Regulator's (CER) guidelines, default values from databases as downloaded from FullCAM's servers are used.
- Plantation species
  - An option of selecting mixed species of environmental plantation is available within FullCAM, which offers conservative abatement modelling for cases where the mix of species planted in the vegetation boundary is not precisely known. Due to limitations in retrieving detailed information while maintaining realistic abatement estimates, it is deemed that a combination of different species was planted for each of Council's plantation activities.
- Stocking density
  - Consistent with recommendations by the Clean Energy Regulator (CER), it is assumed that a 'normal stocking' approach (i.e. standard number of seedlings per unit area) was utilised in Council's plantations, numerically equivalent to 0.1 dry matter tonnes per hectare (dmt/ha) of dry material for each component of the saplings – stems, branches, bark, leaves, coarse and fine roots.
- Soil conditions
  - Default values for soil-specific parameters such as soil properties and parameters relating to soil moisture have been adopted, as provided in the FullCAM database for each location.
- Events
  - Management activities and disturbance occurrences can be modelled as 'events' within FullCAM. Events were modelled in accordance with data supplied by Council.

4.6.4 Simulation of carbon stocks for each work zone per reporting period

Upon setting the key input parameters listed above, simulation for each vegetation zone was conducted to estimate the amount of cumulative carbon stored within the forest's biomass over time, within selected start and end dates for the simulation. Alternatively referred to as 'carbon stock', the cumulative stored carbon is further subdivided into different 'pools' consisting of above-ground and below-ground biomasses. The amount of carbon stock at the start of each financial year was then retrieved from the simulation output and subtracted from the value at the end of year to obtain the net carbon mass for the reporting period per unit area of land.

4.6.5 Calculation of net emissions abatement per reporting period

Net carbon masses for each reporting period as described in the previous step are then multiplied by a factor of 3.66, or the ratio of molecular weight of carbon dioxide CO_2 to the atomic weight of carbon C, to obtain the corresponding net amount of sequestered CO_2 into the forest's biomass for the reporting period per unit area of land. Consistent with Climate Active's guideline of discounting the modelled abatement by 30% to account for permanence and risk of reversal buffers, and in conjunction with Council's prescribed assumption of vegetated area only covering 75% of each work zone, the modelled abatement estimates are further multiplied by 70% and 75%, and subsequently by the corresponding land area of vegetation work.

4.7 Impact of sequestration on RCC's carbon footprint and emissions trend

Utilising the modelling methodology established in the previous section, sequestration from plantation activities for the sites was calculated, and the abatement for each year is presented in Table 8 below. Detailed calculations corresponding to each identified work zone across all four sites are tabulated in Appendix 12.

TABLE 8: TOTAL EMISSIONS ABATEMENT FROM COUNCIL SITES FOR EACH REPORTING PERIOD

Scope	Total emissions abatement per reporting period (t CO_2-e)					
	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
RCC's 4 Listed Sites	1,625	1,616	1,649	1,705	1,736	1,779

Subtracting sequestered carbon dioxide from the six-year trend of emissions estimates presented in Section 3.4, Council's regeneration work at the four sites amounts to abatement of around 29-36% for each year. Provided below is an amended emissions trend graph that shows the net emissions reduction due to Council's revegetation initiatives.

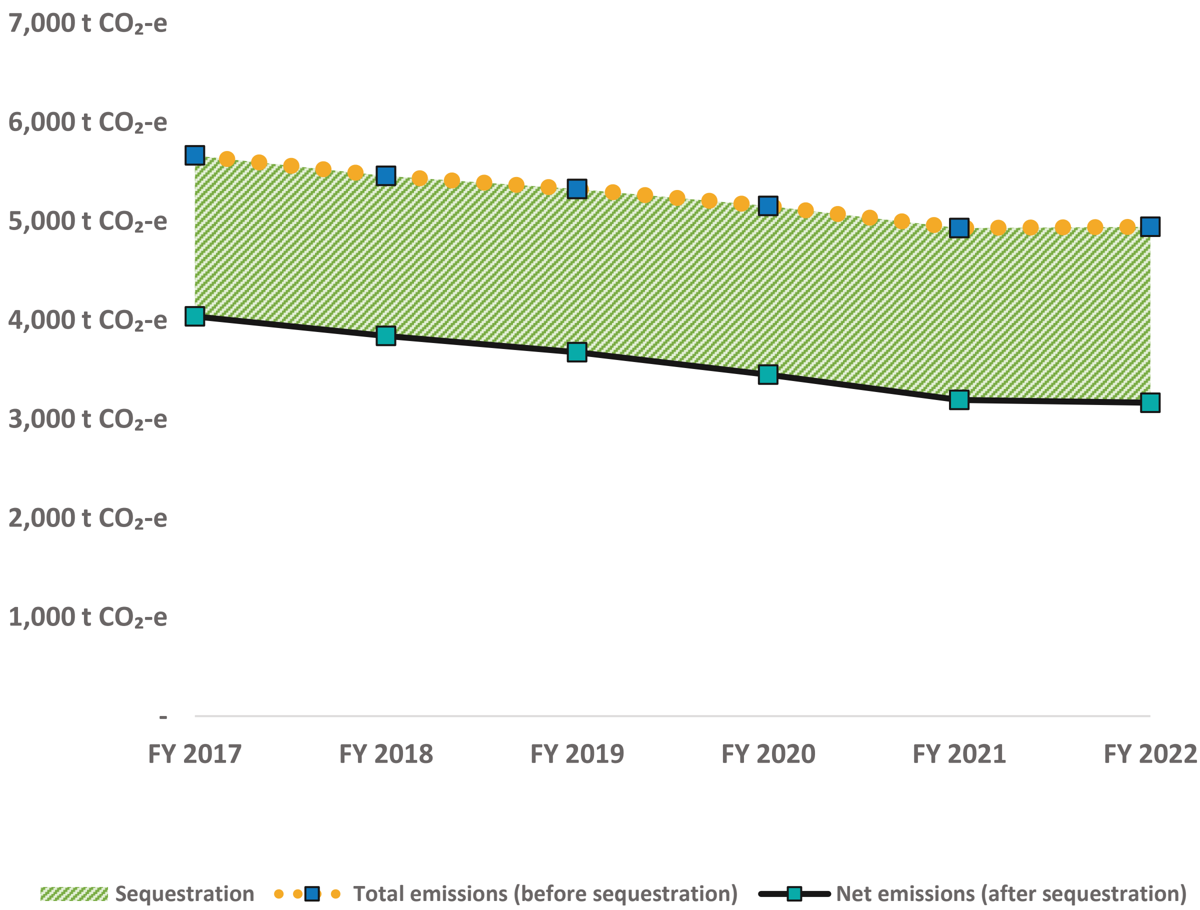


FIGURE 24: ROUS COUNTY COUNCIL'S AMENDED HISTORICAL EMISSIONS TREND

4.8 Strategic implications of sequestration dynamics

The dynamics of how carbon is cumulatively sequestered by a growing forest over a long period of time has implications for emissions reduction planning. To provide a picture of the ongoing cumulative impacts of Council's plantation activities on its emissions reduction goals, three (3) distinct work zones of similar land areas but different dates of plantation were modelled. The cumulative abatement for each planting "event" has been projected until 2050 and graphically presented below in Figure 25.

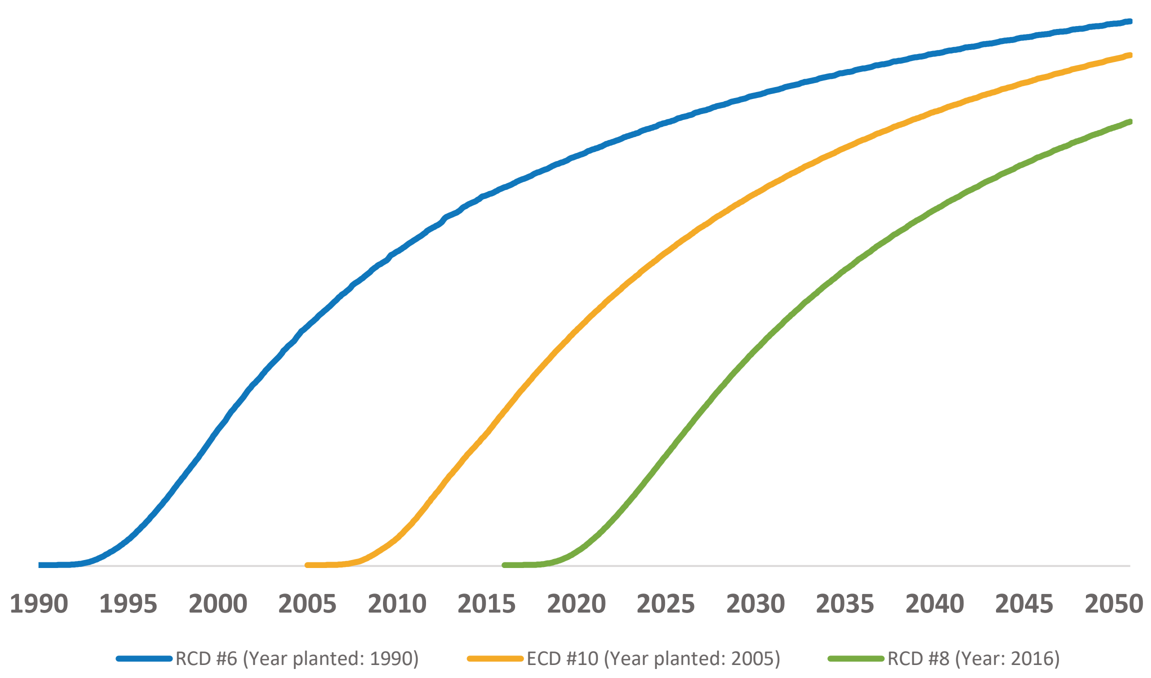


FIGURE 25: PROJECTED TRENDS OF CUMULATIVE EMISSIONS ABATEMENT FOR SELECT RCC SITES

The purpose of this analysis is to assess and demonstrate variations in the rate of sequestration over time, assuming no devastating fire occurs in the future. It can easily be seen in the graphical output that, while sequestration accrues exponentially in the short to medium term (10 to 15 years) as vegetation grows towards maturity, over the longer term (20+ years) sequestration dynamics are characterised by a logarithmic growth pattern with the rates of cumulative abatement diminishing significantly as time progresses.

The main strategic implications of forest growth and sequestration dynamics, as modelled by FullCAM, are that:

- Tree planting at the scale historically undertaken by RCC can have substantial mitigating effects on Council's carbon footprint and could represent a cost-effective means of managing Council's GHG emissions.
- Historical plantings should not be relied upon by Council to provide substantive year-on-year abatement benefits in the longer term.
    - Council should therefore consider, at the very least, maintaining tree planting activities at current rates.

- If availability of land for replanting activities becomes reduced as time goes on, this would likely lead to a corresponding reduction in year-on-year sequestration amounts in the longer term.
- Council should consider measures to support the resilience of revegetated areas to possible future disturbance by fire, as this would have a step change negative impact on Council's carbon footprint.

In summary, while RCC's historic tree planting activities have a had a substantial impact on Council's net emissions outcomes over the last 6 years, the likelihood of declining sequestration benefits over time, or even reversal of benefit due to fire, should be considered and managed accordingly.

Adopting a comprehensive and holistic emissions reduction strategy, that prioritises cost-effective measures, but that does not rely too heavily on any one particular abatement option (whether that be tree planting, renewable energy, or energy efficiency) is likely to deliver the greatest benefits in the long term, with the lowest risks.

4.9 Formal requirements for Climate Active certification

If Council wishes to pursue Climate Active certification in future, further work will be required to formalise sequestration estimates to be compliant with the emerging standards. Third-party verification is required in the first year of including plantings in the emissions boundary. Entities with experience in vegetation assessments meeting specific criteria can undertake the verification.

The formal requirements for quantifying tree planting carbon impacts for Climate Active certification can be summarised as follows:

- Evidence of Time of Planting: Various forms of evidence can be used to verify the time of planting, including aerial or satellite images, date-stamped photographs, records of hiring contractors or purchasing plants/seeds, and canopy area estimates.

- Location Verification: The boundaries of each plot must be defined using field surveys, aerial photographs, date-stamped geo-referenced remotely-sensed imagery, or soil/vegetation/landform maps.

- Ongoing Requirements: If there are changes in site characteristics, land management regime, or parts of a planting fail to achieve forest potential, the plot must be modified. Modified boundaries must be identified in the next technical report submitted to Climate Active.

    - Biomass Harvesting: Certain biomass harvesting activities are allowed under specific conditions, such as ecological thinning or utilization of fruits/nuts/seeds.

    - Clearing Emissions: If a plot or portion of a plot is cleared, the emissions associated with clearing will be considered equivalent to the carbon sequestration that occurred since the tree plot was included in a carbon account.

    - Tree Clearing and Offset Retirement: If trees are deliberately cut down, offset units equivalent to the previously claimed sequestration must be retired. Once a tree planting is included in certification, it must remain within the emissions boundary even if certification is terminated and restarted.

- Proficiency Requirements: Modelling practitioners are expected to be proficient in using FullCAM, GIS, and vegetation carbon assessment.
- Statutory Declaration: Each technical report to Climate Active must include a completed statutory declaration that certifies compliance with certain requirements, including no clearing of vegetation outside the modelled area and no double counting of carbon sequestration.

5 Feasibility assessments for solar PV and battery systems at RCC sites

The project required assessment of a number of potential actions for site upgrades, additional PV installations, and replacing combustion engine outdoor equipment with battery-powered equipment. Assessment of feasibility was conduced using a variety of approaches including undertaking review of current technology performance, site evaluation, appropriate system sizing, performance modelling, and financial cashflow forecasting. Cost estimates have been provided for equipment installation, and the methodologies adopted have assessed lifecycle cost viability including estimation of net present values (NPV).

5.1 Battery technology benefits and feasibility

RCC has requested that the project provide advice on the current viability and of use of battery energy storage system (BESS) solutions. A detailed battery technology “memo” has been provided as an Appendix to this strategy. Provided below is a brief summary of the key issues and findings from the memo.

5.1.1 Benefits of BESS to water utility providers

BESS offer numerous potential benefits to water utility providers. As water utility electricity costs are so high, BESS can support substantial electricity cost savings when paired with onsite solar PV, especially by helping avoid peak rate electricity charges which typically occur after solar PV generation hours. From a climate change perspective, BESS enables reduced reliance on emissions-intensive grid electricity. BESS can also support improved equipment reliability/resilience and increased local grid stability through peak demand mitigation and voltage regulation. By using hybrid inverters and other appropriate hardware, many battery systems can also be wired to support back-up power provision.

5.1.2 Examples of BESS installed at water utilities in Australia

There are now many examples of combined PV and BESS being installed at water utilities across Australia. A few examples include Unitywater’s (QLD) 95 kW / 450 kWh system at its Kenilworth Water Treatment Plant, Yarra Valley Water’s (VIC) 100 kW / 200 kWh system at its Mitcham Water Treatment Plant, Western Water’s (VIC) 30 kW / 80 kWh system at its Sunbury Water Treatment Plant, and South East Water’s (VIC) 250 kW / 500 kWh system at its Boneo Water Recycling Plant. All of these installations use lithium-ion batteries.

5.1.3 Technology maturity and cost-effectiveness

Lithium-ion batteries can be considered a mature, reliable technology with clear advantages over other battery types. Although new battery types are under development, they cannot yet compete with lithium-ion for most applications. Beyond 2030, new battery types are likely to surpass lithium-ion for combined cost and performance, but this does not look likely before then. Most of the decline in lithium-ion battery prices has already occurred, and there is probably no financial benefit in waiting for further cost reductions, especially as electricity prices have been rising quickly, so any benefit gained by waiting would be more than offset by the need to pay more for electricity in the meantime.

Payback periods for BESS systems installed at water utilities are typically in the range of 6 to 10 years, depending on the specific circumstances of each installation. Factors affecting economic viability and payback period include:

- Absolute amount of exports at various times of the year
- Degree of match between exports and import quantities
- Degree and regularity of mismatch between solar production and grid demand
- Extent to which grid demand is occurring in peak vs off-peak times
- Degree of variation between peak and off-peak retail electricity charges
- The extent to which battery size and management have been optimised in relation to the above.

5.2 Feasibility assessment methodology

This section provides an overview of the methodology used to undertake feasibility assessments for each of the potential projects. The assessment process includes the following steps:

Review summary of sites' energy demand, import and export data

- Select potentially feasible sites on this basis, discard some from further analysis ie. Wyrallah Road.

Assess site energy demand and costs

- Examine distribution of grid energy demand and, where applicable, solar generation and export profiles.
- Determine electricity prices for purchased grid imports.

Consider site constraints and opportunities

- Unshaded rooftop/ land availability.
- Risks assessment including natural disasters and conflicts with other land uses
- Additional capital costs associated with site.

Determine appropriate system sizes for financial feasibility modelling

- Appropriate system size is one that is optimised to deliver reasonable payback period and net present value by avoiding underutilisation.
- A detailed description of battery size optimisation principles and issues is provided in the appended Battery Technology Memo.

Undertake cumulative cashflow analysis

- Include sensitivity analysis for at least one site.

Provide data summary

- Provide tables of modelling assumptions and related outputs.

Note: The assessments are intended to provide indicative feasibility only and are not intended to be used for determining actual system specifications, detailed business case planning or budgeting purposes.

5.3 Summary of sites with PV installations

Council has made progress in implementing solar PV and battery energy storage systems (BESS) at 6 sites since its adoption of the Greenhouse Gas Abatement Strategy in 2018. Among the systems is a 100-kW array recently installed in February 2023 at the Nightcap Water Treatment Plant for which data is not yet available. For the remaining five sites, exported and self-consumed energy from solar PV in comparison to imported electricity is summarised below:

TABLE 9: SOLAR GENERATION VS. GRID ELECTRICITY IMPORTS AT FIVE (5) ROUS WATER SITES

Site	FY 2020			FY 2021			FY 2022		
	Exports (kWh)	Self-consumed (kWh)	Grid imports (kWh)	Exports (kWh)	Self-consumed (kWh)	Grid imports (kWh)	Exports (kWh)	Self-consumed (kWh)	Grid imports (kWh)
Emigrant Creek WTP	1,791	18,042	301,254	5,910	49,214	328,773	5,678	44,545	423,641
Newrybar Pump Station	13,850	27,250	35,731	19,050	25,240	16,163	19,170	22,760	18,940
South Lismore Depot	-	-	-	1,333	30,483	4,818	917	24,234	4,179
Woodburn Depot	1,430	909	1,710	5,895	3,193	6,446	3,273	4,767	2,703
Wyrallah Road Depot	-	-	-	456	3,967	4,061	1,370	9,604	13,298
Total	**17,071**	**46,201**	**338,696**	**32,644**	**112,095**	**360,261**	**30,408**	**105,910**	**462,760**

A review of the data leads to several key observations:

- Total amount of exported electricity across all sites represents a relatively small proportion of total solar electricity generated, indicating that the solar PV systems are generally well-matched to site energy requirements in terms of quantity and sizing.
- Total amount of exported electricity, while small in proportional terms, is still significant in absolute terms. Capturing some of this exported energy to avoid costly grid imports could yield useful financial benefits while reducing emissions from electricity use.
- Some sites, specifically Newrybar Pump Station and Woodburn Depot, are good candidates for BESS installation in that the amount of exports is similar to the amount of grid imports, meaning a battery could help avoid almost all need for grid imports at those sites.

- For sites where the amount of exports is small in absolute terms, specifically Wyrallah Road (which already has a small battery installed), any potential financial benefits from (further) capacity increases would likely be outweighed by administrative cost, complexity and maintenance burden, and so BESS installation has been deemed as unfeasible/unnecessary.

5.4 Feasibility assessment: *Newrybar Pump Station*

A desktop-only approach was carried out for the modelling of a possible BESS implementation at the Newrybar Pump Station (located at Knockrow). The analysis highlights the relative mismatch between exports and grid imports as informed by the solar generation and load profiles.

Council has provided interval data for select dates around solstices and equinoxes of years 2019-2022. Depicted in the following charts are comparisons of solar self-consumption and export data, with imported grid electricity for representative dates in autumn, winter and spring of the calendar year 2022. The profiles suggest variation in grid electricity consumption in terms of times of peak-demand use between consecutive days, as well as frequent non-utilisation of exports due to site demand being relatively higher outside of peak sun hours, often between 10:00 am and 3:00 pm.

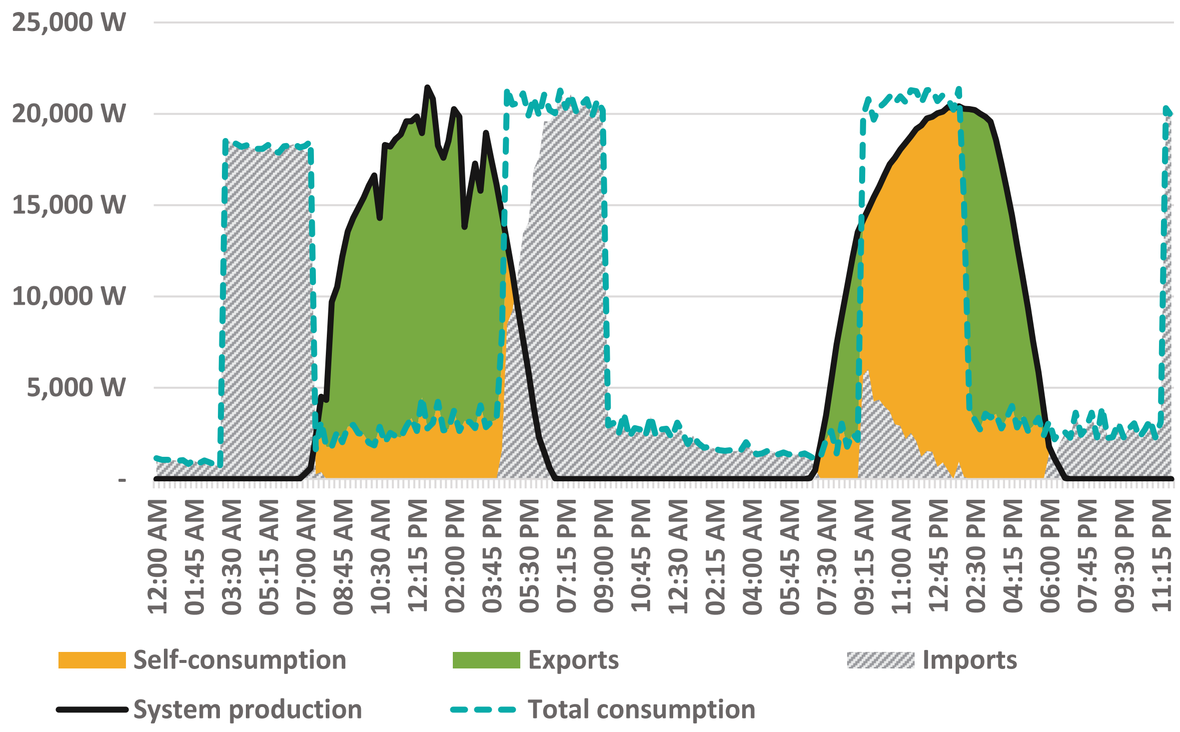


FIGURE 26: NEWRYBAR PS - SELF-CONSUMED & EXPORTED SOLAR AND GRID IMPORTS ON 21-22 MAR 2022

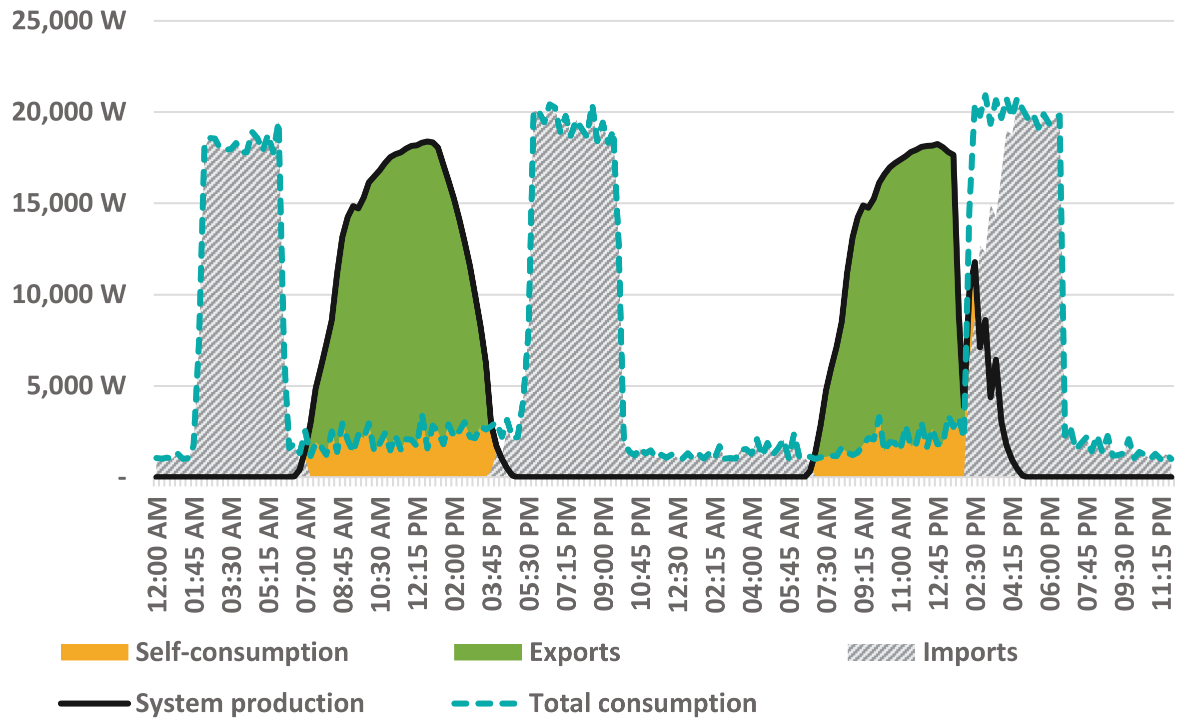


FIGURE 27: NEWRYBAR PS - SELF-CONSUMED & EXPORTED SOLAR AND GRID IMPORTS ON 22-23 JUN 2022

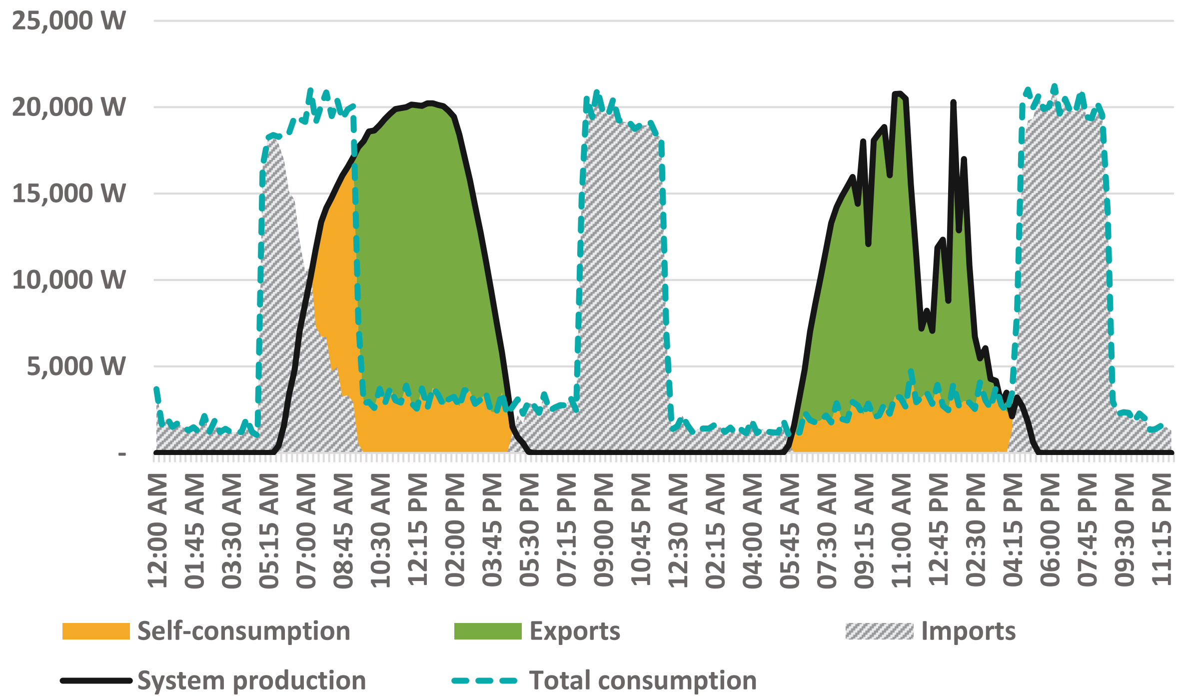


FIGURE 28: NEWRYBAR PS - SELF-CONSUMED & EXPORTED SOLAR AND GRID IMPORTS ON 19-20 SEP 2022

Installing battery storage with 45 kWh capacity would allow for a large proportion of currently exported solar to be consumed on-site and reliance upon the grid to be reduced during shoulder, peak and off-peak hours, with priority given to reducing grid imports during peak hours.

Based upon a high-level feasibility assessment, recent monthly consumption and generation data, a summary of the proposed system's performance is tabulated below:

TABLE 10: NEWRYBAR PUMP STATION 45-KWH BATTERY STORAGE SYSTEM PERFORMANCE SUMMARY

BESS size	Estimated annual storage	Estimated site demand	Energy offset by combining solar & BESS
45 kWh	14 MWh pa	45 MWh pa	50.5%

A summary of cost-benefit analysis for the proposed BESS system is presented below. Cost and savings figures are presented to be GST-exclusive.

TABLE 11: NEWRYBAR PUMP STATION 45-KWH BESS COST-BENEFIT ANALYSIS (2% ESCALATION RATE)

Description	Value
System size	45 kWh
Capital cost	$ 40,581
Year-1 annual savings	$ 4,445
Internal rate of return	7%
Payback period	9.2 years
Net present value	$ 6,553
Annual storage	14,401 kWh pa
Electricity savings (includes self-consumed solar)	29,836 kWh pa

The following assumptions were considered in our initial assessment of the economic feasibility of adding battery storage at the site.

- Imported electricity, exported and self-consumed solar data were drawn from a monthly billing dataset from January to December 2022.
- Electricity rate of ~$ 0.31 per kWh for estimating annual savings offset by battery storage is derived from mean electricity rates (excluding fixed costs eg meter reading) from January to December 2022.
- Indicative feed-in tariff for solar exports is estimated at ~$ 0.06 per kWh.
- Escalation rate for electricity charges is at ~2% per annum.
- Degradation rate of BESS capacity estimated at ~3% per year.
- Battery reaches its useful life at Year 13 and is due for replacement.
- Discount rate of ~5% is applied for estimating battery replacement cost and net present value.

To provide an overview of the investment's financial performance throughout its lifecycle, cumulative net cashflow was calculated based on the assumptions listed above. The outputs are shown in the figure below.

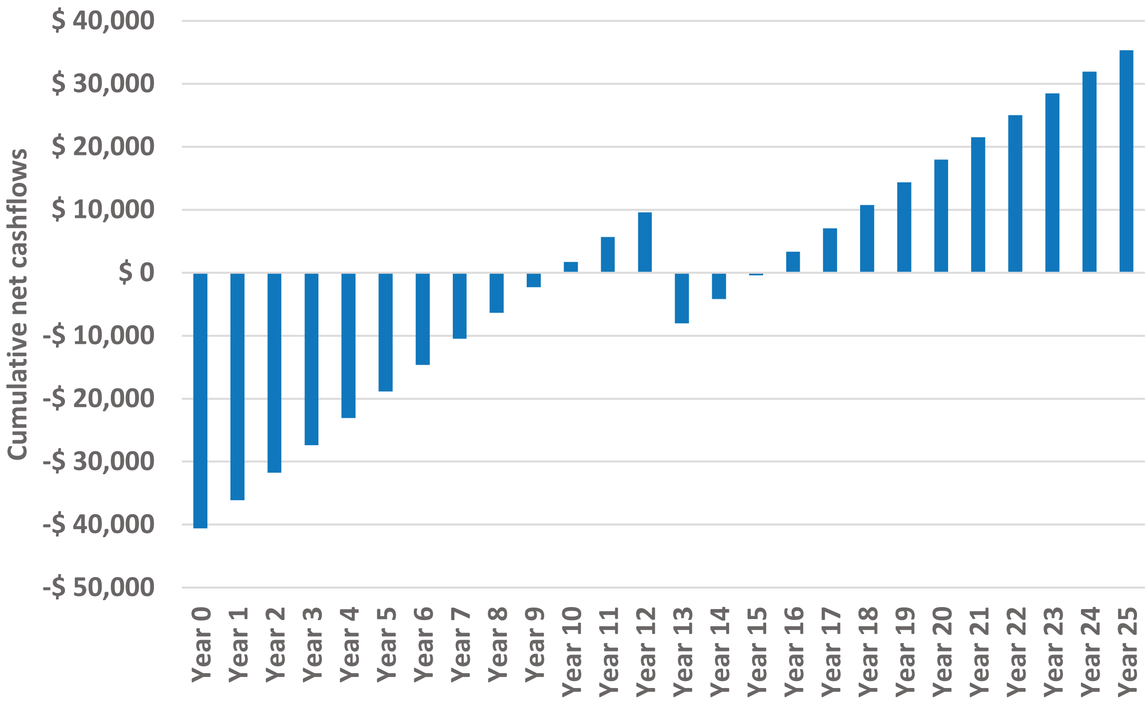


FIGURE 29: NEWRYBAR PUMP STATION 45-KWH BESS CUMULATIVE CASHFLOW (2% ESCALATION RATE)

In order to assess cost-benefit sensitivity to future changes in energy prices, an upper range estimate for price increase can also be tested. If the assumption for annual energy price 'escalation' is revised up from 2% per year to 10% per year, in line with current trends, then the project payback period improves from 9.2 to 7.2 years and net present value improves substantially, as shown below:

TABLE 12: NEWRYBAR PUMP STATION 45-KWH BESS COST-BENEFIT ANALYSIS (10% ESCALATION RATE)

Description	Value
System size	45 kWh
Capital cost	$ 40,581
Year-1 annual savings	$ 4,609
Internal rate of return	16%
Payback period	7.2 years
Net present value	$ 81,271
Annual storage	14,401 kWh pa
Electricity savings (includes self-consumed solar)	29,836 kWh pa

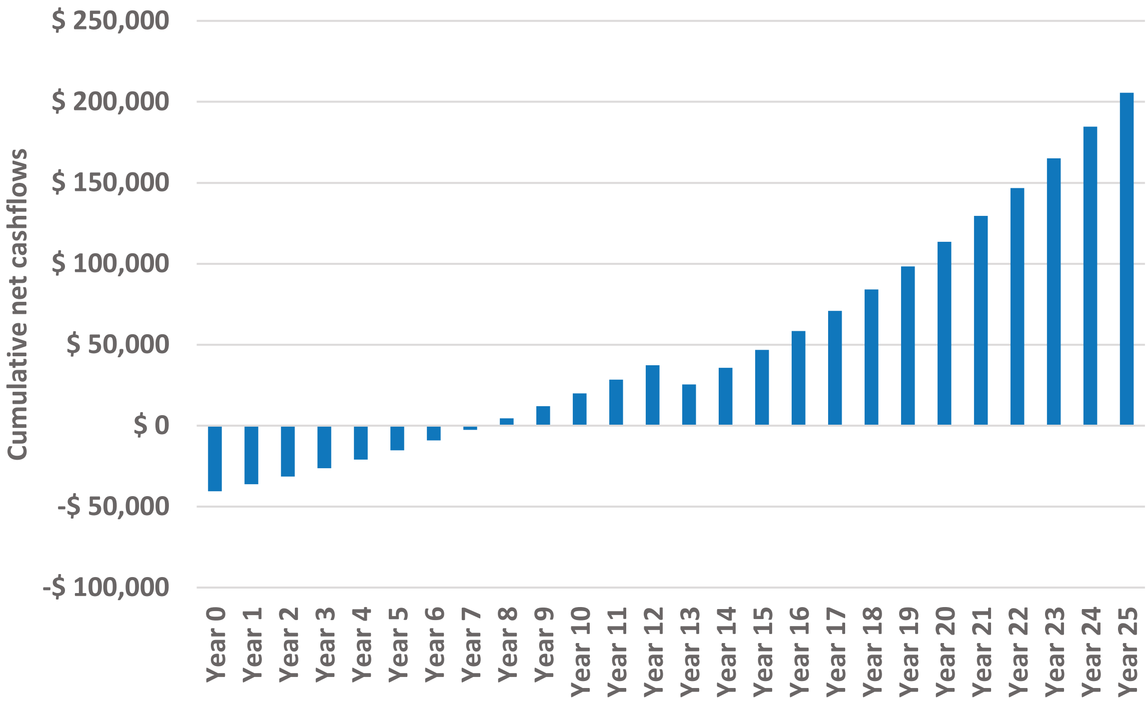


FIGURE 30: NEWRYBAR PUMP STATION 45-KWH BESS CUMULATIVE CASHFLOW (10% ESCALATION RATE)

5.5 Feasibility assessment: Emigrant Creek Water Treatment Plant

Following the battery sizing methodology conducted for the feasibility assessment for Newrybar Pump Station at Knockrow, including consideration of PV generation, self-consumption and export data from the pre-existing 40-kW array at the Emigrant Creek Water Treatment Plant, it is recommended to assess feasibility for a 30-kWh battery that would capture exports amounting to ~5.7 MWh from FY 2022. The proposed system's performance is summarised below:

TABLE 13: EMIGRANT CREEK WTP 30-KWH BATTERY STORAGE SYSTEM PERFORMANCE SUMMARY

BESS size	Estimated annual storage	Estimated site demand	Energy offset by solar & BESS
30 kWh	11 MWh pa	272 MWh pa	18.4%

It is noted that the combined solar PV & BESS system's capability to offset site energy demand measuring up to only about ~18% is primarily due to the limited capacity of the 40-kW array in relation to the substantial site demand. The table below presents a picture of the proposed system's cost-effectiveness.

TABLE 14: EMIGRANT CREEK WTP 30-KWH BESS COST-BENEFIT ANALYSIS

Description	Value
System size	30 kWh
Capital cost	$ 26,664
Year-1 annual savings	$ 3,185
Internal rate of return	12%
Payback period	7.6 years
Net present value	$ 25,157
Annual storage	10,814 kWh pa
Electricity savings (includes self-consumed solar)	51,905 kWh pa

The methodology used for developing the economic assessment is consistent with that of Newrybar Pump Station. The on-site electricity rates used for estimating associated annual savings from the additional storage are $ 0.33 per kWh for Emigrant Creek WTP, and a mean escalation rate for such charges at 6% per annum. 6% has been used as the standard assumption for annual electricity price increase at each site as it is the mid-point between the likely range of 2% to 10% per annum.

Illustrated below is a cashflow diagram built upon the assumptions. Note the payback occurring between Years 7 and 8, as well as a cash outflow at Year 13 associated with charges for potential battery replacement.

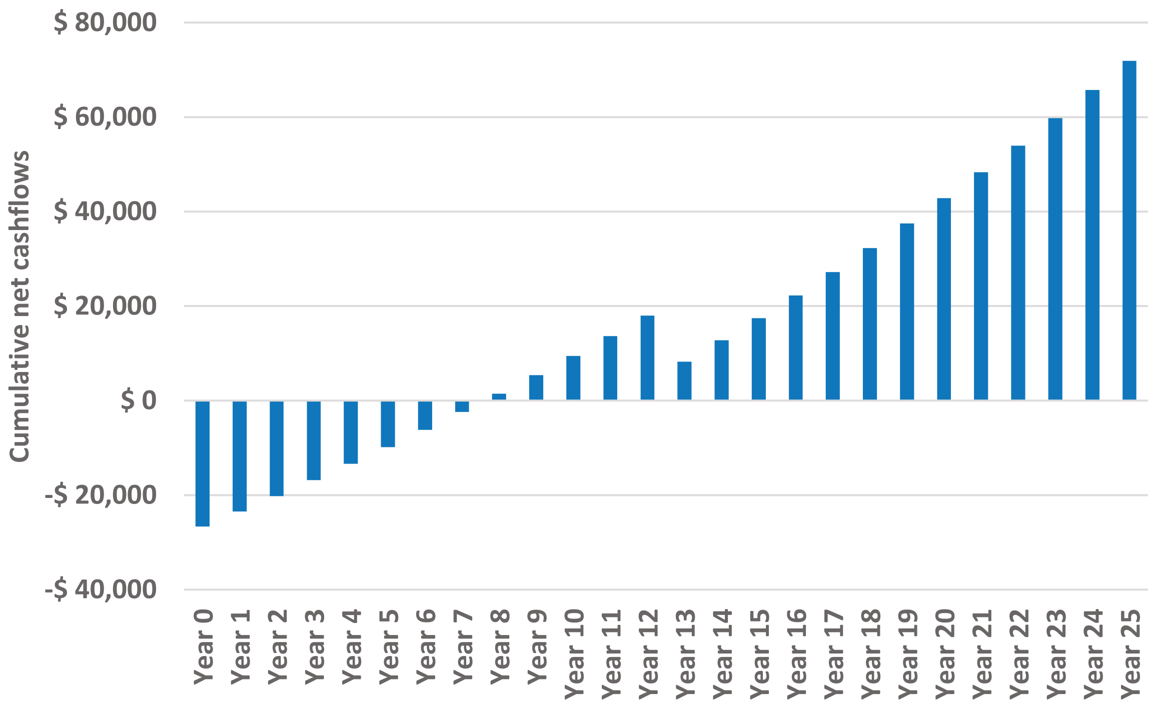


FIGURE 31: EMIGRANT CREEK WTP 30-KWH BESS CUMULATIVE CASHFLOW

5.6 Feasibility assessment: *Gallans Road Site*

Three separate options were considered for the Gallans Road site: PV only, PV plus BESS, and on-ground solar farm.

5.6.1 Rooftop solar PV

Modelling of the potential solar array at the Gallans Road Administration Offices was conducted via a desktop-only approach with HelioScope™, a commercial solar PV modelling software.

The analysis and feasibility assessment for solar were predicated upon energy demand for the site as informed by available interval data and load profiles, potential roof space to accommodate modules as given by up-to-date aerial satellite images by NearMap™, shading restrictions presented by nearby trees, obstructions from various components such as condenser units, as well as optimal roof selection as supported by shading constraints from differences in roof heights and pitches.

Select load profiles from representative days from March until June 2022 (the last four months of FY 2022) are illustrated below. As indicated from the availability of interval data, site load has been increasing substantially since October 2021 and it is assumed that the site has now reached expected occupancy and thus normal operations as at March 2022. Any future increases to occupancy are likely to further increase site electricity demand.

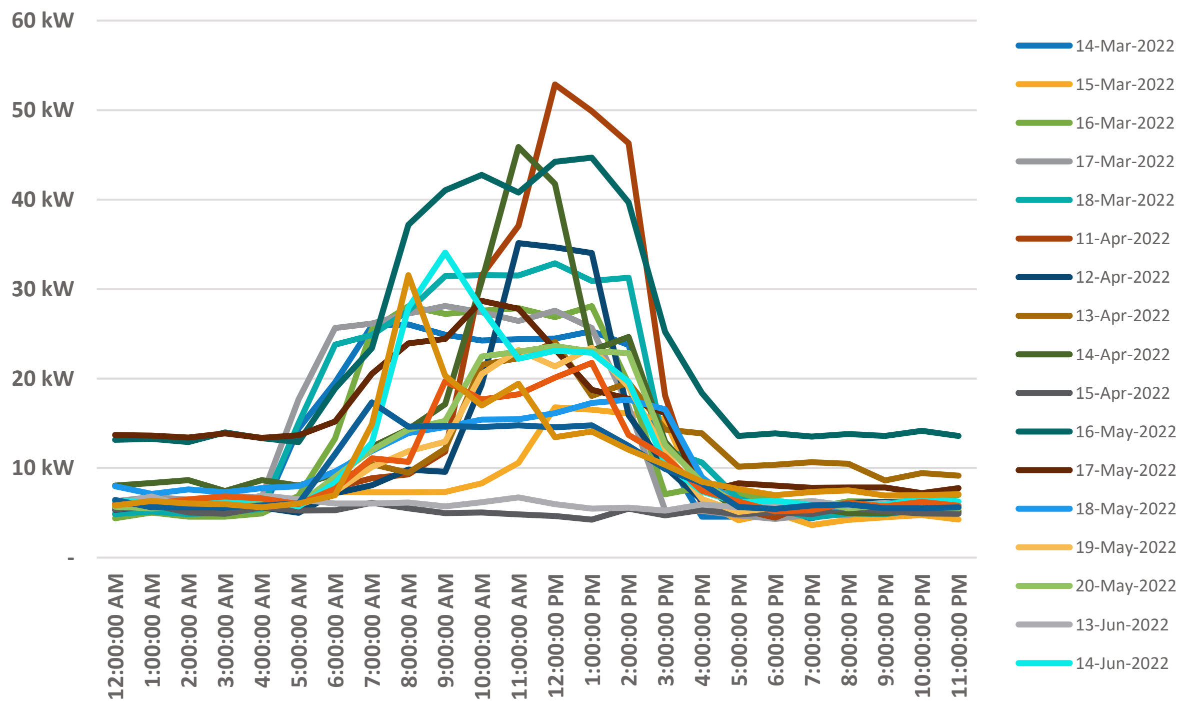


FIGURE 32: GALLANS RD ADMINISTRATION OFFICES LOAD PROFILES

We determined that the northern section of roof at the operational building would be an optimal placement for a flush-mounted 35.9-kW array comprised of individual 390-W modules. Annual system solar yield of ~51 MWh would be ~80% self-consumed on site, with ~20% exports back to the grid. Layout configuration was optimised to allow for maintenance access and sufficient setback from roof edges of about ~0.5 m, as well as to limit induced shading losses from the N-W trees during the winter months.

Estimated from the solar output and demand profiles is a summary of the proposed system's performance, as presented in the table below:

TABLE 15: GALLANS RD ADMINISTRATION OFFICES 35.9-KW SOLAR PV PERFORMANCE SUMMARY

Solar PV capacity	Estimated annual self-consumption	Estimated site demand	Energy offset by solar
35.88 kW	41 MWh pa	92 MWh pa	44.1%

Below is an aerial view of the proposed system's layout configuration, highlighting shading induced by the closest N-W trees.

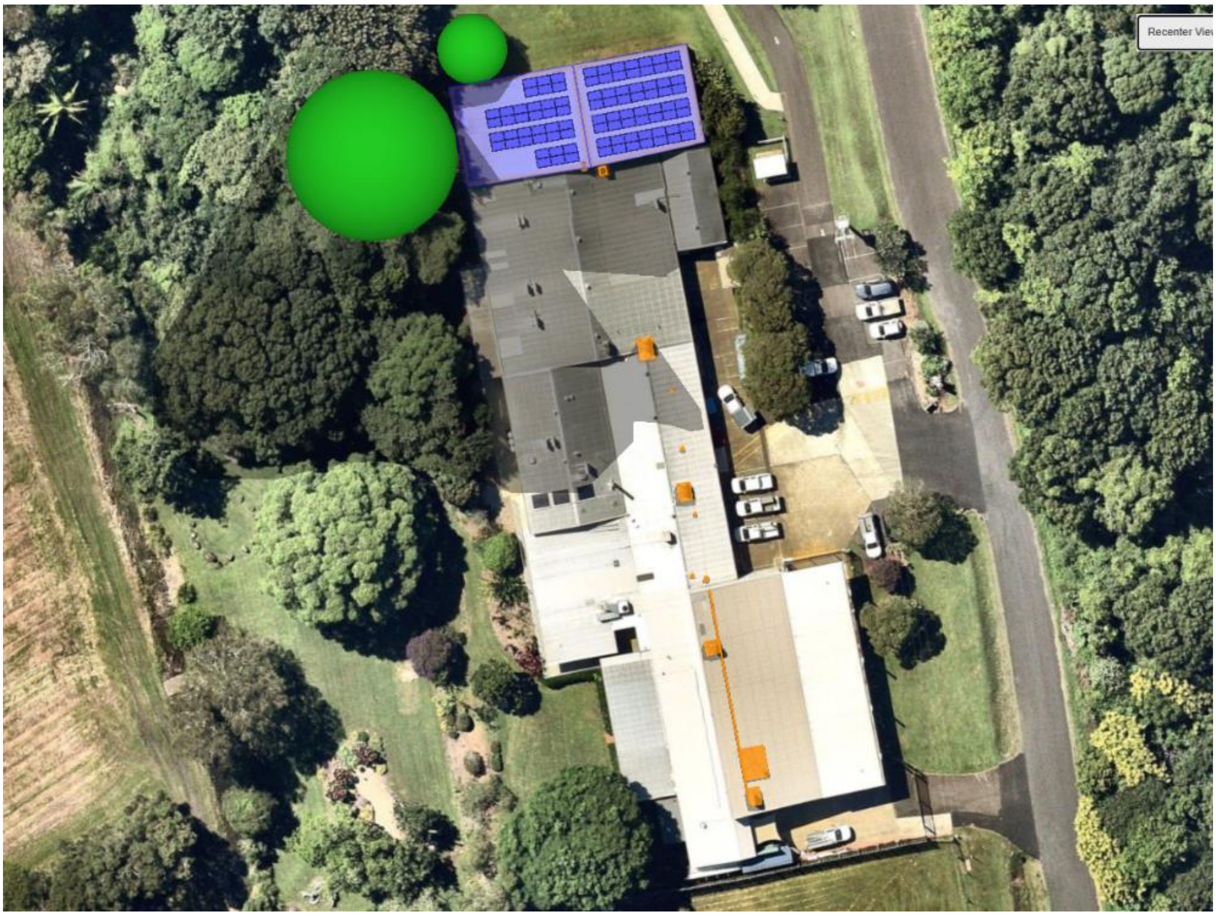


FIGURE 33: GALLANS RD ADMINISTRATION OFFICES 35.9-KW SOLAR PV SYSTEM

Illustrated below is a chart showing mean grid consumption before and after solar PV installation, as calculated from the available site's interval data and solar generation figures.

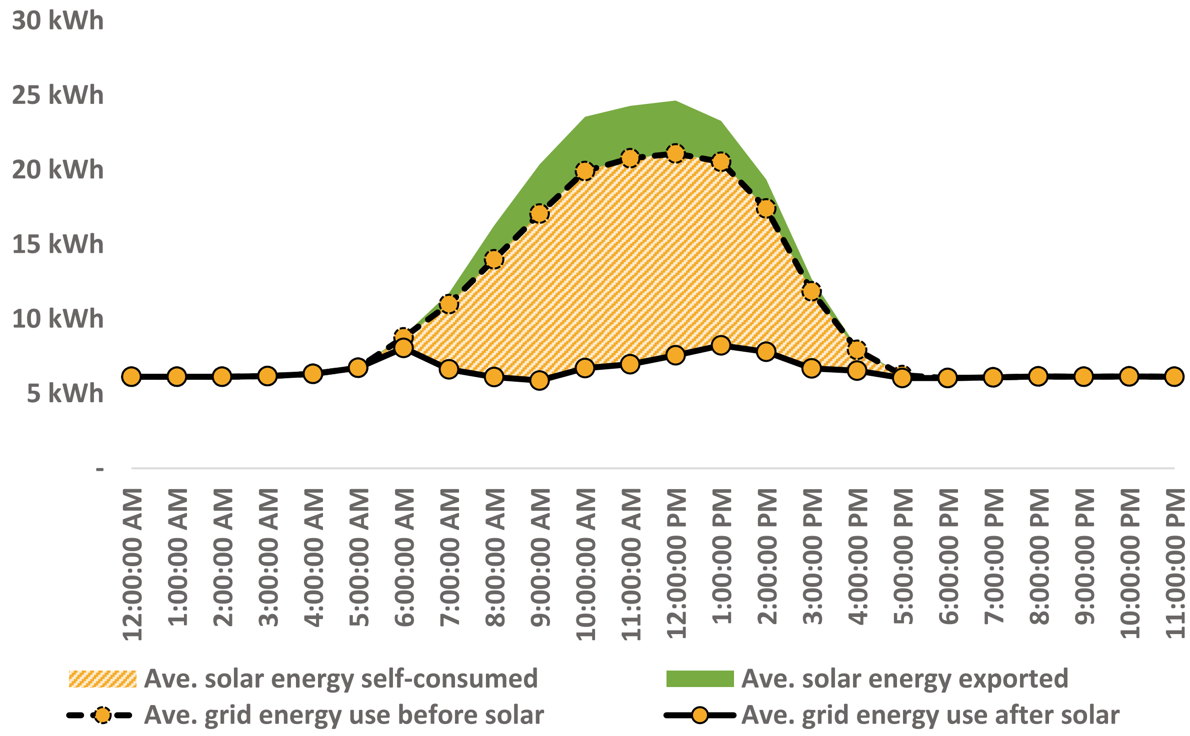


FIGURE 34: GALLANS RD ADMIN OFFICES AVERAGE GRID IMPORTS BEFORE & AFTER SOLAR PV

Presented below is a tabulation of costs and savings for the proposed system, with all figures being GST-exclusive:

TABLE 16: GALLANS RD ADMINISTRATION OFFICES 35.9-KW SOLAR PV COST-BENEFIT ANALYSIS

Description	Value
System size	36 kW
Capital cost	$ 50,232
Annual savings	$ 12,636
Internal rate of return	30%
Payback period	3.7 years
Net present value	$ 247,838
Annual self-consumption	41 MWh pa

Assessing the economic viability of the solar array involved similar assumed figures as that of the BESS-only opportunity at Emigrant Creek WTP for feed-in tariff rates, escalation rates for electricity charges, and discount rates for calculating net present values, with the exception of annual solar PV capacity degradation rate of ~1% and $ 0.37 per kWh for non-fixed electricity charges, as derived from retail rates for the Administration Offices. The following cashflow diagram indicates a favourable payback by the 4th year, which is primarily driven by low investment costs for solar PV and relatively high electricity charges at this site together with a good match between demand and generation profiles.

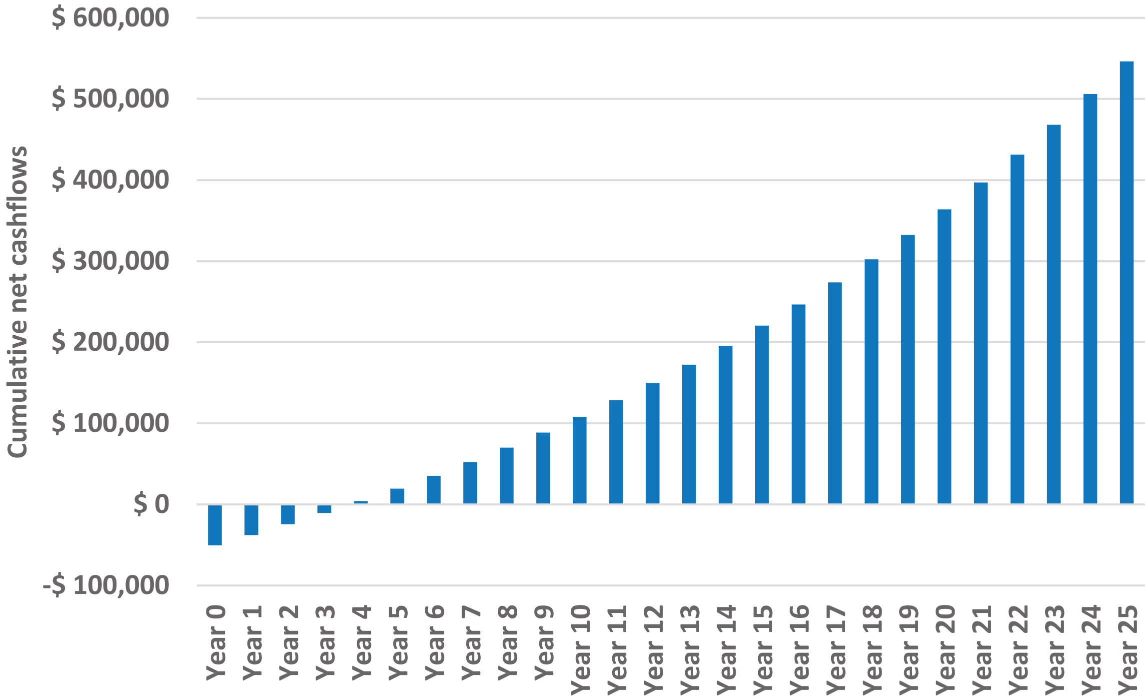


FIGURE 35: GALLANS RD ADMINISTRATION OFFICES 35.9-KW SOLAR PV CUMULATIVE CASHFLOW

5.6.2 Rooftop plus solar PV + BESS

A secondary option for the Administration Offices at Gallans Road is to upsize the solar array to utilise roof spaces that are optimal in terms of minimising shading losses caused by nearby elevated roofs and trees, and install BESS to capture solar yield for self-consumption that otherwise would have been exported back to the grid.

We determined the roof at the middle portion of the operational building premises to have ample space for a further 17-kW array on top of the preceding 36-kW system, and was estimated via calculations using Google StreetView™ images to have enough elevation to minimise shading losses induced by the N-W trees. In addition, we recommend up to a 140-kWh battery storage system to capture surplus solar energies. Presented in the table below is a summary of the proposed system's performance:

TABLE 17: GALLANS RD ADMIN OFFICES 53.0-KW SOLAR PV + 140-KWH BESS PERFORMANCE SUMMARY

Solar PV capacity	BESS capacity	Est. consumption from solar + BESS	Estimated site demand	Energy offset by solar + BESS
53.04 kW	140 kWh	71 MWh pa	92 MWh pa	43.5%

We present below an optimal configuration of the flush-mounted 53-kW solar array below, noting layout limitations due to obstructions in the form of rooftop equipment, and keeping adequate space for maintenance access and setback from roof edges:

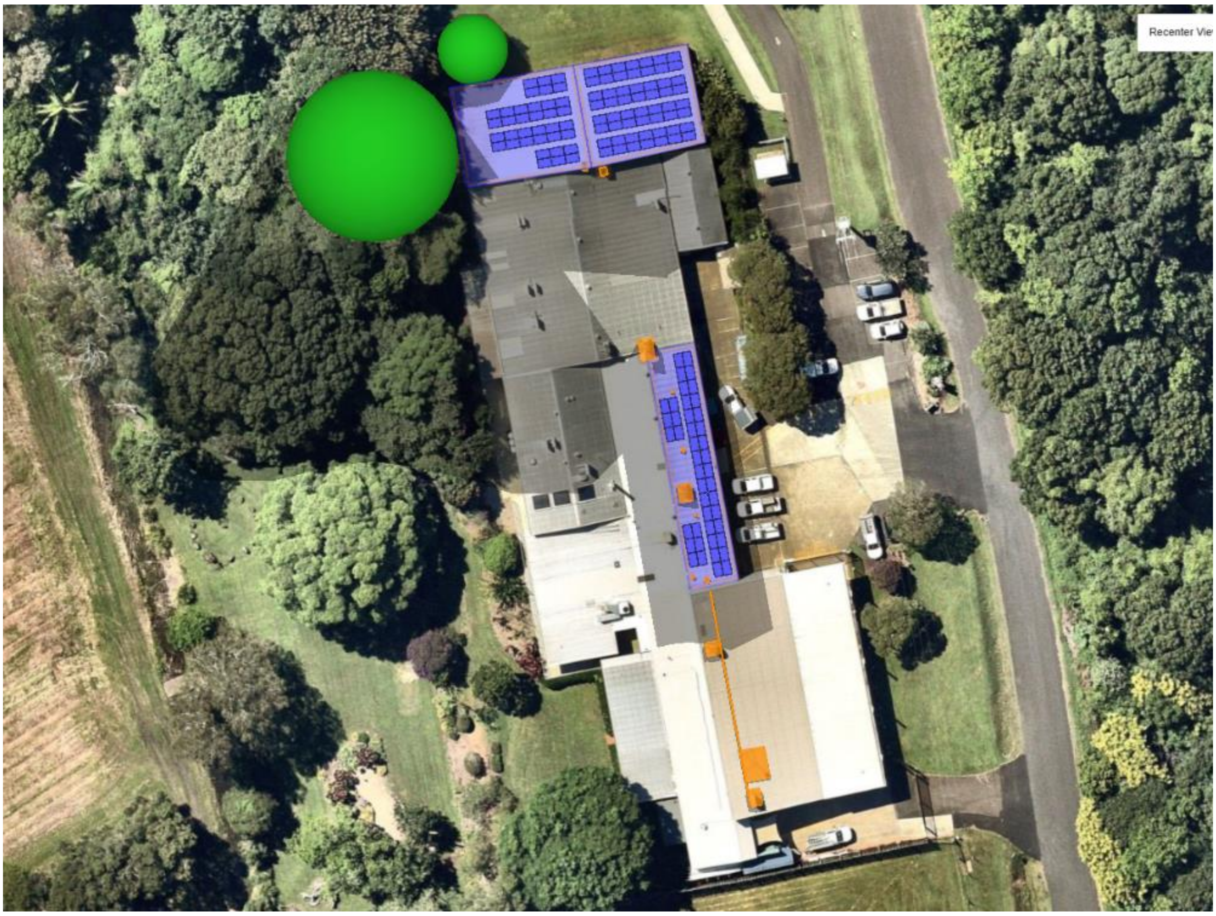


FIGURE 36: GALLANS RD ADMINISTRATION OFFICES 53-KW SOLAR PV SYSTEM

The figure below builds upon the preceding chart, now highlighting the influence of adding battery storage, as it is presumed to charge off generated solar during peak sun hours and discharge at other hours (primarily late afternoon and evenings) when the system does not produce adequate (or any) solar power.

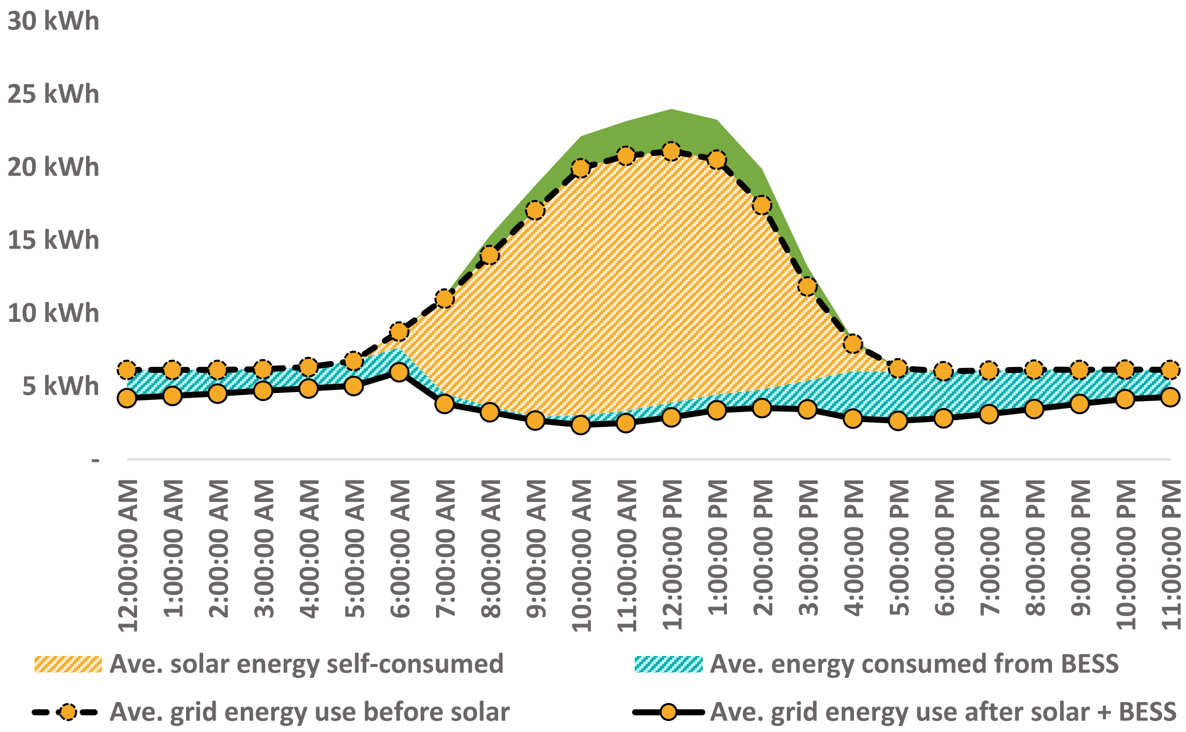


FIGURE 37: GALLANS RD ADMIN OFFICES AVERAGE GRID IMPORTS BEFORE & AFTER SOLAR PV + BESS

A summary of associated costs and savings is presented in the following table, with currency figures being GST-exclusive:

TABLE 18: GALLANS RD ADMIN OFFICES 53.0-KW SOLAR PV + 140-KWH BESS COST-BENEFIT ANALYSIS

Description	Value
Solar PV capacity	53 kW
BESS capacity	140 kWh
Capital cost	$ 200,256
Annual savings	$ 21,827
Internal rate of return	13%
Payback period	7.9 years
Net present value	$ 253,404
Annual self-consumption	71 MWh pa

It can be inferred that the more expensive price ranges for battery storage on a per-kWh basis compared with PV alone has quadrupled the capital costs and increased the payback period to 7.9 years. Cash inflows in the form of savings and outflows in the form of overhead and replacement costs are presented in the following chart:

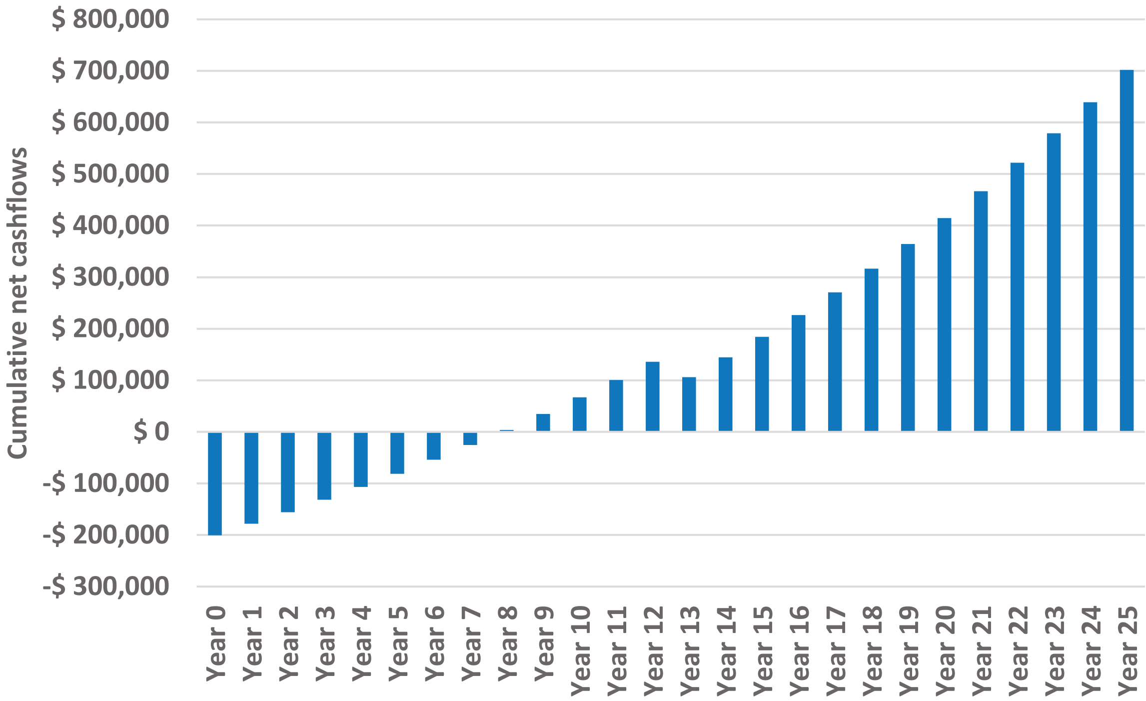


FIGURE 38: GALLANS RD ADMIN OFFICES 53.0-KW SOLAR PV + 140-KWH BESS CUMULATIVE CASHFLOW

5.6.3 Potential for on-ground solar

The project investigated potential for a large on ground solar array at the Gallans Road estate. Due to flood risk and the likely need for elevated mounting costs, the costs would be high relative to rooftop options. A solar glare study would also need to be undertaken to ensure risk to aviation was avoided. Project economic feasibility would largely depend on the price paid or credited (e.g. through virtual metering arrangement) for the exported solar.

FIGURE 39: ROUS COUNTY COUNCIL'S LAYOUT OF A 2.7-MW SOLAR FARM AT GALLANS RD ESTATE

5.7 Feasibility assessment: *Rocky Creek Rainforest and Water Reserve*

Council's 2018 GHG Abatement Strategy considered the potential for solar PV at the Rocky Creek Dam Rainforest and Water Reserve, specifically for supplication of the aerator's energy demand, to be economically unviable at the time, owing to factors such as subpar location of the land being on a hill, extra overhead costs for cabling to the aerator and tilt frames, as well as lower efficiency and higher costs for PV modules at that time. Council requested that the potential project be re-evaluated as part of the current project.

The load profiles below illustrate the demand for representative days for each of the four seasons, indicating a peak demand that continuously falls between 80-90 kW when the plant is operational throughout the day except for some duration during peak hours from 7:00 am until 1:00 pm. Such is the apparent trend for the aerator except during winter, for which the plant is ru n for shorter intervals in the late afternoon (4:00 – 6:00 pm) and evening (11:00 pm – 2:00 am).

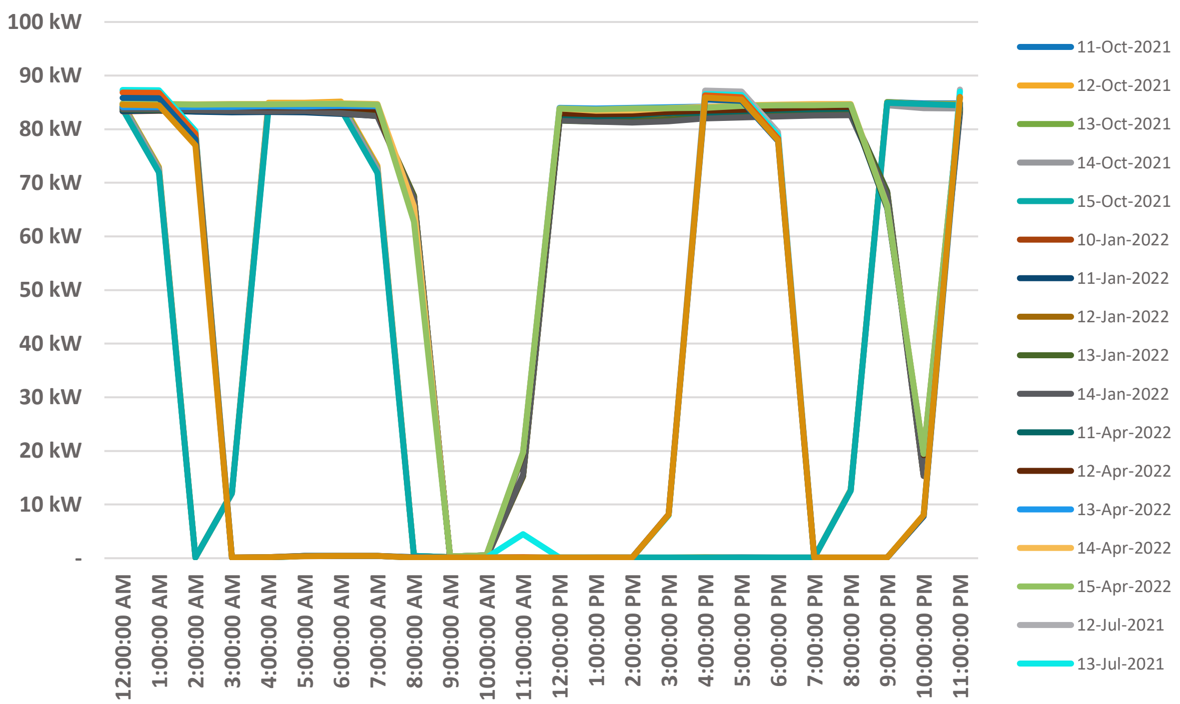


FIGURE 40: ROCKY CREEK DAM AERATOR LOAD PROFILES

It has been determined that an STC-scale ground-mount solar array of 97.50 kW capacity will be sufficient to cover land area that will also necessitate minimal land clearing and avoid shading constraints caused by nearby trees. A summary of the proposed system's performance is provided below:

TABLE 19: ROCKY CREEK DAM 97.50-KW SOLAR PV PERFORMANCE SUMMARY

Solar PV capacity	Estimated annual self-consumption	Estimated site demand	Energy offset by solar
97.50 kW	48 MWh pa	408 MWh pa	10.5%

We recommend the tilt orientation of ground-mount array to be 30° facing direct north, as the location's latitude is around this value in the southern hemisphere and thus will allow for optimal solar irradiance on the panels. A 2.0-m row clearance between the panels has been set to limit inter-panel shading and to allow for maintenance access. These configurations are illustrated in the following HelioScope™ images:

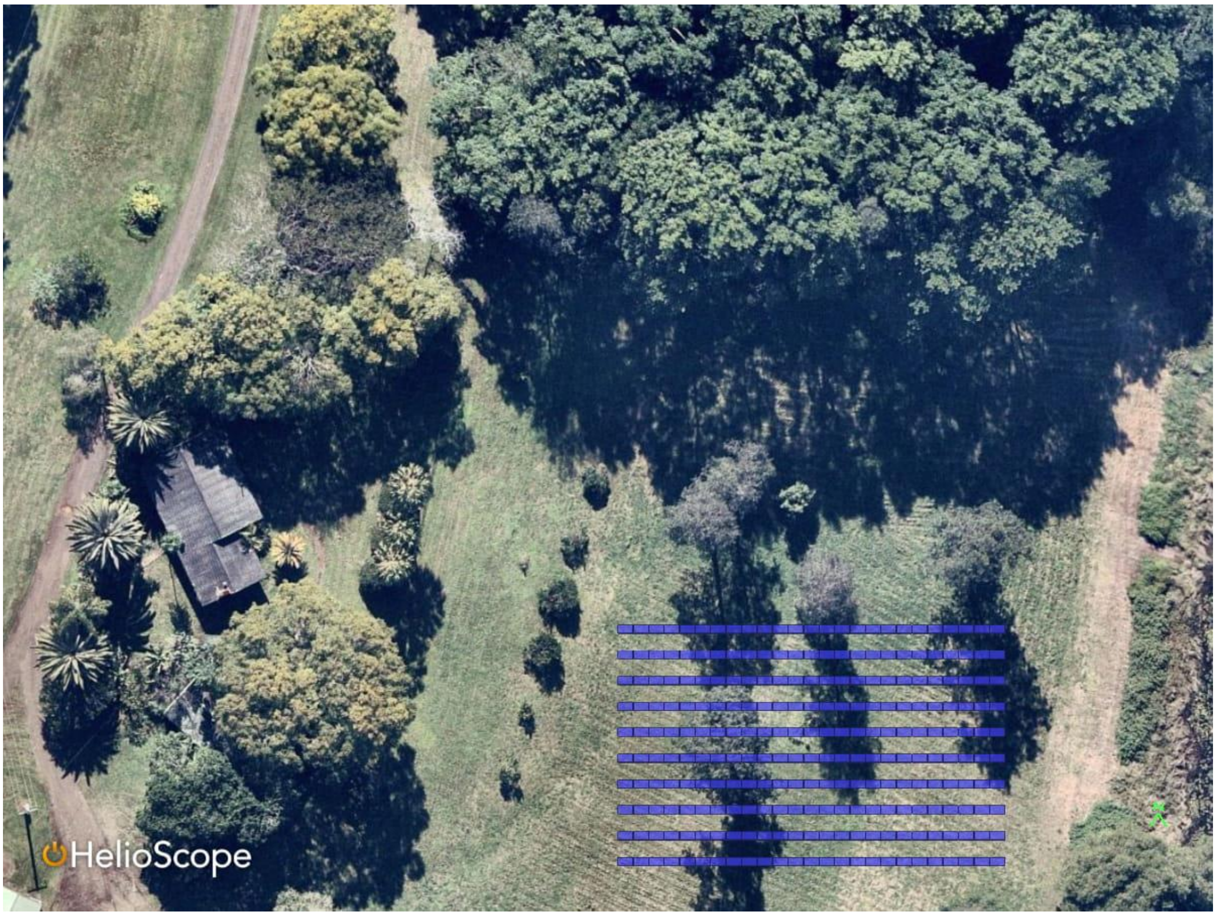


FIGURE 41: ROCKY CREEK DAM 97.5-KW SOLAR PV SYSTEM (TOP VIEW)

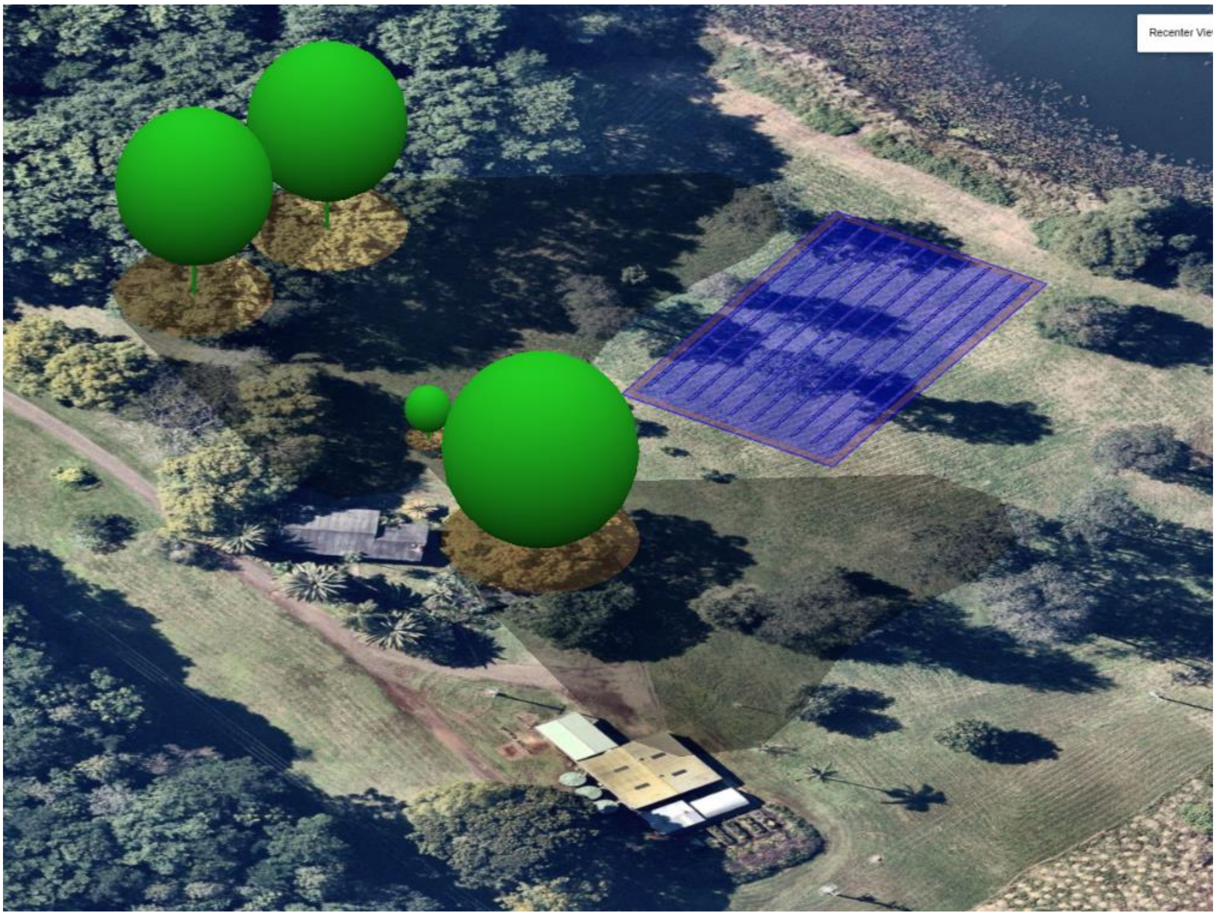


FIGURE 42: ROCKY CREEK DAM 97.5-KW SOLAR PV SYSTEM (ISOMETRIC VIEW)

A cost-benefit assessment for the site is provided in the following table and chart. Additional overhead costs for land clearing, ~400-m cabling to the aerator and extra racking systems have increased capital costs significantly leading to a relatively long payback period.

TABLE 20: ROCKY CREEK DAM 97.5-KW SOLAR PV COST-BENEFIT ANALYSIS

Description	Value
System size	98 kW
Capital cost	$ 212,673
Annual savings	$ 13,881
Internal rate of return	7%
Payback period	12.8 years
Net present value	$ 58,619
Annual self-consumption	48 MWh pa

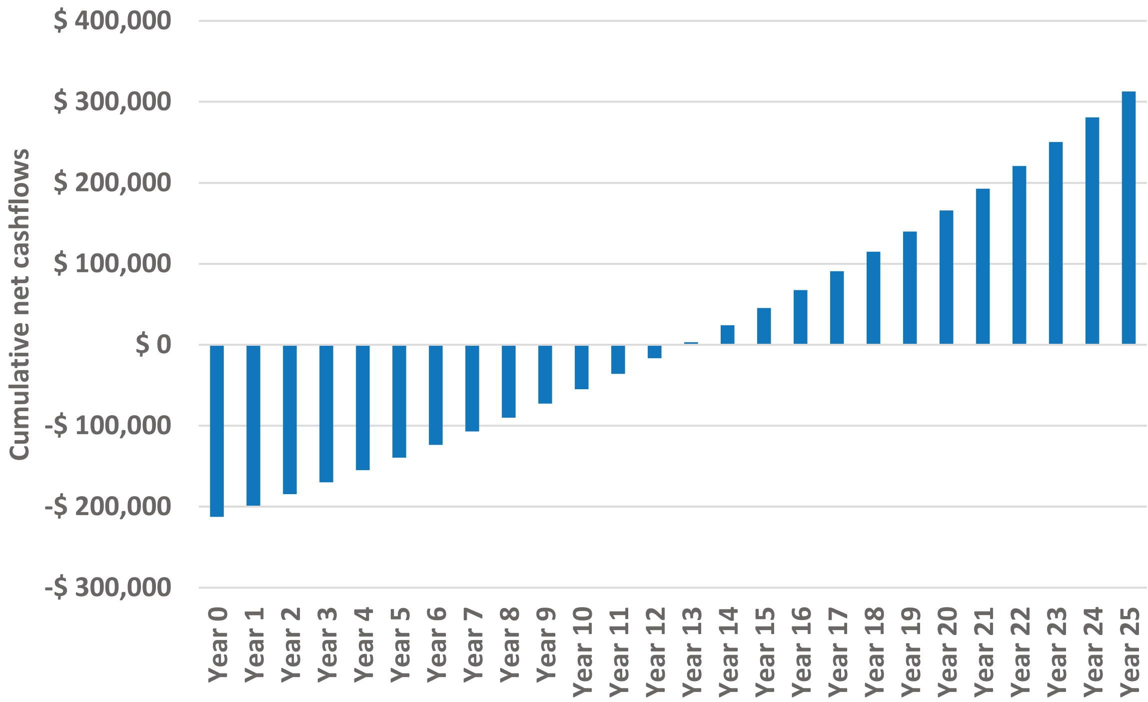


FIGURE 43: ROCKY CREEK DAM 97.5-KW SOLAR PV CUMULATIVE CASHFLOW

The low cost-effectiveness of the system may be attributed to the underutilisation of solar energy due to the lack of operation during peak hours. To enhance the economic viability of the system, it is recommended to shift the site's utilisation forward for more utilisation during daytime. Taking hourly demand averages on a seasonal basis and transposing forward by six hours yields the following profiles:

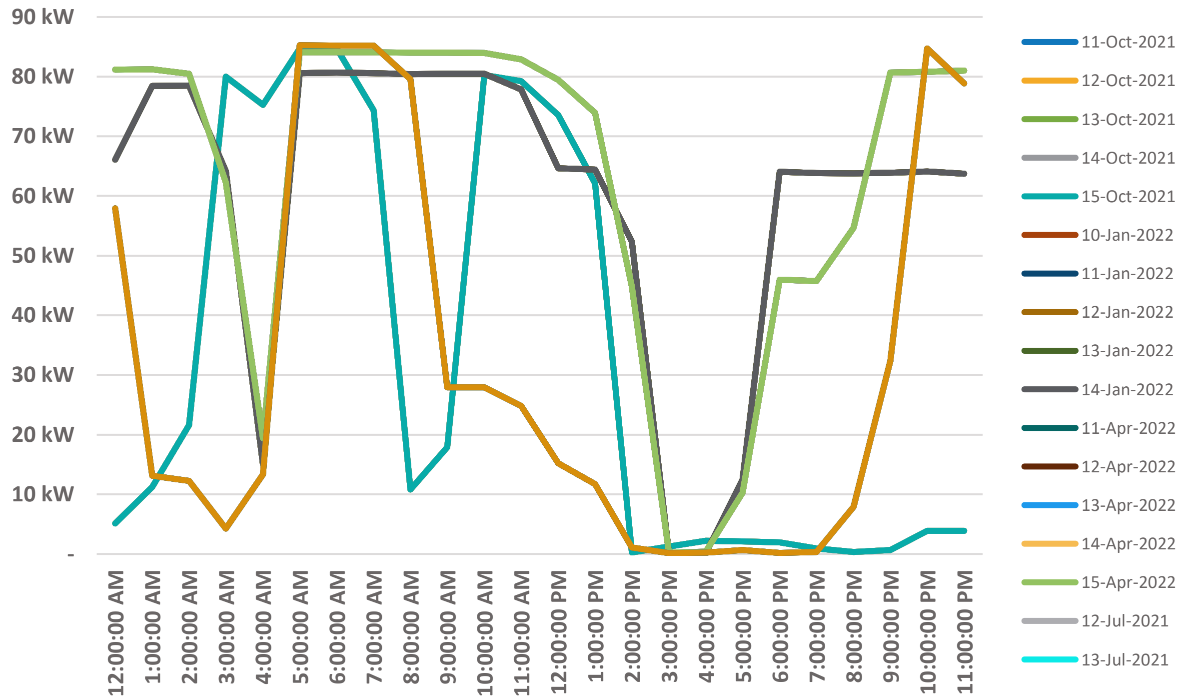


FIGURE 44: ROCKY CREEK DAM AERATOR SIMULATED LOAD PROFILES (DEMAND-SHIFT-TO-DAY TIME SCENARIO)

This would translate into an increase in self-consumption of solar energy and overall offset of grid imports by the system, as given by the following table:

TABLE 21: RCD 97.5-KW SOLAR PV PERFORMANCE SUMMARY (DEMAND-SHIFT-TO-DAY TIME SCENARIO)

Solar PV capacity	Estimated annual self-consumption	Estimated site demand	Energy offset by solar
97.50 kW	48 MWh pa	408 MWh pa	10.5%

Associated with this shift in demand profiles is an improvement on the system's profitability, as indicated by the financial assessment and cashflow diagram below:

TABLE 22: RCD 97.5-KW SOLAR PV COST-BENEFIT ANALYSIS (DEMAND-SHIFT-TO-DAY TIME SCENARIO)

Description	Value
System size	98 kW
Capital cost	$ 212,673
Annual savings	$ 23,256
Internal rate of return	14%
Payback period	7.8 years
Net present value	$ 324,714
Annual self-consumption	116 MWh pa

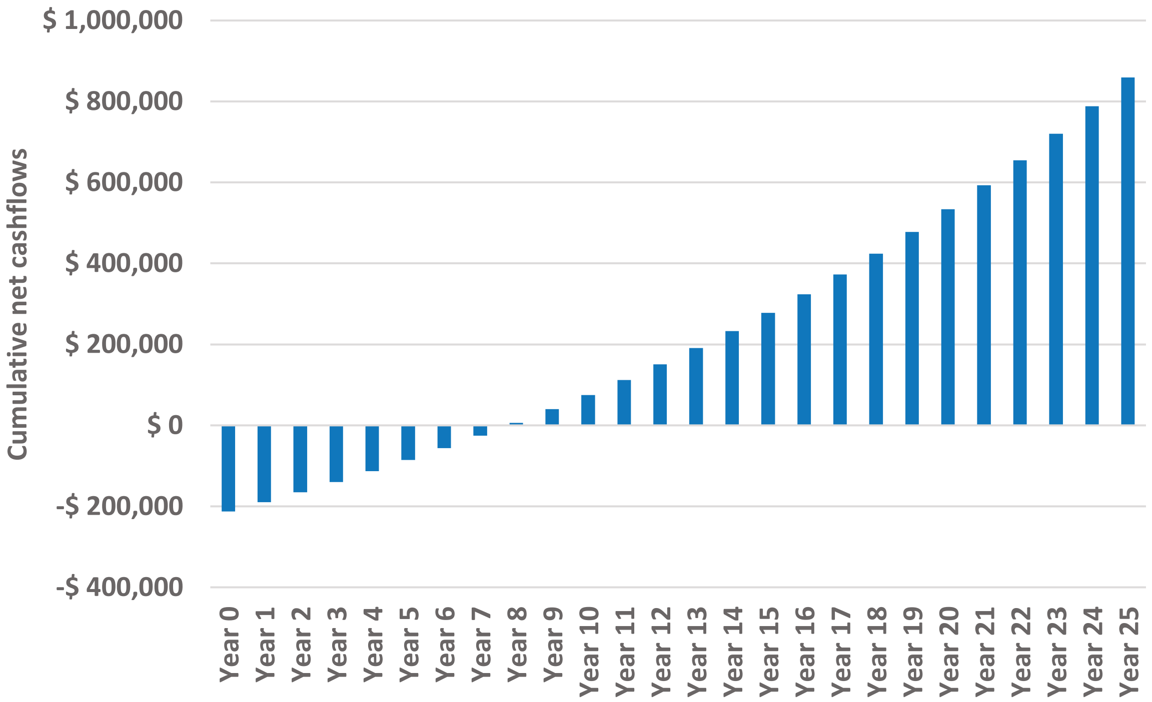


FIGURE 45: RCD 97.5-KW SOLAR PV CUMULATIVE CASHFLOW (DEMAND-SHIFT-TO-DAY TIME SCENARIO)

5.8 Feasibility assessment: *(Proposed) Russellton Estate Water Treatment Plant*

Council has affirmed that a new Water Treatment Plant will be constructed at the Russellton Estate in Wollongbar. It was suggested that the demand profiles will roughly be equivalent to that of the existing Emigrant Creek WTP, for which a 40-kW flush-mounted rooftop array is installed. Hence, for this solar PV opportunity, it is assumed that the proposed establishment will have a similar structural configuration and dimensions in length, width and height as that of Emigrant Creek WTP's, as well as the capacity to accommodate rooftop solar PV. By simultaneously considering proxy demand, location and structural constraints, we approximate a flush-mounted rooftop solar PV system with a maximum capacity that ranges between 90-100 kW combined with a battery storage close to ~200 kWh in capacity will be feasible to meet site demand. Presented in the table below is a performance summary of a modelled sample configuration, which helps to provide a picture of the potential system output.

TABLE 23: (PROPOSED) RUSSELLTON ESTATE WTP SAMPLE SOLAR PV + BESS SYSTEM PERFORMANCE SUMMARY

Solar PV capacity	BESS capacity	Est. consumption from solar + BESS	Estimated site demand	Energy offset by solar + BESS
93.60 kW	210 kWh	127 MWh pa	429 MWh pa	29.5%

A cost-benefit analysis tabulated below was derived from the specifications listed above, with all figures being GST-exclusive.

TABLE 24: (PROPOSED) RUSSELLTON ESTATE WTP SAMPLE SOLAR PV + BESS SYSTEM COST-BENEFIT ANALYSIS

Description	Value
Solar PV capacity	94 kW
BESS capacity	210 kWh
Capital cost	$ 320,040
Annual savings	$ 37,819
Internal rate of return	14%
Payback period	7.4 years
Net present value	$ 444,200
Annual self-consumption	127 MWh pa

A cashflow chart supporting the assessment above is presented below, with consideration for a potential battery replacement at Year 13.

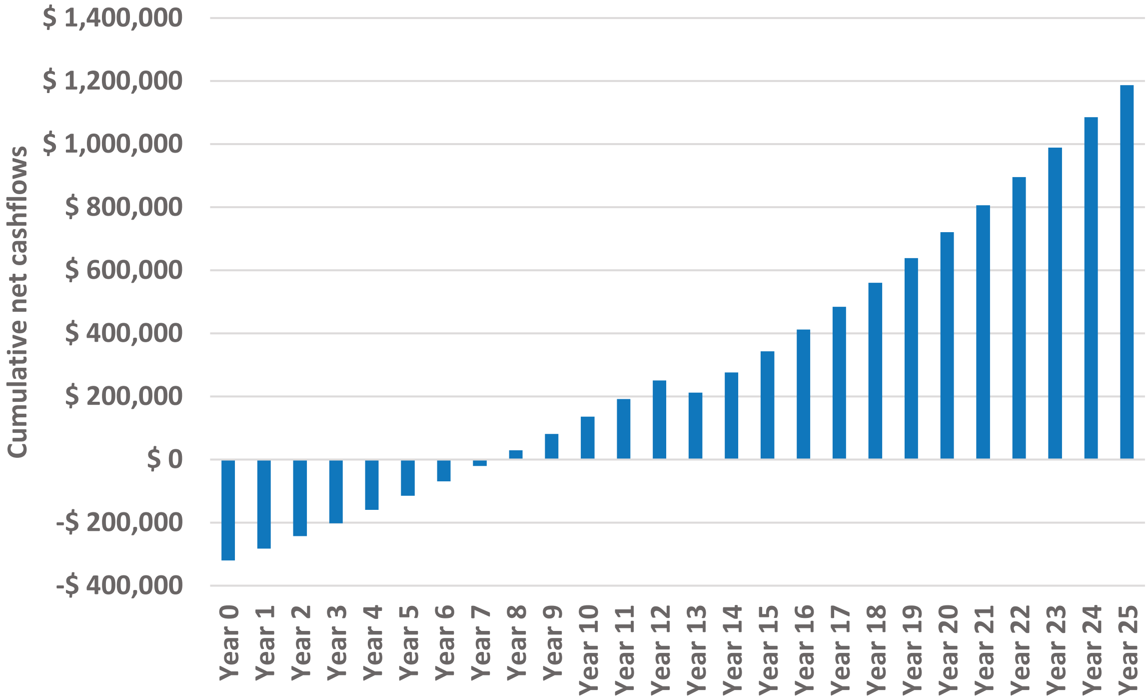


FIGURE 46: (PROPOSED) RUSSELLTON ESTATE WTP SAMPLE SOLAR PV + BESS CUMULATIVE CASHFLOW

5.9 Feasibility assessment: *Nightcap Water Treatment Plant and Raw Water Pumps*

Council commissioned a ~100-kW solar PV array in February 2023 at the Water Treatment Plant along Nightcap Range Road in Dorroughby. Council requested an assessment of the feasibility of battery storage for supplementing the array's capacity. However, as the system is newly installed, detailed interval data on its solar generation for a full year was unavailable, thus a granular analysis based on actual data was not possible at this time. Presented below is a model of the system via HelioScope^{TM}, which was accomplished by making inferences from site images and supplier-provided specifications.

FIGURE 47: NIGHTCAP WATER TREATMENT PLANT ~100-KW SOLAR PV SYSTEM (RE-MODELLED)

Estimating the exported solar energy from this system to be 10% and following the high-level approach conducted previously for sizing BESS, the overall system performance summary for an additional 54-kWh battery is as follows:

TABLE 25: NIGHTCAP WTP ~100-KW SOLAR PV + 54-KWH BESS PERFORMANCE SUMMARY

Solar PV capacity	BESS capacity	Est. consumption from solar + BESS	Estimated site demand	Energy offset by solar + BESS
~100 kW	54 kWh	145 MWh pa	1,890 MWh pa	7.1%

Costs and savings over the system's lifespan are presented below, with figures being GST-free:

TABLE 26: NIGHTCAP WATER TREATMENT PLANT ~100-KW SOLAR PV + 54-KWH BESS COST-BENEFIT ANALYSIS

Description	Value
Solar PV capacity	~100 kW
BESS capacity	54 kWh
Capital cost	$ 186,878
Annual savings	$ 24,339
Internal rate of return	17%
Payback period	6.6 years
Net present value	$ 381,819
Annual self-consumption	145 MWh pa

A cumulative net cashflow diagram is given below, with calculations accounting for both expenditures on the recently installed ~100-kW solar PV and proposed battery:

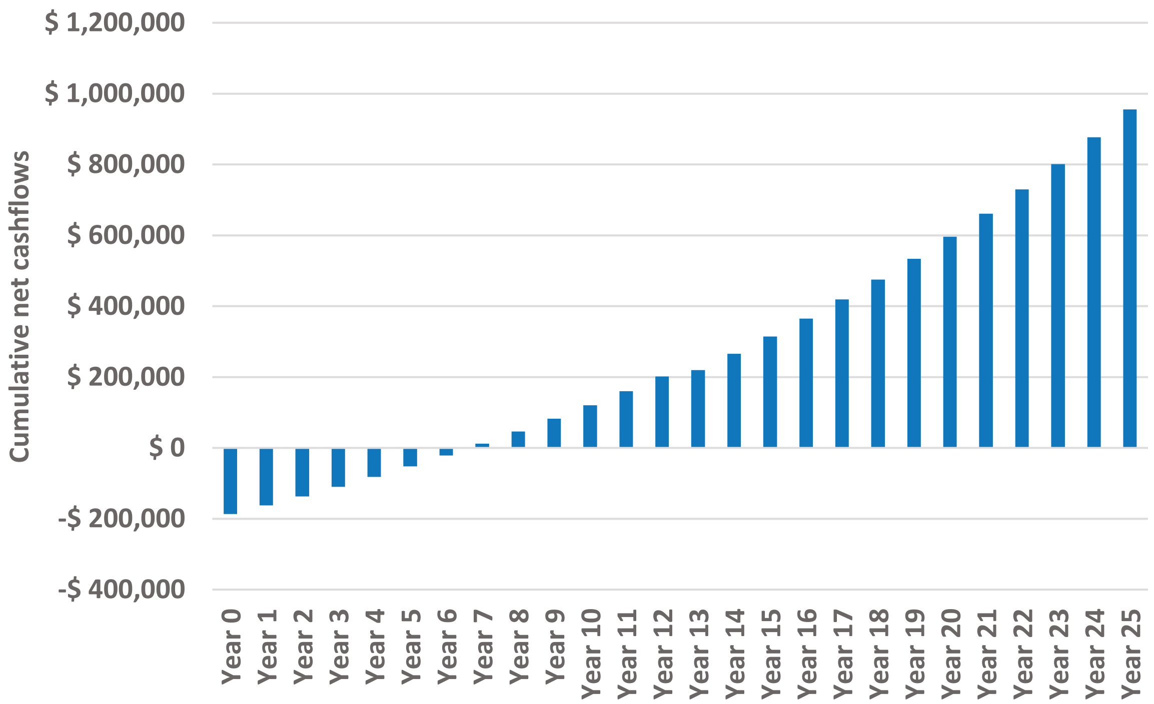


FIGURE 48: NIGHTCAP WATER TREATMENT PLANT ~100-KW SOLAR PV + 54-KWH BESS CUMULATIVE CASHFLOW

Council also confirmed its consideration to installing another ~100-kW system on the roof of the nearby water reservoir, which will be connected to the separate NMI dedicated to the Raw Water Pumps. The layout for this system was derived from supplier's specifications and was re-modelled for the purpose of simulating the annual solar yield output.

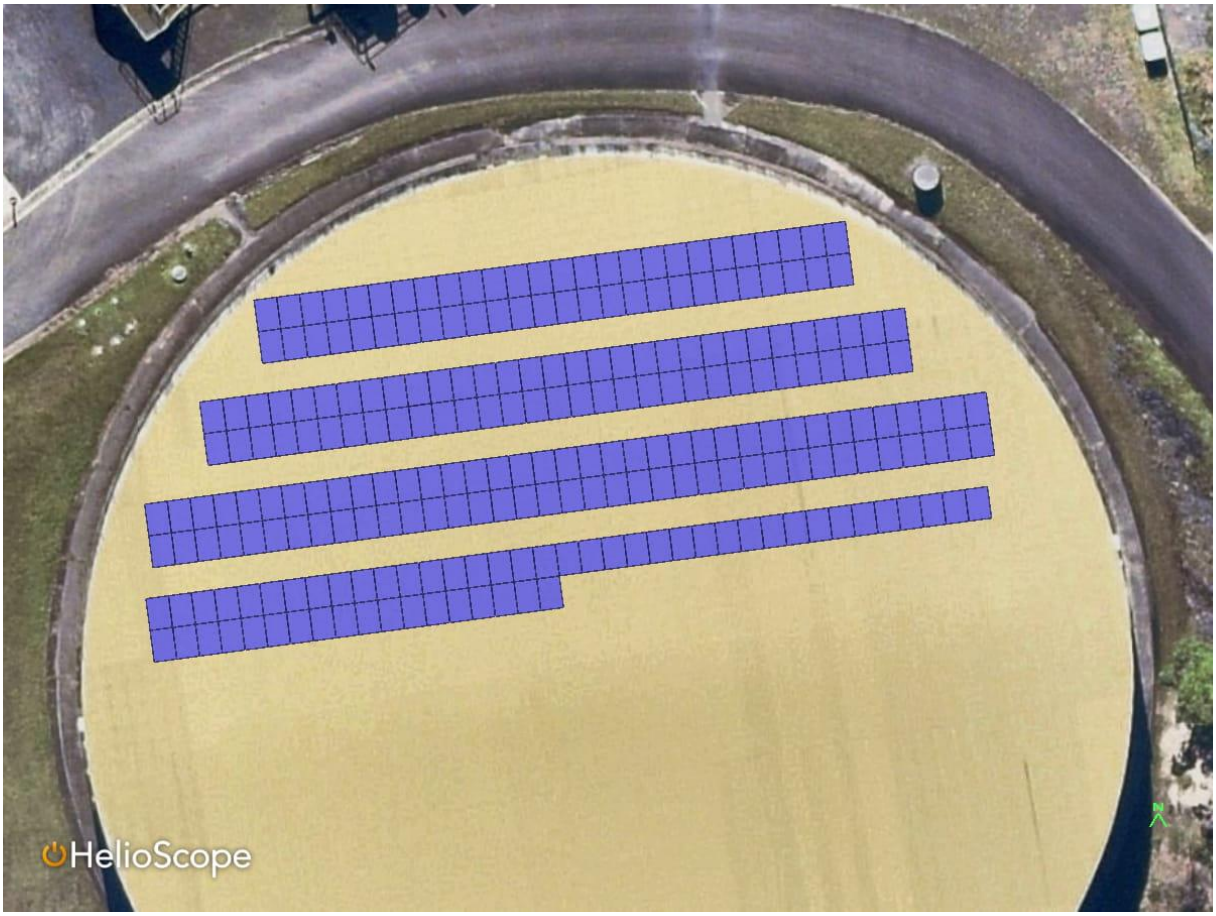


FIGURE 49: NIGHTCAP RAW WATER PUMPS ~100-KW SOLAR PV SYSTEM

To augment the system, a 68-kWh of additional battery storage was modelled, and overall system performance was summarised as follows:

TABLE 27: NIGHTCAP RAW WATER PUMPS ~100-KW SOLAR PV + 68-KWH BESS PERFORMANCE SUMMARY

Solar PV capacity	BESS capacity	Est. consumption from solar + BESS	Estimated site demand	Energy offset by solar + BESS
~100 kW	68 kWh	168 MWh pa	1,182 MWh pa	12.5%

Expected costs and savings for the proposed combined system are tabulated below. Indicative capital costs include quoted price of ~$ 200K for the ~100 kW system, on top of estimated costs for the additional battery. Cumulative cashflow diagram for this system is presented in the succeeding chart.

TABLE 28: NIGHTCAP RAW WATER PUMPS ~100-KW SOLAR PV + 68-KWH BESS COST-BENEFIT ANALYSIS

Description	Value
Solar PV capacity	~100 kW
BESS capacity	68 kWh
Capital cost	$ 264,149
Annual savings	$ 26,710
Internal rate of return	13%
Payback period	8.2 years
Net present value	$ 355,333
Annual self-consumption	168 MWh pa

Cumulative cashflow diagram for this system is presented in the following chart.

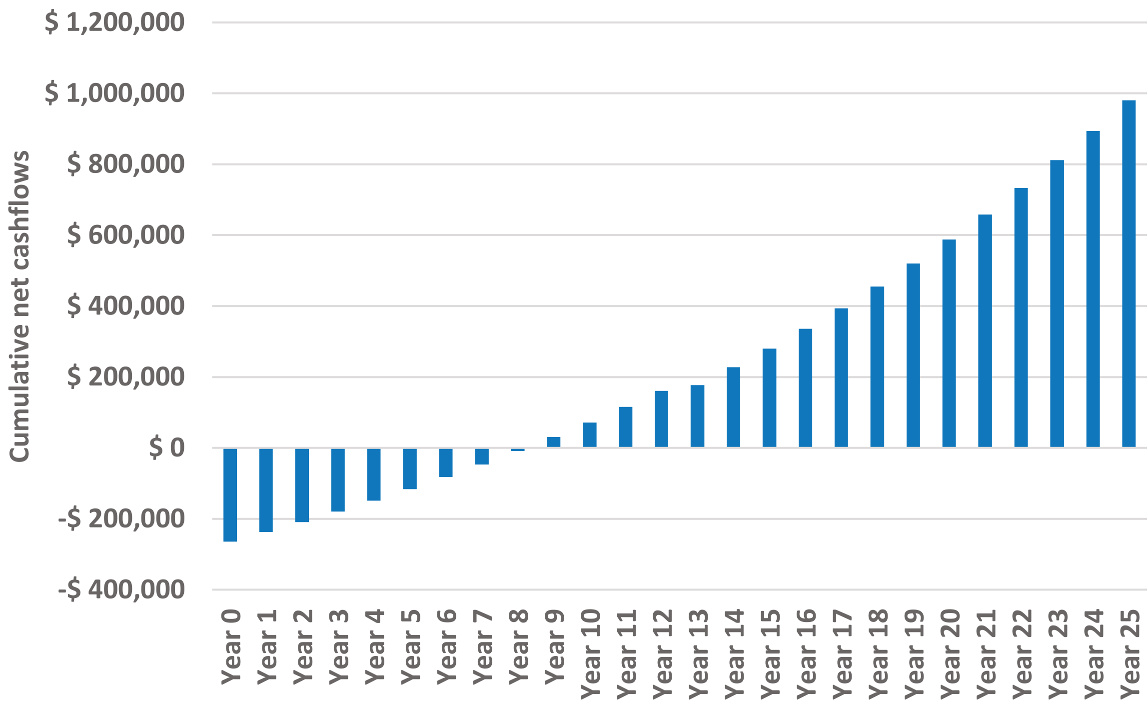


FIGURE 50: NIGHTCAP RAW WATER PUMPS ~100-KW SOLAR PV + 68-KWH BESS CUMULATIVE CASHFLOW

5.10 Summary of feasibility assessments for solar PV & battery storage at Rous County Council sites

Tabulated below are the initiatives for solar PV and BESS systems identified in the preceding sub-chapters that are deemed to be feasible for Council to implement in the coming years.

TABLE 29: SUMMARY OF SOLAR PV & BESS OPPORTUNITIES AT ROUS COUNTY COUNCIL SITES

Site name	Description of potential opportunity	Solar PV size	Battery capacity	Indicative capital costs ($)	Payback[9] (years)	IRR[9]	Year-1 savings ($)	NPV[9] ($)
Gallans Road Admin Offices	*Option 1:* Install a 35.9-kW roof-mounted solar PV at the northern roof to offset most of the site's daytime grid imports.	35.9 kW	-	~50,232	~3.7	30%	~12,636	~247,838
	Option 2: Alternatively, Council can consider utilising roof spaces in the middle portion and expand the solar PV capacity to 53.0 kW with ~140 kWh of battery storage.	53.0 kW	140 kWh	~200,256	~7.9	13%	~21,827	253,404
Newrybar Pump Station	Consider supplementing the existing 30-kW solar PV system with a ~45-kWh battery storage unit to reduce exports back to the grid.	-	45 kWh	~40,581	~8.0	12%	~4,609	~$ 33,869

[9] For estimation of payback period, internal rate of return & net-present values, escalation rate for electricity charges is set at 6% (average of 2-10% based on market ranges).

Site name	Description of potential opportunity	Solar PV size	Battery capacity	Indicative capital costs ($)	Payback[9] (years)	IRR[9]	Year-1 savings ($)	NPV[9] ($)
Emigrant Creek WTP	Investigate the potential to implement a ~30-kWh battery storage unit to support the existing 40-kW solar array.	-	30 kWh	~26,664	~7.6	12%	~3,185	~25,157
Rocky Creek Dam aerator	Council can consider installing a ground-mount 97.5-kW solar array in a small area south of the aerator. Additionally, it is suggested to transpose the site's operational hours forward to daytime to improve the system's economic viability amidst additional expenses for land clearing and extra cabling works.	97.5 kW	-	~212,673	~7.8	14%	~23,256	~324,714

Site name	Description of potential opportunity	Solar PV size	Battery capacity	Indicative capital costs ($)	Payback[9] (years)	IRR[9]	Year-1 savings ($)	NPV[9] ($)
Nightcap Raw Water Pumps	Council confirmed its plans of installing a further ~100-kW system on the roof of the water reservoir next to the Nightcap WTP. It is suggested to investigate the potential of augmenting the system with a battery storage unit for capturing exports during daytime.	~100 kW	68 kWh	~264,149	~8.2	13%	~26,710	~355,333
(Proposed) Russellton Estate Water Treatment Plant	Council affirmed that a new WTP will be situated at the Russellton Estate. Taking energy load profiles and structural configurations from the existing Emigrant Creek WTP as proxy, it is estimated that a roof-mounted solar PV system of 90-100 capacity with a ~200-kWh battery will be suitable to meet the proposed site's demand.	93.6 kW	210 kWh	~320,040	~8.3	12%	~33,276	~345,913

5.11 Virtual Net Metering

RCC requested consideration be given to the potential for "virtual net metering", which in theory has significant implications for PV and BESS strategies. In virtual net metering, the solar panels typically aren't connected to the energy end-user. The solar panels never directly provide power to the consumer; instead, all the electricity produced goes straight into the grid in return for credits.

Potential applications for a virtual net metering arrangement in the RCC context would include:

- Crediting excess solar PV from a large rooftop or ground mounted / solar farm to a site with high grid demand (such as Emigrant Creek WTP)
- Providing an alternative to batteries in trying to get better value out of exported solar electricity

Virtual net metering was originally proposed in the context of efforts to establish discounted tariffs for local generation to reduce the full network charges, but there has been little progress towards achieving its initial aims. Research undertaken for this project indicates that virtual net metering remains somewhat of an abstract ideal rather than a practical reality.

However, there are options already available in Australia by which an organisation can credit renewable energy generated at one site against its grid demand at one or more other sites. In this arrangement a retailer/broker would allow the credit at the time of use retail rate of the site receiving the credit.

The main issue to consider whether is the value or credits received for the exported solar can provide sufficient cashflow to make the business case competitive with other potential investment options. In terms of emissions reduction accounting, if the PV array is STC-scale then the emissions benefits will be realised anyway whether exported for a feed-in-tariff or credited elsewhere.

6 Energy efficiency measures

6.1 Demand scheduling

Analysis of demand profiles at RCC sites shows that the pattern of electricity demand varies considerably from day to day. On some days the electrical demand occurs in hours when there is no PV generation (e.g. early morning or at night), meaning grid electricity must be imported while solar PV generation goes unused and must be exported. The pumping station at the Knockrow reservoir is a good example of this.

The project investigated if there is any scope for scheduling demand at RCC sites so that it more regularly occurs during full sunshine (i.e. PV generation) hours. Feedback the from questionnaire of operational staff suggests most processes operate in response to water demand but it may be possible to run some equipment more during sunlight hours subject to more detailed assessment.

6.2 Pump upgrades

The 2018 GHG Abatement Strategy identified that the bulk of potential efficiency savings lies in pump system upgrades and decisions taken on whether to incorporate VSDs and other controls that will optimise pump system performance and energy consumption, noting that operational benefits would likely drive the final decision and cost-benefit analysis. The potential for energy savings across RCC sites in the medium term was assessed as likely to be 5-10% or less.

The current project investigated if the pumping equipment has been, or could be, be fitted with VSDs. Feedback from operational staff indicated that most pumps are already using VSDs, and that further measures to improve pump efficiency are likely limited to pump replacement cycles.

6.3 Note on energy efficiency measures and PV/battery sizing

Changes to demand scheduling and/or pumping equipment is likely to significantly affect the business case for, and optimal sizing of, PV and BESS systems. It is therefore recommended that any feasible measures be implemented prior to PV/BESS system specification/installation.

7 Rous County Council vehicle fleet emissions

As part of this project, Rous County Council has requested advice about what an optimal emissions reduction and fleet transition strategy for Council's vehicles might look like. This section provides an overview of key issues relevant to advising on target dates for replacement of light vehicle fleet with hybrid vehicles, followed by replacement with zero emissions vehicles.

7.1 Emissions and energy use

Fleet emissions currently represent 7.6% of RCC's carbon footprint. Transport fuel use had been steadily dropping from 2017 to 2021, however 2022 saw a significant uptick in consumption with transport diesel use increasing 22%. This is likely due to increased operational requirements in response to wet weather and/or floods. When complete, the data for 2023 will indicate whether 2022 was just a temporary exception to a downward trend, or the beginning of a trend reversal. This ought to be monitored and managed accordingly.

Fleet fuel use for FY 2022 is provided in the table below.

Vehicle sub-type & fuel type	Diesel	Petrol	Ethanol
Passenger vehicles	**15,553 L**	**10,528 L**	**208 L**
Small car	-	1,876 L	208 L
Medium car	646 L	8,652 L	-
Large car	14,907 L	-	-
Commercial vehicles	**98,703 L**	**-**	**-**
Utility	95,168 L	-	-
Truck	3,534 L	-	-

TABLE 30: SPLIT OF TRANSPORT FUEL USE BY VEHICLE TYPE AND SIZE

7.2 Fleet characteristics

RCC's fleet consists of staff leased vehicles plus operational (field duty) vehicles.

7.2.1 Fleet age and turnover

The frequency distribution of RCC's vehicle ages indicates 2 classes of vehicle:

- Short term turnaround (staff lease vehicles – up to 3 years)
- Long term turnaround (operational vehicles – up to 11 years)

Information gathered from survey of RCC staff indicated that Rous has no standard fleet turnover period, however this is currently under review. RCC's fleet replacement processes are informed by several internal policy documents including *D21/436 – Procurement Policy* and D21/522 - *Conditions of use for road registered motor vehicles procedure*.

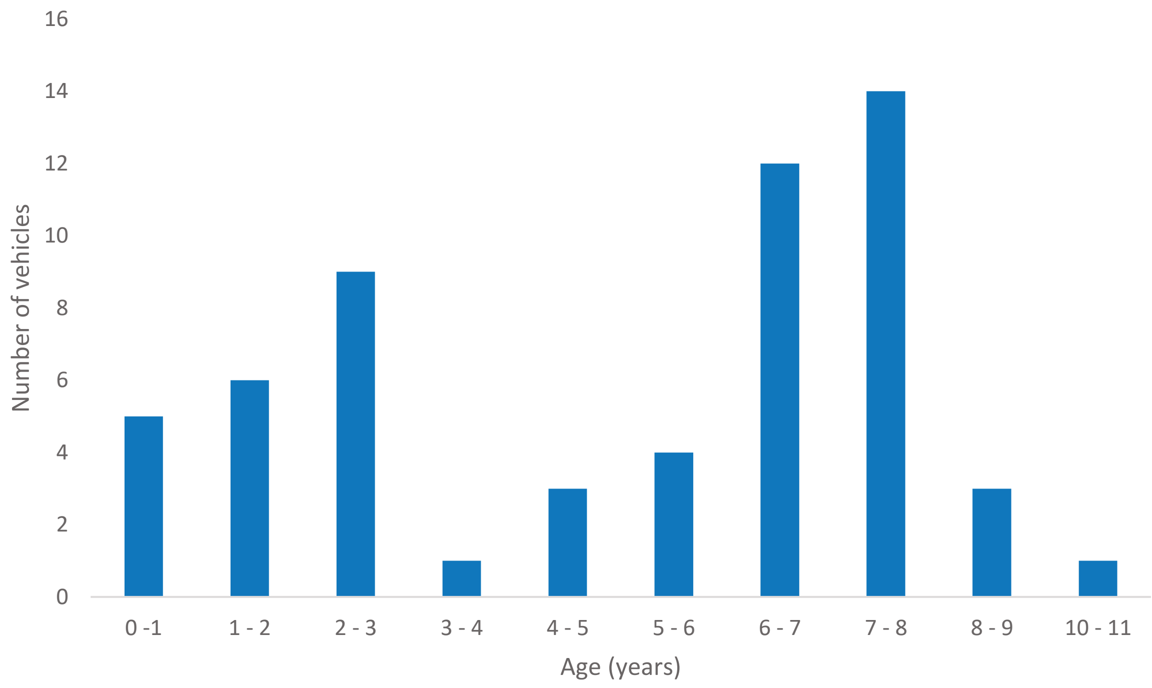


FIGURE 51: DISTRIBUTION OF RCC VEHICLE FLEET BY AGE (YEARS)

7.2.2 Operational requirements

Council currently uses a lot of utility vehicles (utes) in its operations, and they are needed on a regular basis, including for carrying heavy bulky loads.

Project investigations indicated there is limited potential to reduce the proportion (or absolute number) of utes within the fleet without compromising service delivery.

There may be some further opportunities to purchase hybrid vehicles in the short term, building on the existing small fleet, without compromising service capacity.

RCC operational vehicles can cover hundreds of kilometres per day, and ought to be able to operate all day without charging downtime.

7.3 Options to reduce fleet emissions

RCC could consider a number of options as part of an overall emissions reduction and fleet transition strategy. These options include:

- Replacing current internal combustion engine (ICE) vehicles with hybrids
- Replacing current ICE vehicles with EVs
- Replacing current ICE vehicles with more fuel-efficient ICE vehicles
- Reducing the amount of kilometres driven
- Encouraging fuel-efficient driving practices
- Purchasing renewable electricity to charge EVs
- Purchasing carbon offsets to offset some or all of Council's fleet emissions
- Council currently uses a lot of utility vehicles (utes) in its operations.

7.4 ICE vehicle fuel efficiency potential

ICE vehicles getting are towards the end of their development potential in terms of further fuel efficiency (and thus emissions reduction) potential. The difference between the current standard fuel efficiency in Australia and the Euro 6D, the current highest standard in the world, is only about 13%. Beyond the 13% improvement potential, many ICE manufacturers recognise its difficult to get much more efficiency out of them, without adding hybrid drivetrains, and have planned to cease R&D activities over the coming years, preferring instead to focus their resources on the development of hybrids and EVS.

The other way to get more efficiency out of ICE fleet is right sizing to the requirements, and encouragement of efficient driving practices. Studies have shown there is about a 30% difference in fuel efficiency between the best and worst drivers in terms of efficiency. However, these savings are just as likely to be achievable regardless of vehicle type.

7.5 Likelihood of ICE vehicle sales ban

Many jurisdictions around the world including in Australia are already announcing bans in the sale of ICE vehicles by 2035. Countries with proposed bans or implementing 100% sales of zero-emissions vehicles include China, Japan, Singapore, the UK, South Korea, Iceland, Denmark, Sweden, Norway, Slovenia, Germany, Italy, France, Belgium, the Netherlands, Portugal, Canada, and the U.S. states that adhere to California's Zero-Emission Vehicle (ZEV) Program.

In Australia, The Australian Capital territory is the first jurisdiction to ban the sale of new petrol vehicles by 2035. There is a high chance that other jurisdictions in Australia may follow their example in the coming years. This suggests there is a risk in *not* planning for fleet transition to all electric, and that it is best to move well in advance to avoid a less than optimal changeover.

7.6 Hybrids

Hybrid vehicles typically have better fuel efficiency than conventional vehicles, but the exact amount of fuel saved depends on the specifics of the hybrid system. In general, hybrid vehicles can offer fuel savings of up to 30-40% compared to conventional ICE vehicles. The claims of fuel efficiency for some brands of hybrids have not borne out in real world driving conditions, with some hybrids saving less than 20%. Toyota’s hybrid system is considered superior to most other brands, as it has been developed and refined over many decades. Real world fuel efficiency savings for Toyota hybrids can be in excess of 40%.

Australia’s most popular utes, Toyota Hilux and Ford Ranger, both plan on releasing hybrid versions in the coming years as a transition technology before releasing full electric models towards the end of the decade. The Hilux is likely to only be fitted with a “mild” hybrid system, that may only save 15-20% fuel use, a low number compared with the Toyota Rav4 hybrid which can deliver up to 40% fuel savings. The Ranger is expected to be a fully developed plug-in hybrid, and so would have significantly more emissions reduction potential than the Hilux, especially if paired with a renewable electricity supply, however abatement potential may be limited by its final battery capacity.

Over the next few years, buying hybrid vehicles could provide a more practical and cost-effective route to reducing emissions for some applications, especially where EV model availability is limited.

7.7 Electric vehicles (EVs)

Beyond 2026, electric vehicles will have clear emissions advantages compared with both conventional ICE vehicles and hybrids. Electric vehicles (EVs) are generally considered to be the surest path to reducing vehicle emissions over the longer term, especially as the grid becomes substantially decarbonised after 2030.

However, EVs have a number of short-term limitations relevant to Rous County Council:

- In terms of total-cost-of-ownership (TCO) EVs will (for the next few years, at least) cost more than both conventional vehicles and hybrid vehicles
- Model availability for EVs is still very limited, especially for utes.
- The emissions reduction potential of EVs is currently limited by the high emissions intensity of grid-sourced electricity.

7.7.1 EV Range

The typical EV range beyond 2025 is expected to be in the 300 – 500km range. Some EV utes will feature range in excess of 500kms. The perception of EVs as having limited range is only partially valid. Most drivers only travel 30kms per day and so have ample spare charge at all times. Even for the most heavily used of RCC's vehicles, operational range requirements are not likely to be compromised by transitioning to EVs, provided models are selected appropriately.

7.7.2 Projections for EV upfront cost decline

Similar to batteries, EVs are getting cheaper but at a declining rate. The graph below shows the expected cost decline trajectories for a variety of different priced utility vehicles.

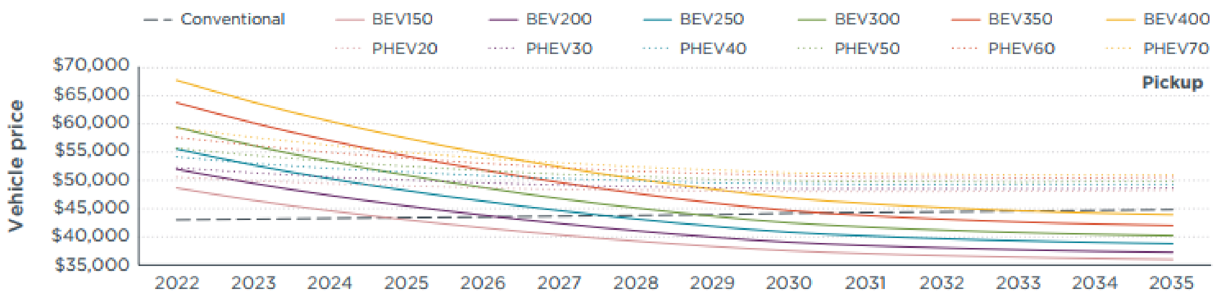


FIGURE 52: PRICE FORECAST OF ELECTRIC UTILITY VEHICLES IN USD[10]

Source: International Council on Clean Transportation, 2021

The forecasts suggest an approximate 20% reduction in upfront (not TCO) cost for EV utes over next 5 years to 2028, and about 33% or a third cheaper by 2033. Rate of decline expected to slow significantly after 2033.

7.7.3 Battery warranty

EV batteries can last for up to 10 years or sometimes longer, however the standard warranty period is 8 years. Review of the age of RCC's vehicle fleet shows that it is rare for vehicles to be kept for longer than 8 years and therefore this likely marks the logical maximum age at which to change over vehicles.

[10] Sourced from ICCT: https://theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf

After 8 years of ownership it is likely that the cost of new EVs will have fallen sharply and the technology will have improved significantly including potentially much better battery performance and range.

7.7.4 Total cost of ownership (TCO)

The TCO of electric vehicles (EVs) compared to conventional vehicles in Australia is influenced by various factors, including the cost of the vehicle, fuel costs, maintenance costs, and government incentives. According to recent studies, it is predicted that the TCO of EVs in Australia will reach parity with conventional vehicles in the mid 2020s, after which owning an EV will become cheaper than owning a conventional vehicle when all costs are factored in.

Several factors are contributing to this trend, including the falling cost of EV batteries, which are the most expensive component of EVs. Additionally, the increasing availability of public charging infrastructure and the increasing popularity of EVs are driving down the cost of EV ownership.

In Australia, the federal government and several state governments are offering incentives to encourage the uptake of EVs, such as grants, tax credits, and exemptions from registration fees. These incentives are helping to make EVs more affordable and accessible to Australian consumers.

Overall, the TCO of EVs in Australia is expected to become cheaper than conventional vehicles after 2025, but the exact timing will depend on various factors such as the pace of technological advancements, government policies, and consumer adoption rates.

7.7.5 Low emissions vehicle model availability

A literature review was undertaken to identify the likely dates of availability of low emissions vehicle models. The focus of the investigation was limited to low emission utility vehicles.

For most popular ute models, including Hilux and Ranger, there are no plans for full electric options until late this decade. In the meantime, hybrid versions will start to come online from 2024.

As at April 2023, there are currently only potentially viable 2 electric 4WD utility vehicles available in Australia, the Chinese LDV and the locally-converted electric Landcruiser (used mainly in mining operations). However, there are a number of American ute manufacturers planning to release electric utes from 2025 onwards, including Ford Lightning, Dodge Ram, and Rivian Ute. It is currently unclear whether or not the Tesla Cybertruck will ever make it on to Australian roads.

Electric ute model availability is expected to increase exponentially, with a rapid expansion in available vehicle models after 2027.

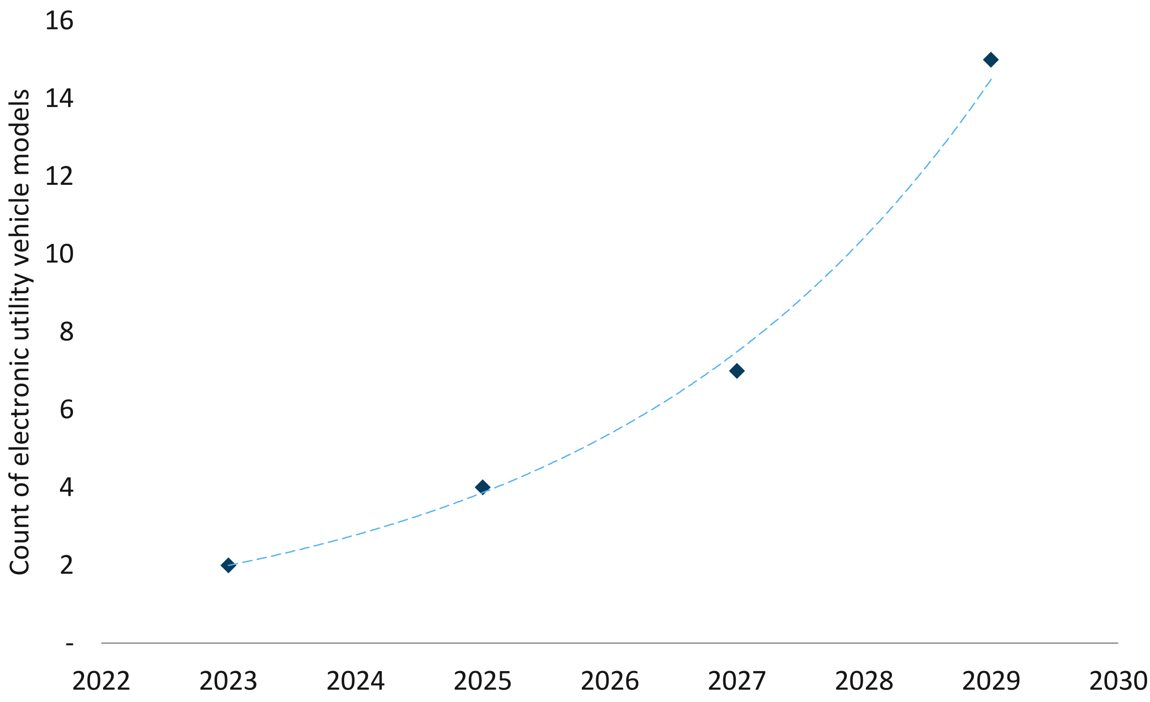


FIGURE 53: AVAILABILITY OF ELECTRIC UTILITY VEHICLE MODELS

7.7.6 Novated leasing of EVs

Due to an Australian Government policy change (November 2022), employers providing electric vehicles for staff have been exempt from fringe benefits tax (FBT) from 1 July 2022. The changes have resulted in a substantial reduction to the annualised cost of electrified vehicles purchased by employers on behalf of their staff, while potentially slashing tax costs on electric cars operated by fleets and company-car drivers.

Organisations looking to take advantage of the new policy settings may wish to consider the case for switching to EVs in their novated lease arrangements. When running costs are factored in, we may soon be approaching a tipping point where it will no longer make economic sense to buy an internal combustion car from a dealer. Providing employees with the option to upgrade to an EV could assist organisations to attract and retain staff, while providing a practical pathway towards reducing emissions.

7.8 Charging infrastructure

There are different levels of electric vehicle (EV) charging, each with its own electrical infrastructure requirements and costs.

- Level 1 Charging: This is the slowest and most basic type of EV charging, using a standard domestic power outlet (2.3 kW). Level 1 charging can take up to 12-20 hours to fully charge an electric vehicle, depending on the battery size. The electrical infrastructure requirements for Level 1 charging are minimal, as it only requires a standard power outlet.
- Level 2 Charging: This type of EV charging is faster than Level 1 and requires a dedicated charging station that is usually installed at home or in public places like parking lots, workplaces, and shopping centres. Level 2 charging typically takes 3-8 hours to fully charge an electric vehicle, depending on the battery size. The electrical infrastructure requirements for Level 2 charging include a dedicated circuit, a higher amperage breaker, and a 22kw (3 phase) 240-volt power supply.
- DC Fast Charging: This is the fastest type of EV charging and is commonly found at public charging stations along highways or in metropolitan areas. DC Fast Charging can fully charge an electric vehicle in as little as 30 minutes, depending on the battery size. The electrical infrastructure requirements for DC Fast Charging include a high-voltage transformer, a specialized charger, and a high-voltage cable.

7.9 Charging infrastructure costs

The cost of installing public EV charging infrastructure in Australia can vary widely depending on a range of factors, including the type of charger, the number of charging stations, the location, and the necessary electrical upgrades.

- Public Level 2 EV chargers have significantly higher installation costs compared to home charging stations, accounting for 60-80% of the total cost. Charging unit costs for single-port public charging stations typically range from $2000 to $3,000, while installation costs can be up to $10,000.
- For DC fast charging stations (Level 3), the hardware costs are significantly higher, ranging from $50,000 to $100,000 per station. Installation costs for Level 3 chargers can range from $30,000 to $60,000, depending on the specific project requirements and the need for electrical infrastructure upgrades.

Project-specific factors affecting per-unit charger price include:

- The number of chargers being set up per site (with per-unit costs declining for multiple chargers). Similarly, dual socket systems or dual-mounted chargers are available, which can further affect the per-unit installation expenses.
- The distance between the charger and the breaker box plays a crucial role in determining installation expenses. If the distance exceeds 30 meters, installation costs can become prohibitively high, requiring consideration of relocating the charging point.
- Curb side vs building mounted.
    - Curb side / pedestal-mounted stations tend to be relatively expensive due to associated costs like trenching or directional boring for conduit and wiring.

    - Installing Level 2 EV chargers in car parks and garages tends to be a simpler and more cost-effective option.
- If the chargers require management and billing connectivity, such as Ethernet or 4G, additional costs will be incurred.

7.10 Charging infrastructure for RCC vehicles

DC Fast Charging stations are far more expensive to install than Level 2 charging stations due to their higher electrical infrastructure requirements. Council may not require fast chargers to meet normal requirements, however, at least one or two fast chargers should be provided in the area for emergency situations and potentially be made available for public use (for example to support tourism at Rocky Creek Dam, and to enable community electric vehicle transition).

The most logical and convenient locations to begin trialling Level 2 charging infrastructure are at RCC's most used infrastructure locations, depots, offices, and at home for commuter use vehicles. In the medium term, Level 2 charging stations for RCC use should be provided at all depots and water treatment plants, although Molesworth Street and Emigrant Creek may be exceptions. Emigrant Creek has limited use for vehicles as the plant is not operational most days.

RCC could also consider a trial of solar PV covered charging/carparking at the Gallan's Road administration / operational site. Solar PV covered EV charging offers a number of benefits including reduced emissions from grid electricity, cost savings from lower electricity bills, shade and protection, and increased infrastructure visibility and support for EV adoption.

If RCC's budgetary and procurement framework allows, charging infrastructure could easily financed by product suppliers.

7.11 Key dates to consider for fleet transition

A review of key milestones in the evolution of the low emissions vehicle market is summarised below. The dates shows a coalescing of key events in the 2026 to 2028 time period that, taken together, tip the scales in favour of seriously progressing the transition to EVs. Until then, hybrid vehicles will continue to have a lot of advantages over ICE-only vehicles both economically and environmentally. Beyond 2028, the case for electric vehicles becomes undeniable, just as model availability will be expanding rapidly. It would be wise to complete the transition to an all-electric fleet by 2035 in order to avoid both the risk of being impacted by an ICE vehicle ban as well as the likelihood of missing out on the substantial total cost of ownership and emissions savings offered by EVs by that time.

TABLE 31: KEY MILESTONES IN THE TRANSITION TO LOW-EMISSION VEHICLES

Key Milestone	Year
EVs become cheaper on total-cost-of-ownership (TCO) basis	2025
EVs become less emissions-intensive over their lifespan than hybrids	2026
EVs become 20% cheaper to buy (relative to 2023 prices)	2027
Rapid expansion in electric Ute model availability	2028
Grid emissions drop by 50% (relative to 2023 levels)	2030
EVs become 33% cheaper to buy (relative to 2023 prices)	2033
Risk of ban on internal combustion vehicles	2035

8 Emissions from outdoor equipment

A requirement of the project is to consider RCC's outdoor equipment emissions and provide advice on the viability and timing of replacing outdoor equipment with electric alternatives.

8.1 Fuel consumption breakdown

A review of RCC's outdoor equipment fuel consumption reveals the types of equipment responsible for most of the fuel consumption (and thus emissions).

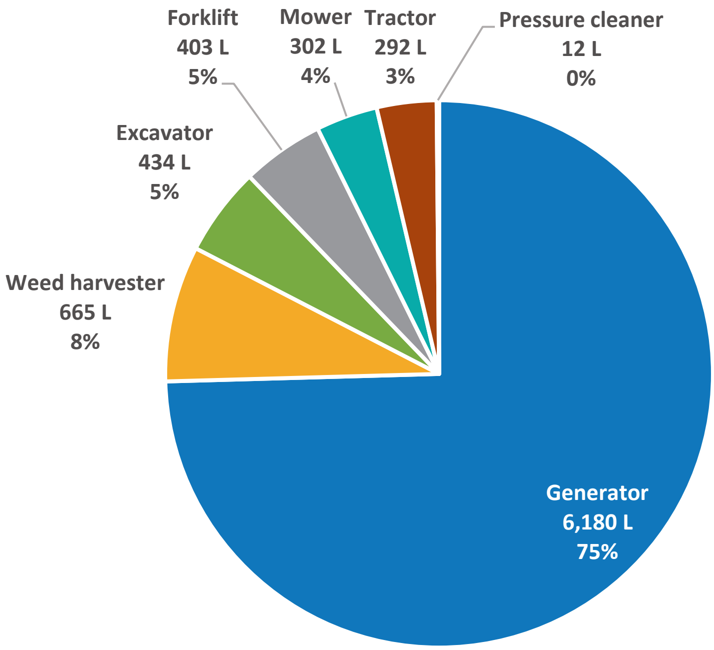


FIGURE 54: SPLIT OF OUTDOOR EQUIPMENT FUEL USE BY EQUIPMENT TYPE

As can be seen in the pie chart above, the generator used 75% of the outdoor equipment fuel. However this is due to its major refuelling in 2022 with 6.15 kL of diesel, which has had a small but significant impact on the carbon footprint for the 2022 FY.

The project investigated how essential is the generator to RCC's operations and system resilience, and what are the practical potential/known impediments for replacement with a renewable energy/battery storage solution. The generator(s) provide backup to the primary water treatment plant and are considered a critical asset. As they are only utilised occasionally, their remaining lifespan is likely substantial and swapping to a solar/BESS system lacks operational and financial feasibility.

Generators could in future provide emergency charging capability for EVs. The most feasible way to reduce emissions from generator use would be through the use of biodiesel, however an assessment of the engine's compatibility with various levels of biofuel blends would need to be undertaken to better assess the suitability of this strategy.

Aside from the pressure cleaner, all other equipment categories consume a significant share of fuel with the weed harvester having consumed the most, followed by excavator, forklift, mower and tractor.

8.2 Availability of electric alternatives

Desktop research was undertaken to assess the availability of electric alternatives built by high quality brand names, such as John Deere, Komatsu, Wacker Neuson and Toyota. The review indicated that by 2026 there will be high quality electric alternatives for all equipment types. In the case of the weed harvester, electric alternatives are already available but at small scale. RCC has since outsourced the weed harvesting function to an external contractor.

TABLE 32: AVAILABILITY OF ELECTRIC ALTERNATIVES PER OUTDOOR EQUIPMENT TYPE

Equipment type	Availability of e-alternatives by 2026
Weed harvester	Unsure
Excavator	Yes
Tractor	Yes
Forklift	Yes
Mower	Yes
Pressure cleaner	Yes

Most equipment types can be charged from standard Type 2 EV chargers

8.3 Synergy with electric fleet transition

Like electric vehicles, the availability of electric outdoor equipment is set to expand rapidly around the middle to the end of this decade. Electric outdoor equipment shares other similarities with EVs, for example in the potential total cost of ownership savings, and in the requirement for similar (type 2) charging infrastructure. For these reasons, it would be advisable to consider outdoor equipment transition and fleet transition as one process and undertake planning and technical trials accordingly, with a target date for 100% transition to be 2035 in both cases.

9 Recommendations

The recommended plan for RCC has considered a range of factors including:

- Progress on renewable energy and emissions reduction measures since 2018.
- Views of RCC stakeholders including Councillors and operational staff.
- Current global, state and local government policy context.
- Outlook on technology maturity, costs and benefits.
- Economic and practical feasibility of potential capital works projects.
- Relevant trends, constraints, risks and opportunities.
- The current and projected impact of RCC's historic tree planting activities.

With these factors in mind, it is advised that RCC consider and adopt the following recommendations:

Emission reduction targets

- Council to target zero emissions by 2050 (in line with State and Federal targets).
- Council to target 70% emissions reduction by 2035 (in line with NSW Government target).
- **Grid decarbonisation will deliver the bulk, but not all, of these required reductions.**

Tree planting / revegetation

- Maintain or (if space allows) increase current rates of revegetation until at least 2035 in order to ensure significant rates of cumulative sequestration can be supported through to 2050.
- Consider measures to support the resilience of revegetated areas to possible future disturbance by fire to avoid any negative "step change" impacts on Council's carbon footprint.

Energy efficiency

- By 2025, review options for demand scheduling optimisation.

PV & BESS Projects

- By 2028, implement prioritised projects. Prioritisation should be made with the following factors in mind:
    - Economic feasibility as indicated by payback period, Net Present Value (NPV), and other financial metrics. The ratio of capital cost to NPV can also be considered as a rough indicator of project return on investment.
    - Scale of additional renewable energy generation and emissions reductions.
    - Potential for "bundling" or scheduling with other infrastructure projects, where clear synergies or efficiencies can be identified.

Renewable electricity purchases

- From 2023, conduct market sounding ahead of contract cycle along with constituent councils and look to secure a PPA where there is no additional cost compared with a regular grid offer.

Fleet and outdoor equipment transition

- Implement trial program to run 2025 to 2028.
- Trial findings to inform full scale transition to be implemented 2028 to 2035.
- Target for all new vehicle and equipment purchases to be electric by 2035.

Residual emissions

- From 2028 to 2035, implement a strategy to reduce emissions from suppliers in order address any of RCC's residual scope 3 emissions.
- From 2035 progressively build a quality carbon offset portfolio to offset any remaining emissions by 2050.

REERP Review

- Undertake a review of this Plan in 2028 to include at a minimum:
  - Review of progress on implementing PV/BESS projects and assessment of additional opportunities in relation to new/planned infrastructure or building works.
  - Review progress on PPA implementation. In the absence of a PPA, and with consideration to positive cashflow forecasts from projects, agreements, and EV transition, revisit capacity for Greenpower purchases.
  - A detailed business case assessment for a ground-mounted PV array at Gallans Road estate including a detailed business case assessment for 'virtual net metering' and a comparison to other potential larger-scale projects such as pumped hydro.

The recommendations for getting to net zero emissions by 2050 have been presented in timeline form below:

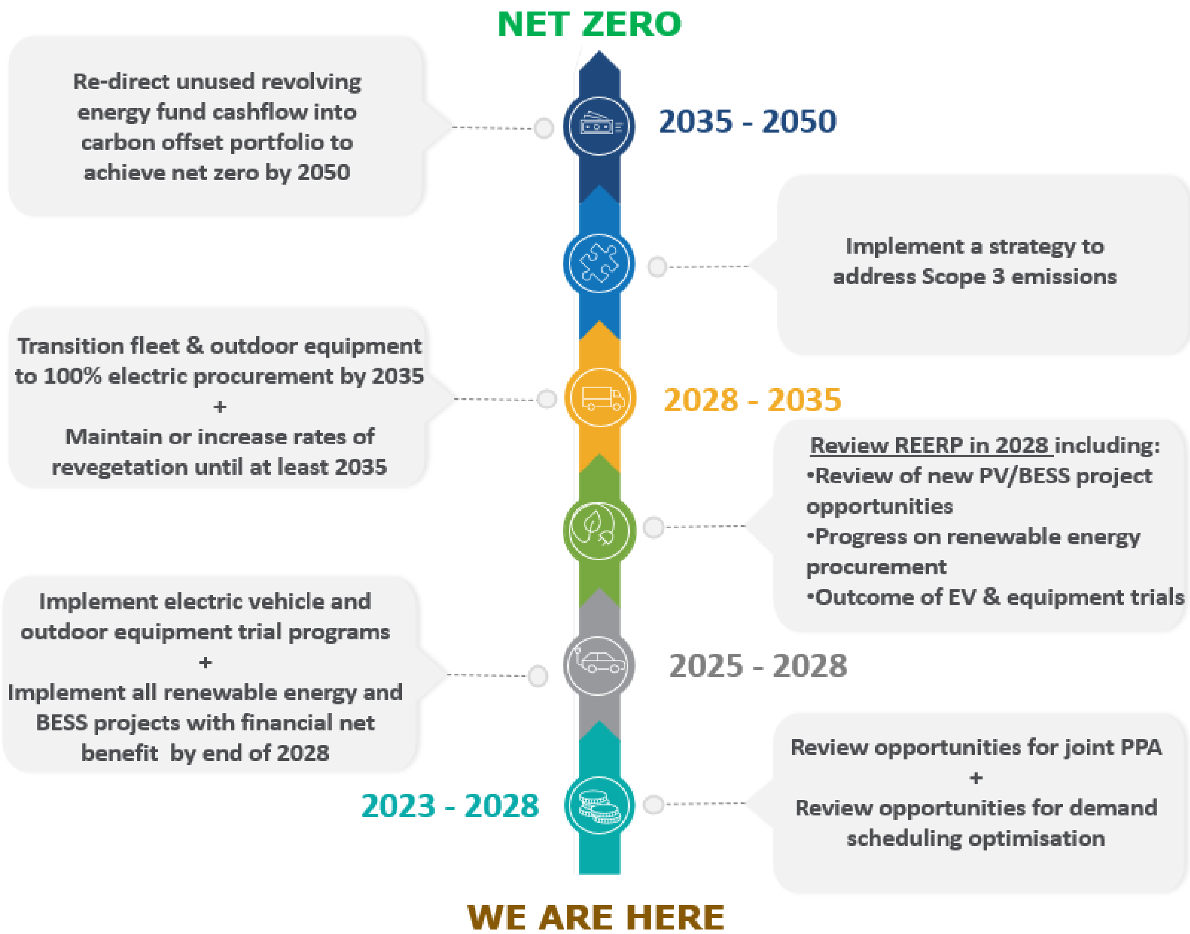


FIGURE 55: ROUS COUNTY COUNCIL'S TIMELINE OF ACTIONS TOWARDS NET ZERO BY 2050

10 APPENDIX: Survey results

10.1 Summary of findings

The summary of the questionnaire findings is provided below.

10.1.1 Emission reduction trajectory and financial capacity

The survey collected information on Councillors' views regarding emission reduction trajectories and financial capacity for accelerated decarbonisation. The responses indicated support for alignment with Federal and State emission reduction targets, however did not support bearing additional costs (at least in the short term) to pursue more ambitious targets.

TABLE 33: COUNCILLORS' RESPONSES ON EMISSION REDUCTION PROPOSALS

Proposal	Response summary
Having an emissions reduction strategy ensuring at a minimum, that emissions are reduced in line with Federal Government and NSW Government targets for 2030 (43%), 2035 (70%) and 2050.	Majority for
Developing emission reduction targets that are more ambitious than these targets, for example to align with targets more closely being set by NSW regional councils.	Majority against
Rous has the ability to absorb the additional costs necessary for adopting more ambitious targets and paying extra for renewable electricity.	Unanimous against
Accept a small (>10%) premium on electricity costs to reduce emissions further.	Majority against
Switch to 100% renewable electricity immediately if it could be sourced at similar or cheaper price.	Majority for

10.1.2Replacing fleet and outdoor equipment

The survey collected information on Councillors' views regarding replacement of fleet and outdoor equipment with electric alternatives. The responses indicated general support for a transition to electric or low-emission alternatives when they become available, including support to undertake trials of electric vehicles and install related infrastructure where appropriate.

TABLE 34: COUNCILLORS' RESPONSES ON THE ELECTRIFICATION OF FLEET AND OUTDOOR EQUIPMENT

Proposal	Response summary
Undertake trials of electric vehicles, including electric utes	Strongly support
Replacement of Light vehicle fleet with hybrid or electric vehicles	Support / Strongly support
Installing electric vehicle charging infrastructure at appropriate sites	Support / neutral
Replacement of outdoor equipment with electric alternatives when available	Support / neutral

10.1.3Large-scale renewable energy

The survey collected information on Councillor's views regarding investing in large-scale renewable energy projects. Responses indicated this was not very likely, but that support would probably be stronger for proposals within RCC's operational areas as opposed to projects beyond council boundaries. Responses indicated no objections to sourcing large scale renewable energy if it could be purchased at a similar or cheaper price, for example through a joint Power Purchase Agreement (PPA).

TABLE 35: COUNCILLORS' RESPONSES ON INVESTING IN LARGE-SCALE RENEWABLE ENERGY PROJECTS

Proposal	Response summary
Investment in large scale renewable energy projects in the region (e.g. solar farms)	Somewhat likely
Investment in a large-scale renewable energy project for an area outside of RCC's operational area	Less likely
Sourcing large scale renewable electricity at similar or cheaper price (e.g. through PPA)	Likely

10.1.4New PV and battery projects

The survey collected information on the level of Councillor's support for a range of potential emissions reduction projects including solar PV and battery storage projects. All potential projects were supported, assuming net financial benefit and practical feasibility can be indicated.

TABLE 36: COUNCILLORS' RESPONSES ON POTENTIAL SOLAR PV AND BATTERY OPPORTUNITIES

Proposal	Response summary
Solar PV and BESS at Gallans Road administration buildings and large estate	Support / strongly support
Solar PV and Battery Energy Storage Systems (BESS) at future water project sites	Support / strongly support
Investigate new sites for renewable energy projects	Support / strongly support
Solar PV and BESS near the Rocky Creek Dam Rainforest and Water Reserve	Support / strongly support / neutral
Installation of BESS solutions at viable sites	Support / strongly support / neutral
Other projects not listed above, which are viable for meeting renewable energy and emissions reduction targets	Support / strongly support / neutral

11 APPENDIX: Battery technology memo

This battery technology memo has been prepared to assist Rous County Council to consider the feasibility of installing more Battery Energy Storage Systems (BESS) at Council's facilities.

11.2 Battery technology overview

This section provides an overview of the current state of battery technology and feasibility.

11.2.1 Economics of BESS

The economic viability of BESS systems has improved significantly over the last 5 years. This is due to substantial reductions in the cost of battery technology, increases in retail electricity prices, and improvements in battery performance and optimisation. The business case for BESS is particularly strong where the following conditions are present:

Significant levels of solar generation export and grid imports

If existing solar PV systems are exporting large amounts of energy to the grid due to temporal mismatches between generation and demand, BESS can be effective in allowing greater use of available onsite renewable energy and thereby reduce the need for purchased energy.

Time-of-use electricity pricing

If the electricity pricing in a given area varies significantly throughout the day (e.g. peak, shoulder and off-peak), batteries can be charged during low-cost periods (for example late at night) and discharged during high-cost periods (for example in the late afternoon and evenings). In NSW, off-peak rates can be much lower than peak demand periods.

Demand charges

Commercial and industrial customers may be subject to demand charges, which are fees based on the peak amount of electricity used during a given period. Batteries can be used to reduce peak demand by discharging stored solar energy during high-demand periods, thereby reducing the amount of electricity purchased from the grid during those times.

Grid instability

In areas with unreliable or emergency-prone infrastructure, batteries can be used to provide backup power during outages or to smooth out fluctuations in solar energy production. The benefit of the ability to provide backup power will vary from site to site. Where the backup power allows the continued function of essential services during emergencies, the benefit can be thought of in terms of avoided negative impacts and/or avoided need for grid infrastructure upgrades.

Remote locations

In remote locations where grid electricity is not available or is prohibitively expensive, batteries can be used to store solar energy generated during the day for use at night or during periods of low solar radiation.

11.2.2 Commonly available technologies

There are several types of battery technologies that are commonly used for commercial applications, including:

Lithium-ion batteries

Lithium-ion batteries are currently the most popular choice for commercial applications due to their high energy density, long cycle life, and low maintenance requirements. They are commonly used for energy storage systems, electric vehicles, and portable electronics.

Different types of lithium batteries rely on unique active materials and chemical reactions to store energy. Each type of lithium battery has its benefits and drawbacks, along with its best-suited applications. The most common type of lithium battery for larger BESS systems is Lithium Iron Phosphate (LFP). LFP batteries use phosphate as the cathode material and a graphitic carbon electrode as the anode. LFP batteries have a long lifecycle with good thermal stability and electrochemical performance. Other lithium-ion battery chemistries with superior energy density are often used for residential or small business applications where space is most limited.

Lithium-ion (Li-ion) batteries are generally considered to be the best type of rechargeable battery available today for a variety of reasons:

- **High energy density**
  Li-ion batteries have a high energy density, which means they can store a lot of energy in a small and lightweight package.
- **Low self-discharge rate**
  Li-ion batteries have a lower self-discharge rate than other rechargeable batteries, meaning they can hold their charge for longer periods of time when not in use.
- **No memory effect**
  Unlike some other types of batteries, Li-ion batteries do not suffer from memory effects, which means they do not need to be fully discharged before being recharged.
- **High cycle life**
  Li-ion batteries have a longer cycle life than other types of rechargeable batteries, meaning they can be recharged and used many times over without a significant loss of capacity.
- **Safe and reliable**
  Li-ion batteries are generally considered safe and reliable when used and handled properly, and they are used in many consumer electronics devices, electric vehicles, and even some aerospace applications.

Flow batteries

Flow batteries uses two different electrolyte solutions separated by a membrane. They are easily scalable and capable of storing large amounts of energy, making them suitable for commercial and utility-scale applications. They are commonly used for load shifting, renewable energy integration, and backup power.

Besides lithium-ion batteries, flow batteries could emerge as a breakthrough technology for stationary storage as they do not show performance degradation for 25-30 years and are capable of being sized according to energy storage needs with limited investment.

The 2 main types of flow batteries are redox and zinc bromine. Rapid improvements are expected in the overall cost, performance, life, technology readiness levels, and manufacturing readiness levels, however the overall system efficiency of redox flow batteries is low. These batteries are best for large projects that require power in the tens of kilowatts to tens of megawatts range.

The zinc-bromine battery is a hybrid redox flow battery. Zinc-bromine batteries offer great promise in terms of cost and life, but their technology and manufacturing readiness levels are currently low.

Nickel-cadmium batteries

Nickel-cadmium batteries have been used for many years for commercial applications due to their high reliability and long cycle life. However, they are less commonly used today due to concerns over their environmental impact and the availability of alternative battery technologies. A major drawback of this technology is that nickel-cadmium batteries suffer from the memory effect leading to capacity decline, which occurs when a Ni-Cd battery is recharged before it is fully discharged. They are also susceptible to damage due to overcharging.

Lead-acid batteries

Lead-acid batteries have been used for energy storage for many years and are still a popular choice for some commercial applications due to their low cost and high reliability. They are commonly used for backup power, uninterruptible power supply (UPS) systems, and off-grid power systems. Due to lower energy density, lead acid batteries require substantially more space.

11.2.3 Battery technologies under development

Battery energy storage system adoption is expanding at a rapid rate and so are the technologies that power the systems. There are several battery technologies that are currently being developed for commercial applications that show promise in terms of their performance, safety, and cost-effectiveness. It is also worth noting there may be other battery technologies that emerge as promising options for commercial applications in the future.

Some of the most promising battery technologies currently under development include:

Solid-state batteries

Solid-state batteries use a solid electrolyte instead of a liquid electrolyte, which can offer several advantages over traditional lithium-ion batteries, including increased safety, higher energy density, and longer cycle life.

Sodium-ion batteries

Sodium-ion batteries have the potential to become lower cost than lithium-ion batteries and may be suitable for use in large-scale energy storage systems. Sodium-ion batteries are emerging as a viable alternative to lithium-ion technology, but until 2030 the cost of manufacture will remain relatively high. Aside from potentially becoming cheaper than lithium-ion batteries, sodium-ion batteries are also less flammable.

Zinc-air batteries

Zinc-air batteries use a zinc anode and oxygen from the air as the cathode. They are lightweight, low cost, and have a high energy density. They have shown promise for use in applications such as grid-scale energy storage and electric vehicles.

11.2.4 Battery "stacking"

Batteries can be stacked in order to increase the overall capacity of the battery bank. Stacking batteries involves connecting multiple batteries together in a series or parallel configuration, depending on the desired outcome. Combining series and parallel configurations can increase both the voltage and capacity of the battery bank, depending on the number and arrangement of the batteries.

It is important to note that when stacking batteries, care must be taken to ensure that the batteries are of the same type, capacity, and voltage, and that they are connected properly to avoid overcharging or over-discharging of individual batteries. Additionally, stacking batteries can be dangerous if not done properly, so it is recommended to seek the advice of a qualified professional before attempting to stack batteries.

11.2.5 Product life expectancy

The lifespan of a lithium-ion battery depends on a variety of factors, including its usage, storage conditions, and overall quality. Lithium-ion batteries can last for 13 years or more if they are well maintained and operated. The warranty periods for commonly available commercial battery brands in Australia can vary depending on the manufacturer and the specific battery model. However, the vast majority of manufacturers provide a 10-year warranty. With much longer cycle life, flow batteries can last over 20 years with some manufacturers offering warranties for longer than 10 years.

Capacity decline

The capacity of a lithium-ion battery, which is its ability to hold a charge, will degrade over time with use. This degradation is a natural process and cannot be avoided entirely, but it can be slowed down by avoiding extremes in temperature, avoiding deep discharges, and avoiding overcharging.

After many years of use, the capacity of a lithium-ion battery can decrease to the point where it is no longer able to provide the required energy storage capacity. For this reason, it may be a good idea to oversize the battery somewhat to allow for this decline.

The rate of battery capacity decline for commonly available commercial battery brands in Australia can vary depending on the manufacturer, the specific battery model, and the usage conditions. However, the typical rate of capacity decline for commercial batteries is in the range of 2–3.5% per year, depending on how well the charge and discharge cycles are managed.

11.2.6 Price trends

The price of lithium-ion batteries has dropped approximately 80% since 2013. However, the rate of decline in battery prices has flattened out since 2020, and Bloomberg have noted a slight increase in the last 2 years, as shown below. The price of installing BESS in Australia is currently about $900 per kWh.

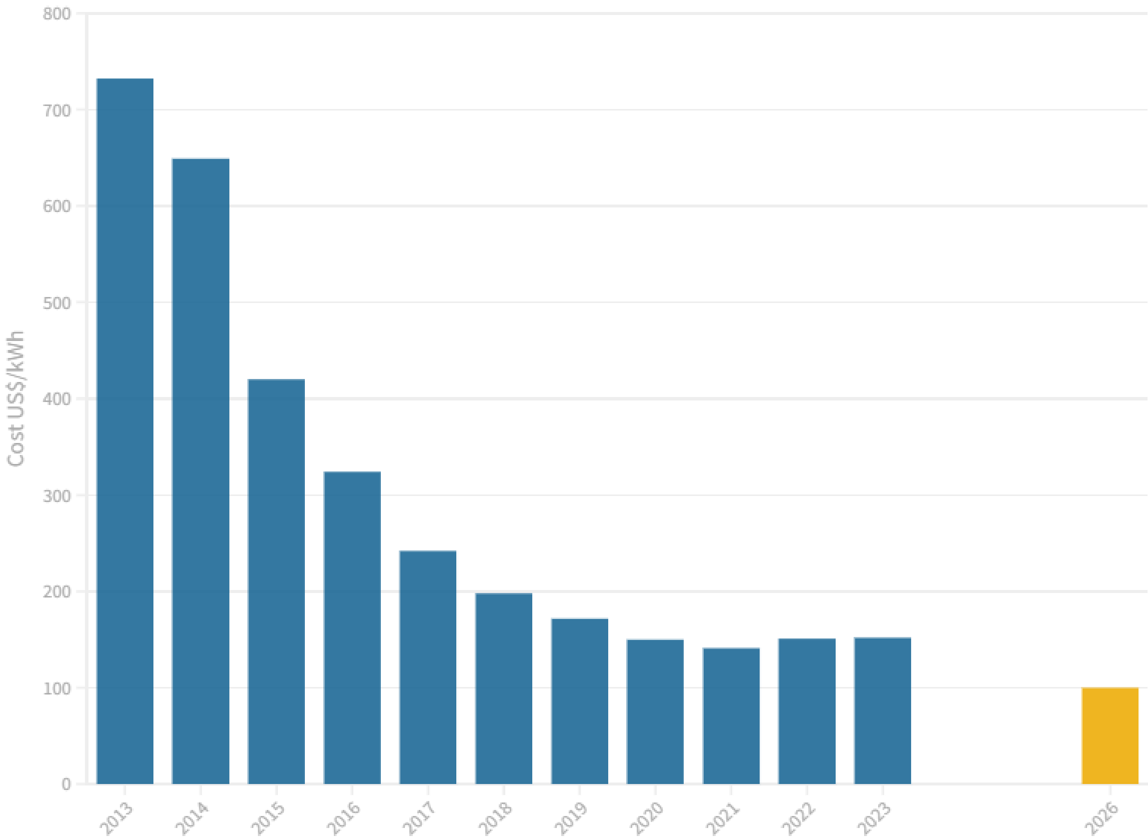


FIGURE 56: BATTERY PRICING TREND IN USD PER KWH OF RATED CAPACITY[11]

The recent temporary reversal of downward trend is likely due to high input costs of metals in recent years including lithium, cobalt, nickel and copper. While the past decade has witnessed substantial reductions in the price of lithium-ion batteries, it is now becoming evident that further cost reductions rely not just on technological innovation, but also on the rate of increase of battery mineral prices.

Fortunately, lithium spot prices peaked in late 2022 and have fallen about 40% in the last 6 months due to an aggressive pullback in demand expectations and signs of strong supply. The overproduction of batteries in China at the end of 2022 to take advantage of Chinese Government subsidies led top battery producer CATL to sell products at a steep discount this year, with the firm expecting carbonate prices to halve in the upcoming months. On the supply side, top producer Australia's projected global output of lithium carbonate equivalent to reach 915,000 tonnes in 2023, a 32% rise from 2022's estimate.

This suggests, following a lag, lithium battery prices should continue to fall again in the next few years though at a slow rate compared to the last decade. Beyond 2025, however, there is a risk metal prices could again rise and exceed their previous peaks, putting upward pressure on battery prices once again.

[11] Energy Storage News – *Lithium battery pack prices go up for first time since BloombergNEF began annual survey:* https://www.energy-storage.news/lithium-battery-pack-prices-go-up-for-first-time-since-bloombergnef-began-annual-survey/

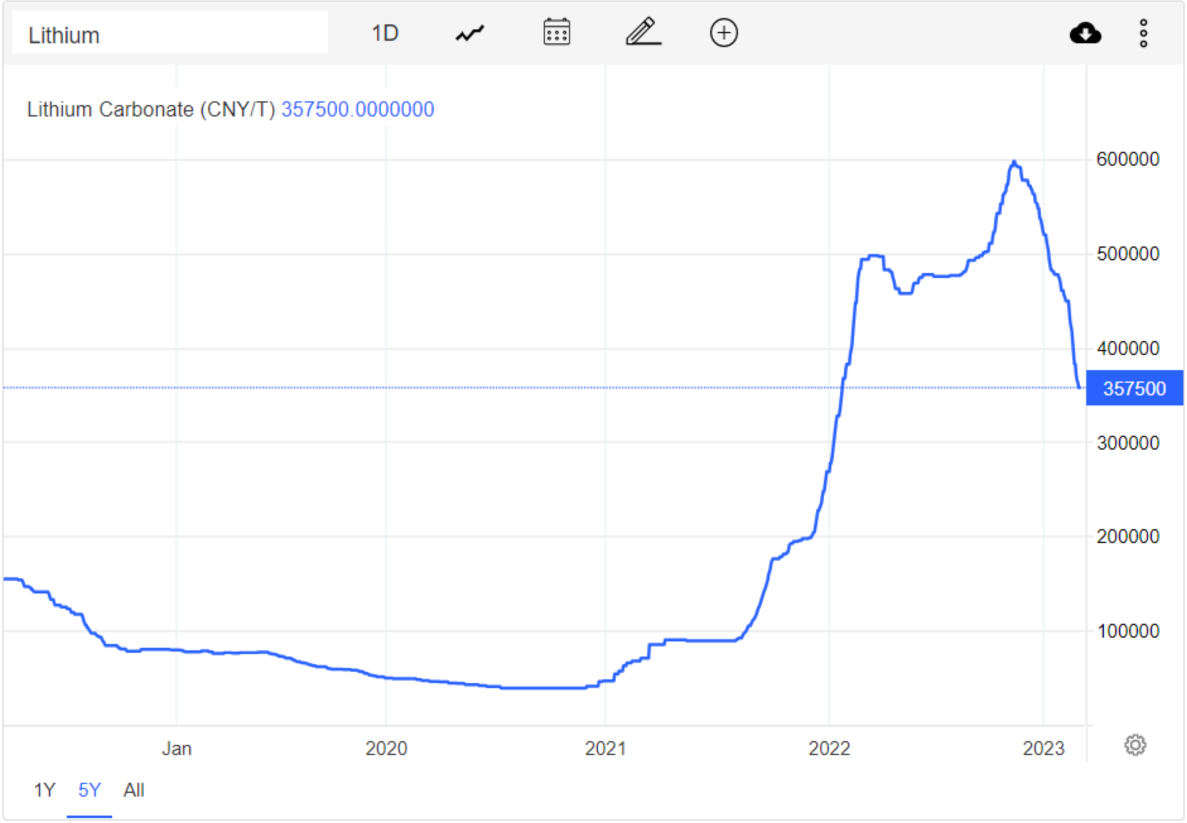


FIGURE 57: FIVE-YEAR TRAJECTORY OF LITHIUM CARBONATE PRICING IN CNY PER TONNE[12]

11.2.7 Future BESS price trajectory

Despite the recent halt in the downward price of batteries, and the potential for future fluctuations, it is likely that commercial battery storage systems will generally tend to get cheaper over time due to several factors:

Technological advancements

As battery technology continues to improve, the cost of manufacturing batteries is expected to decrease. This can be due to advancements in materials, manufacturing processes, and energy density, among other factors.

Increasing demand

As more businesses and industries adopt renewable energy and energy storage systems, there will be increasing demand for commercial batteries. This can lead to economies of scale, which can help to reduce the cost of manufacturing.

[12] Trading Economics – *Lithium carbonate pricing:* https://tradingeconomics.com/commodity/lithium

Policy incentives

Governments and regulatory bodies around the world are implementing policies and incentives to encourage the adoption of renewable energy and energy storage systems. This can include tax credits, subsidies, and grants, which can help to reduce the cost of commercial batteries for businesses.

Competition

As more companies enter the market for commercial batteries, there will be increasing competition. This can lead to innovation and cost reduction as companies try to differentiate themselves from their competitors.

11.2.8 Summary

Lithium-ion batteries can be considered a mature, reliable technology with clear advantages over other battery types. Although new battery types are under development, they cannot yet compete with lithium-ion for most applications. Beyond 2030, new battery types are likely to surpass lithium-ion for combined cost and performance, but this does not look likely before then. Most of the decline in lithium-ion battery prices has already occurred, and there is probably no financial benefit in waiting for further cost reductions. This is especially the case as electricity prices have been rising quickly, so any benefit gained by waiting to buy a slightly cheaper battery system would be more than offset by the need to pay more for electricity in the meantime.

11.3 Benefits of BESS for water and sewage facilities

Installing Battery Energy Storage Systems (BESS) at water and sewage utilities can offer several advantages to utility operators and the community more generally, including:

- **Cost savings**
  Water utilities typically have high electricity costs. BESS can help reduce energy costs by storing excess energy from solar PV or during off-peak periods when energy rates are lower and then using that energy to reduce the need for electricity purchases. This can help utilities save on energy costs and reduce their overall operating expenses.
- **Improved reliability**
  BESS can potentially provide backup power in the event of a power outage, ensuring that critical operations at water and sewage utilities continue to function. This can help prevent disruptions in service and improve overall reliability.
- **Reduced reliance on emissions-intensive grid electricity**
  By using BESS to store and use renewable energy sources, such as solar or wind power, water and sewage utilities can reduce their carbon footprint and support broader climate change initiatives.
- **Increased grid stability**
  BESS can help stabilise the grid by providing grid services such as frequency regulation and voltage support. This can help improve the overall stability and reliability of the local grid, helping ensure continued service delivery.
- **Peak demand management**
  By using BESS to manage peak energy demand, water and sewage utilities can help reduce strain on the grid during periods of high demand. This can help prevent blackouts and brownouts and improve the overall reliability of the grid.

11.4 Examples of BESS systems installed in Australian water utilities

Battery energy storage systems are increasingly being used by Australian water and sewage utilities. Here are some examples of battery energy storage systems used by Australian water and sewage utilities:

- ***South East Water*** **(VIC)**
  South East Water has installed a 250 kW / 500 kWh lithium-ion battery storage system at its Boneo Water Recycling Plant. The system is used to store excess solar energy generated on-site and to provide grid support services, such as frequency regulation and peak demand management.
- ***Sydney Water*** **(NSW)**
  Sydney Water has installed a 500 kW / 1 MWh battery energy storage system at its Bondi Sewage Treatment Plant. The system is used to store excess solar energy generated on-site and to provide grid support services, such as frequency regulation and voltage support.
- ***Unitywater*** **(QLD)**
  Unitywater has installed a 95 kW / 450 kWh lithium-ion battery storage system at its Kenilworth Water Treatment Plant. The system is used to store excess solar energy generated on-site and to provide backup power during grid outages.
- ***Yarra Valley Water*** **(VIC)**
  Yarra Valley Water has installed a 100 kW / 200 kWh lithium-ion battery storage system at its Mitcham Water Treatment Plant. The system is used to store excess solar energy generated on-site and to provide backup power during grid outages.
- ***Western Water*** **(VIC)**
  Western Water has installed a 30 kW / 80 kWh lithium-ion battery storage system at its Sunbury Water Treatment Plant. The system is used to store excess solar energy generated on-site and to provide backup power during grid outages.

These are just a few examples of battery energy storage systems used by Australian water and sewage utilities. There are many more examples across the county, and the use of battery energy storage is expected to continue to grow as the cost of batteries continues to decline and the benefits of energy storage become more widely recognised.

11.5 Risk management

General risk management

Batteries of any kind are a serious safety risk if not correctly installed or commissioned. They can cause electric shock, explosions, flash burns, and exposure to hazardous chemicals. Battery casings can degrade or be damaged from a variety of impacts. If a battery casing is ruptured, the fluid or gel (electrolyte) inside can leak, resulting in toxic fumes, burns, corrosion or explosions.

Workers and management can work together to reduce the risks of battery energy storage systems.

Workers should:

- … use safe systems at work.
- … only do work they are licenced and competent for.
- … take care of their own health and safety as well as the health and safety of others.
- … cooperate with management to meet health and safety requirements and reduce risks.

Organisations have:

- … legal responsibilities as outlined in the Electrical Safety Act 2002 and Work Health and Safety Act 2011 (WHS Act) for the health and safety of every worker and visitor.
- … the option to use the practical advice in the Electrical safety codes of practice 2021 - Managing electrical risks in the workplace.

Relevant standards

Relevant standards include:

- *Electrical Safety Act 2002*
- Electrical Safety Regulation 2013
- AS/NZS 5139 Electrical installations – Safety of battery systems for use with conversion equipment
- AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)

Other relevant standards include:

TABLE 37: OTHER RELEVANT STANDARDS FOR RISK MANAGEMENT RELATING TO BESS IMPLEMENTATION

Code	Name
AS 1319	Safety signs for the occupational environment
AS 1530.4	Methods for fire tests on building materials, components and structures - Fire-resistance test of elements of construction
AS 3011.2	Electrical installations - Secondary batteries installed in buildings - Sealed cells
AS/NZS 4509.1	Stand Alone Power Systems - Installation
AS 4086.2	Secondary batteries for use with stand-alone power systems - Installation and maintenance
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 5033	Installation and safety requirements for photovoltaic (PV) arrays
AS/NZS 4777.1	Grid connection of energy systems via inverters - Installation requirements
AS/NZS 4777.2	Grid connection of energy systems via inverters - Inverter requirements
AS 62040.1.1	Uninterruptible power systems (UPS) - General and safety requirements for UPS used in operator access areas
AS 62040.1.2	Uninterruptible power systems (UPS) - General and safety requirements for UPS used in restricted access locations
AS/NZS 60529	Degrees of Protection Provided by Enclosures (IP Code)
AS/NZS 60898.2	Circuit-breakers for overcurrent protection for household and similar installations - Circuit-breakers for AC and DC operation
AS/NZS 60947.3	Low-voltage switchgear and control gear - Switches, disconnectors, switch-disconnectors and fuse-combination units
AS/NZS 60950.1	Information technology equipment - Safety - General requirements
IEC 62109-1 Ed. 1.0 (English 2010)	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
IEC 62109-2 Ed. 1.0 (Bilingual 2011)	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters

Electrical/chemical fire risk

Lithium-ion Battery Energy Storage Systems (BESS) have a risk of catching fire due to their chemical composition, which can ignite and cause a fire when exposed to certain conditions. The risk of fire in a lithium-ion BESS depends on various factors, such as the quality and design of the batteries, the operating conditions, and the presence of any safety features or protection systems.

Some of the factors that can increase the risk of fire in a lithium-ion BESS include:

- Overcharging or undercharging of the batteries, which can cause overheating and increase the risk of fire.
- Physical damage to the batteries, such as punctures or dents, which can damage the internal components and cause a short circuit.
- Exposure to high temperatures or heat sources, such as direct sunlight or proximity to other heat-generating equipment.
- Poor quality or defective batteries, which may have lower safety standards or may be more prone to failure.

To reduce the risk of fire in a lithium-ion BESS, it is important to take proper safety measures and follow manufacturer guidelines and safety protocols. This may include regular inspections and maintenance of the batteries, proper installation and ventilation of the system, and the use of safety features such as fireproof enclosures or automatic shut-off systems in case of a malfunction.

Overall, while the risk of fire in a lithium-ion BESS cannot be completely eliminated, proper safety precautions and measures can help reduce the risk and ensure the safe and reliable operation of the system.

Bushfire risk

It is important to protect Battery Energy Storage Systems (BESS) from bushfires as exposure to extreme heat and fire can cause significant damage to the batteries and other electrical components, and can also pose safety hazards.

Batteries used in BESS are typically made of flammable materials, such as lithium-ion or lead-acid, which can ignite and cause a fire when exposed to high temperatures. In addition to the risk of the batteries catching fire, extreme heat and fire can also damage other electrical components in the system, leading to a loss of functionality or safety hazards.

In the event of a bushfire, it is important to take precautions to protect BESS, such as installing the system in a location that is less prone to bushfires, using fire-resistant barriers or other protective measures, and having an emergency plan in place in the event of a fire. Additionally, it is important to follow manufacturer guidelines and safety protocols when installing and operating BESS to ensure proper safety and functionality of the system.

Overall, protecting BESS from bushfires is essential to ensure the safety and proper functioning of the system, as well as to prevent potential damage or hazards to people and the environment.

It is possible to purchase fireproof battery enclosures for Battery Energy Storage Systems (BESS). These enclosures are designed to protect the batteries and other electrical components from fire and heat, and can help prevent or minimize damage in the event of a fire. Some enclosures may also be designed with additional safety features, such as ventilation systems or automatic fire suppression systems, to further minimize the risk of fire or damage. When selecting a fireproof battery enclosure for a BESS, it is important to consider factors such as the size and capacity of the battery bank, the location and environment of the system, and any applicable safety regulations or guidelines. It is also important to ensure that the enclosure is properly installed and maintained according to manufacturer guidelines and safety protocols.

Flood risk

It is important to take precautions to protect BESS from flooding, as exposure to water can lead to significant damage to the batteries and other electrical components, and can even cause safety hazards.

Batteries used in BESS typically contain a large amount of electrolyte, which is a liquid or gel substance that can be highly corrosive and can cause damage to the battery cells if it comes into contact with water. Flooding can also cause electrical shorts, which can damage the battery cells and other electrical components in the system.

In addition to damage to the BESS itself, exposure to flood water can also pose safety risks to people and the environment. Flood water can contain hazardous chemicals and debris that can cause harm if they come into contact with people or are released into the environment.

Therefore, it is important to take precautions to protect BESS from flooding, such as installing the system in a location that is less prone to flooding, using flood barriers or other protective measures, and having an emergency plan in place in the event of a flood. It is also important to follow manufacturer guidelines and safety protocols when installing and operating BESS to ensure proper safety and functionality of the system.

11.6 BESS life cycle economic feasibility

11.6.1 Likely payback period

A number of factors need to be considered when assessing BESS feasibility, including the financial business case in terms of net benefits, as well as payback period. Payback periods for BESS systems installed at water utilities are typically in the range of 5 to 10 years, depending on the specific circumstances of each installation. Factors affecting economic viability and payback period include:

- Absolute amount of exports at various times of the year
- Exports as a proportion of total demand and total generation
- Degree of match between exports and import quantities
- Degree and regularity of mismatch between solar production and grid demand
- Extent to which grid demand is occurring in peak vs off-peak times
- Degree of variation between peak and off-peak retail electricity charges

11.6.2 Optimal sizing

In order to optimise the balance between upfront BESS cost and energy cost savings, it is important to ensure BESS are optimally sized. Battery size optimisation is a complex challenge and there are no agreed universal formulas.

Optimisation is particularly challenging for grid connected systems where the demand profile shifts substantially on a day-to-day basis. Precise determination of optimal battery sizing should be undertaken with specialised software modelling packages but is beyond the scope of this project. Instead, for purposes of undertaking indicative feasibility assessment, we have adopted a simple optimisation model that provides an estimate of an appropriate (though not 'perfect') battery size.

There are a number of limitations and trade-offs that we have considered when assessing appropriate BESS size and associated economic feasibility for RCC's potential infrastructure projects.

11.6.2.1 Optimisation objective(s)

Optimal battery sizing requires a method that allows for easy testing of, and selection between, a wide range of potentially suitable battery size scenarios. The final decision of battery size will depend on which aspect (or aspects) of system performance the proponent wishes to maximise. For example, a specific battery size would be preferred depending on whether the main (or singular) objective was:

- Minimizing payback period on investment
- Maximising cumulative cash flow position after 25 years
- Maximising the capture/storage of the available exported electricity

The approach we have taken for indicative feasibility assessment at RCC's sites is to select a battery size for evaluation that represents the most reasonable trade-off between these objectives, given consideration of Council's operational and strategic context.

11.6.2.2 Utilisation

Due to the high upfront cost of installing battery system capacity, subsequent under-utilisation of that capacity is a major detriment to overall project economics. Rather than capturing the maximum possible amount of exported solar power, the economically optimal battery size is one that can capture a substantial proportion of exported solar power while at the same time avoiding frequent under-utilisation of battery capacity.

In sizing batteries for optimal economic outcomes, the focus should be on cost-effectively capturing the main financial benefit of adding batteries, that is, enabling reduced imports of expensive grid-sourced electricity. While there can be an additional financial benefit of adding batteries related to their ability to charge up from the grid at off-peak price periods to offset grid demand during peak price periods, the business case for sizing batteries specifically for this purpose is only marginal, especially for facilities where a large proportion of equipment energy demand is already occurring during off-peak periods - as is the case with RCC's pumping equipment.

11.6.2.3 Onsite energy requirements

In general, battery capacity should not be sized significantly larger than is needed to offset existing grid-sourced electricity. Capturing exported electricity with a battery system only makes economic sense if that electricity can be used to meet existing (or expected) energy demand on site (that would otherwise require the import of grid electricity at retail prices).

Consideration should be given to patterns of energy demand and whether those patterns can be more cost-effectively serviced through the addition of a battery. Analysis of energy demand profiles and how they vary day-to-day and at different times of the year can help inform these considerations.

For example, in the case of Knockrow Reservoir, analysis of a representative sample of demand profiles reveals that there are regular 'blocks' of 20 kW electricity demand occurring outside of solar PV generation hours, over periods of 4 to 5 hours, and equating to around 80-100 kWh per block. These blocks of demand sometimes occur in the evening during peak electricity periods, and sometimes after midnight during off-peak periods.

Assessing energy demand profiles can help provide an indication of upper-range possibilities for battery system storage size requirements as well as charge/discharge capacities.

11.6.2.4 Quantity of exported electricity

The ability of a battery to help offset the need for grid-sourced electricity is necessarily limited to the quantity of exported electricity available for capture and storage. Therefore, the quantity of exported electricity at a site can be used as a useful reference point for estimating an appropriate battery size.

The day-to-day quantity of exported electricity can be significantly affected by the combined impact of variations in solar PV generation output together with variations in the magnitude and timing of energy demand.

For sites where exported electricity is relatively consistent on a day-to-day basis, it is sufficient to refer to the *average daily exported electricity* as the basis for estimating an appropriate battery size.

For sites where exported electricity varies significantly on a day-to-day basis, *average daily exported electricity* can still be used as an initial starting point for battery sizing, however a more detailed, iterative approach that tests multiple scenarios can also be undertaken to inform optimal sizing for these sites.

11.6.2.5 Optimising utilisation through battery sizing in the context of high export variability

For some of RCC's sites, such as Knockrow Reservoir, battery capacity sizing is complicated by the need to consider very large fluctuations in the amount of exported energy available for capture on a day-to-day basis. While the solar PV generation curve remains relatively consistent throughout the year, substantial differences in energy demand patterns are apparent, resulting in a wide range of possible values for daily export quantities.

The choice of battery size in this context directly and significantly affects the number of days per year that the battery capacity can be fully utilised, and the degree of underutilisation on other days. As battery storage size increases, the potential annual cashflow benefit may increase as more grid electricity imports can be offset, however the annual cashflow benefits may not increase in a linear manner but rather demonstrate diminishing returns for each incremental step up in battery size. As progressively smaller annual financial benefits must be balanced against the fixed incremental higher upfront costs for more battery system capacity, there reaches a point where the proposed system is unable to 'pay for itself' over the life of the project.

The way that annual financial benefits vary in response to selection of different battery sizes is largely determined by the pattern of distribution of export data within the typical range of exports for the site. The plot below illustrates the magnitude and distribution of the range of daily export quantities for Knockrow Reservoir. The plot shows estimates for exported electricity for a representative sample of 40 days. Export quantities range from days with less than 10 kWh exported, to days with over 100 kWh exported. The red line represents a theoretical battery size of 45 kWh. The dots above the line are the days in which the system would make full use of its capacity, while the dots below the line represent days when the battery capacity would not be able to be fully utilised.

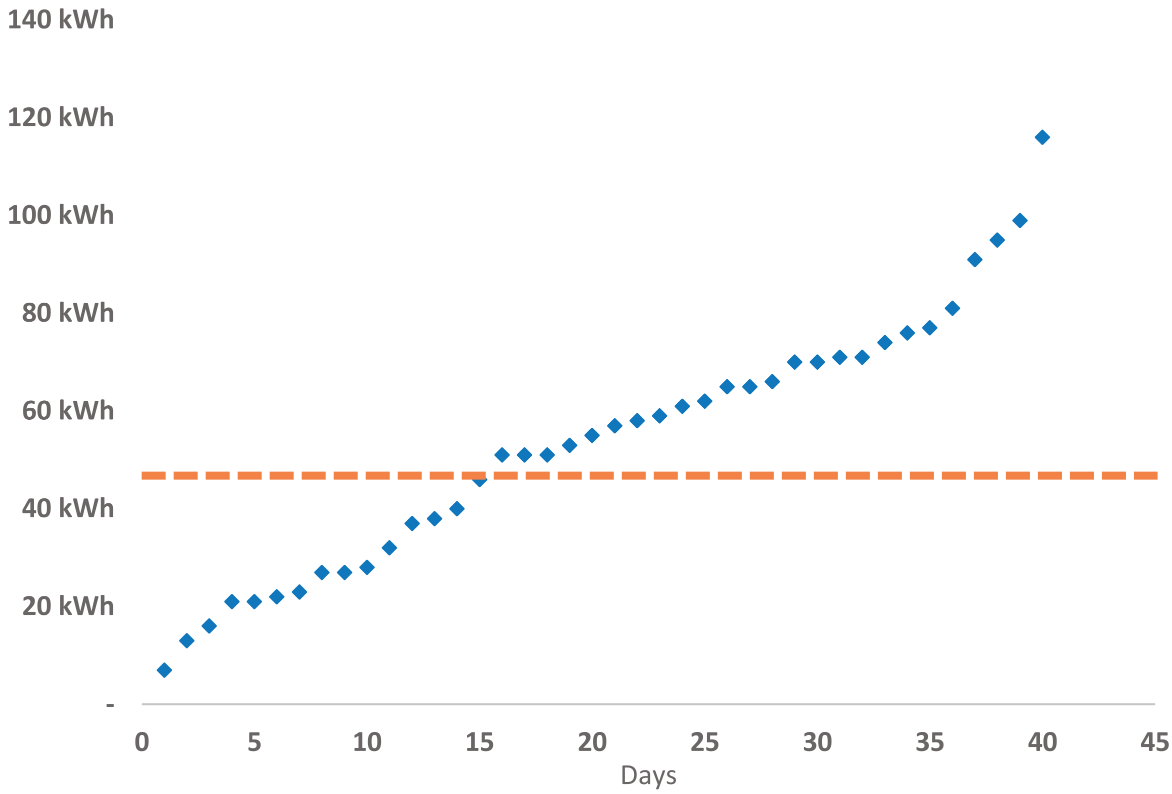


FIGURE 58: MAP OF SOLAR EXPORTS FOR A REPRESENTATIVE SAMPLE OF 40 DIFFERENT DAYS AT NEWRYBAR PS

Optimal battery sizing estimation in this context therefore requires a formula to account for battery utilisation. The calculation approach we have adopted considers:

- The number of days in a year that battery capacity would be 100% utilised
- The quantum of underutilisation for days when battery capacity would not be 100% utilised

For the pattern of export variability at Knockrow Reservoir our calculations show that:

- A 45-kWh battery would have an overall utilisation potential of around 87.5% and could achieve payback on investment in 6 to 10 years, depending largely on future electricity costs.
- A 54-kWh battery would have a lower utilisation potential of around 80%. While its extra size would allow it to offset about 10% more grid electricity than the 45-kWh system, the higher upfront cost combined with lower utilisation potential means it could take 2-3 years longer to achieve 'payback' on investment.

11.6.2.6 Oversizing to increase battery life and system reliability

When finalising battery size specifications, an appropriate 'oversizing factor' may be applied to better account for potential battery degradation issues.

The rate of battery capacity decline for commonly available commercial batteries is in the range of 2 - 3.5% per year, depending on how well the battery's charge and discharge cycles are managed. This can mean battery capacity can decline to as little as two thirds of its original capacity after 10 years.

Battery capacity decline can be minimised by ensuring enough "spare" capacity is initially specified so that the battery does not need to operate regularly at very high or very low states of charge to meet required demand, even as it ages. Good quality battery management software is also essential for making the most of available capacity in a way that preserves battery longevity.

Oversizing in the order of 20% has been shown to improve battery lifespan and reliability, and reduce maintenance and battery changeover costs, thereby improving overall financial outcomes despite the higher upfront costs.

12 APPENDIX: Calculations of emissions abatement from revegetation activities

TABLE 38: EMISSIONS ABATEMENT CALCULATIONS FOR EMIGRANT CREEK DAM

ID	Area (ha)	Plantation date	Net carbon abatement per area for reporting period (t CO_2-e)					
			FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
1	0.878	2006	12.28	11.73	11.08	10.49	9.86	9.30
2	0.99	2003	11.56	10.96	10.38	9.84	9.28	8.77
3	0.633	2003	7.38	6.99	6.62	6.28	5.92	5.60
4	1.605	2007	22.45	21.99	20.95	19.84	18.65	17.58
5	1.832	2007	25.63	25.11	23.92	22.65	21.29	20.07
6	1.293	2008	18.56	18.47	18.06	17.24	16.22	15.28
7	1.31	2008	18.78	18.70	18.28	17.46	16.42	15.47
8	2.629	2009	37.44	38.15	37.91	37.15	35.23	33.22
9	1.234	2008	17.83	17.75	17.36	16.57	15.59	14.69
10	1.744	2005	22.99	21.78	20.58	19.49	18.33	17.30
11	1.256	2005	16.66	15.78	14.92	14.12	13.29	12.54
12	0.533	2006	7.43	7.10	6.71	6.35	5.97	5.63
13	1.199	2006	16.68	15.93	15.06	14.25	13.40	12.63
14	2.776	2005	36.67	34.74	32.83	31.09	29.25	27.60
15	0.549	2005	7.25	6.87	6.49	6.15	5.78	5.46
16	0.821	2017		0.09	0.86	3.11	5.93	8.43

Table 39: Emissions abatement calculations for Rocky Creek Dam

ID	Area (ha)	Plantation date	Net carbon abatement per area for reporting period (t CO_2-e)					
			FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
1	18.839	1990–2010	174.69	166.41	158.15	150.60	142.40	135.11
2	9.787	1990–2010	90.65	86.37	82.09	78.18	73.93	70.15
3	9.119	1990–2010	83.10	79.17	75.25	71.66	67.76	64.29
4	5.159	1980–1990						
5	40.923	2020–2022					4.42	41.12
6	1.869	1990	9.10	8.94	8.70	8.44	8.11	7.80
7	5.831	2010–2022	0.63	5.84	20.85	40.03	56.74	68.98
8	1.258	2010–2022	0.14	1.26	4.51	8.66	12.27	14.92
9	3.103	2000–2010	40.34	38.21	36.10	34.18	32.14	30.33
10	4.153	2010–2022	0.46	4.31	15.40	29.58	41.93	50.98
11	3.941	2010–2022	0.43	4.08	14.57	27.99	39.67	48.23
12	1.241	2010–2022	0.14	1.29	4.60	8.82	12.51	15.21
13	8.409	2010–2022	0.92	8.69	31.02	59.57	84.45	102.67
14	7.626	2010–2022	0.84	7.87	28.12	54.00	76.55	93.06

Table 40: Emissions abatement calculations for Wilson River

ID	Area (ha)	Plantation date	Net carbon abatement per area for reporting period (t CO_2-e)					
			FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
1	0.569	2009	8.28	8.44	8.38	8.21	7.79	7.34
2	1.737	2010	21.13	22.30	22.69	22.60	21.99	20.91
3	1.26	2010	15.29	16.14	16.41	16.35	15.91	15.13
4	1.721	2010	20.89	22.04	22.42	22.33	21.74	20.67
5	2.285	2011	25.01	27.86	29.36	29.93	29.60	28.89
6	3.932	2011	43.06	47.98	50.55	51.54	50.98	49.75
7	3.202	2011	35.07	39.08	41.18	41.98	41.53	40.53
8	1.281	2009	16.33	16.64	16.54	16.21	15.37	14.50

TABLE 41: EMISSIONS ABATEMENT CALCULATIONS FOR DUNOON

ID	Area (ha)	Plantation date	Net carbon abatement per area for reporting period (t CO_2-e)					
			FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
1	6.69	2002	70.30	66.73	63.22	60.03	56.61	53.58
2	22.098	1990s	149.31	144.49	139.01	133.72	127.45	121.80
3	3.814	1990s	25.61	24.76	23.81	22.90	21.82	20.85
4	3.992	1990s	26.87	26.01	25.02	24.07	22.94	21.93
5	7.028	1990s	47.35	45.82	44.09	42.41	40.42	38.63
6	23.101	1990s	150.59	145.77	140.27	134.94	128.61	122.92
7	2.174	1990s	14.50	14.03	13.49	12.98	12.37	11.82
8	10.038	1990s	65.54	63.45	61.05	58.73	55.98	53.50
9	9.097	2005	112.41	106.48	100.62	95.26	89.58	84.52
10	12.656	1990s	82.55	79.90	76.87	73.95	70.48	67.36
11	2.174	1990s	14.08	13.62	13.11	12.61	12.02	11.49