MURWEH SHIRE COUNCIL
ENERGY & EMISSIONS STRATEGY.

Abstract

This report summarises options for Murweh Shire Council (MSC) to reduce energy costs, reduce energy use and reduce Greenhouse Gas (GHG) emissions. Projects with strong economic viability are presented (e.g. automation and PV solar) as well as strategic / longer terms projects (diversion of biomass from landfills to support industrial operations to reduce energy costs). MSC's carbon footprint was estimated for FY22-23.

All Energy Pty Ltd engaged with six SWQROC Councils to collect detailed data on energy consumption and Scope 1, 2 and 3 Greenhouse Gas (GHG) emissions, analyse the data then develop strategic plans for councils to progress towards being Carbon Zero.

All Energy Pty Ltd

2024

PROJECT: Energy and Emissions Strategy for South-West Queensland Regional Organisation of Councils (SWQROC) LGAs

AUTHORS

Dr Gareth Forde

Registered Practicing Engineering Queensland – Chemical;

Registered Practicing Engineering Queensland – Environmental;

PhD, Chemical Engineering, Cambridge University, UK;

Chartered Engineer (Engineers UK);

BE (Hons I, Chemical), University of Queensland;

Clean Energy Regulator - Greenhouse and Energy Inspector;

Chartered Scientist (Science Council, UK);

Fellow of the Institute of Chemical Engineers;

Member Australian Institute of Company Directors.

Max Barnes

BEng (Hons I, Process), Queensland University of Technology

Associate Member of the Institute of Chemical Engineers

REVISION

Date	Purpose	Rev	Authors
21/10/24	Murweh Final Report	C	MB, GF

All Energy Pty Ltd: ABN 95 16 9802 555, ACN 16 9802 555; Telephone: 0437 249 745; Email: info@allenergypl.com.au

Table of Contents

Executive Summary

All Energy Pty Ltd analysed the energy consumption and greenhouse gas (GHG) emissions for the Murweh Shire Council (MSC) to generate an energy and emissions reduction strategy.

Detailed power consumption data was obtained from Ergon and analysed, key MSC goods and services used by MSC were considered and a wide range of options were formulated.

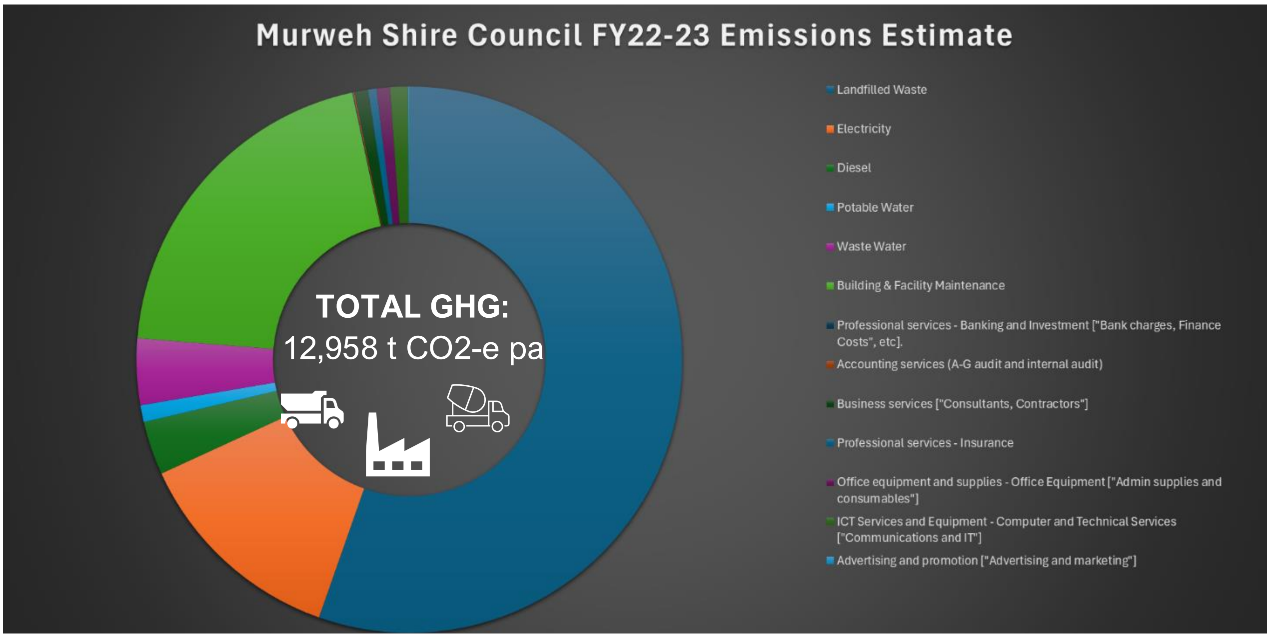
The following table summarises “low hanging fruit” opportunities that are relatively low CAPEX and rapid (<4 year) paybacks shaded in green followed by a section on larger (>$40k CAPEX) projects shaded in yellow.

COMPARISON	kWh pa	CAPEX $	$/kg CO2-e p.a.	Payback - years.
Low Hanging Fruit Projects				
Forest St, Augathella 13 kWp solar PV	24,549	$21,900	$2.87	3.1
Charleville swimming pool 13 kWp solar PV	24,549	$21,900	$2.87	3.1
Airport Dr Charleville 13 kWp solar PV	24,549	$21.900	$2.87	3.1
Lot 53 Warrego Hwy Morven 6.6 kWp solar PV	12,182	$14,700	$3.89	4.1
Bore 5 Lot 53 Partridge St 13.3 kWp solar PV	24,549	$21,900	$2.87	3.1
Burke St Charleville Bore 13.3 kWp solar PV	24,549	$21,900	$2.87	3.1
Energy efficiency measures 1. Timer on main 18.5 kW filtration pump at Charleville swimming pool	$10,135.7	$420	$0.52	0.4
Culture: Incentivise energy efficiency (e.g. data tracking with celebration of greatest % reduction).	Towards 30%	$0	Very small	Days
Culture: Incentivisation for energy efficiency ideas e.g. rewards for best ideas				
Larger / Longer Payback Projects				
Grinding and screening of all organics / biomass for diverting ~8,000 tpa away from landfill	Emissions savings: 8,400 tpa CO2-e	$2.23 mil (shared SWQROC equipment)	NA	NA
Gasifier of 9,551 tpa of material diverted from landfill	28,000,000	$7.2 mil	3.78	4.9 yrs

All Energy assisted with preparing a submission to the *Community Energy Upgrade Fund (CEUF)* for the above suggested low hanging fruit projects. At time of writing in October 2024, the outcome of this grant is not currently known.

For the CEUF, all projects use a flat 0.31kg CO2e/kWh emissions multiplier for all states which was used in the above table. The actual emissions intensity for QLD grid electricity in the *Australian National Greenhouse Accounts Factors 2023* is 0.88 kg CO2e/kWh meaning that actual amount of emissions abatement and abatement cost will be improved.

The Greenhouse Gas (GHG) emissions estimate for the 2022-2023 Financial Year was estimated in accordance with the GHG Protocol and includes Scope 1, Scope 2 and upstream Scope 3 emissions, with the results presented in the following pie chart (further details discussed in Section 2.2).



One caveat to the above emissions inventory is that it only aggregates assets and activities under MSC control, that is, emissions from residential and private commercial sources and activities are excluded.

One "Carbon Zero Pathway" for MSC to achieve Carbon Neutrality is summarised in the following table. These targets are aspirational and over a 10 to 25 year time horizon and will rely on technical advancements, however, does show the large in-roads that can be made into emissions reduction.

Emissions Source	Action Towards Carbon Zero	Residual t CO2-e pa
Landfilled Waste	Maximum recycling, then Energy from Waste facility to convert waste into power and road base (ash).	3,750
Electricity	Low emissions power from "Energy from Waste", distributed solar+batteries, zero emissions grid power.	0
Diesel	Electrification (and / or H2, biofuels, e-fuels)	0
Potable Water	Zero emissions chemicals and operations	0
Waste Water	"Managed aerobic treatment" and/or biogas capture and reuse; sludge composting (or gasification).	112.3
Building & Facility Maintenance	Procurement of zero emissions goods and services	0
Professional services		
Accounting services		
Business services		
Professional services - Insurance		
Office equipment and supplies		
ICT Services and Equipment		
Advertising and promotion		
Remaining emissions for indirect abatement (e.g., offset via carbon credits).		3,862.3

1 Introduction

1.1 Background & Motivation – QLD State Government / DSDILGP Objectives

Since 2017 the Queensland Government has been leading by example to reduce Greenhouse Gas (GHG) emissions across its Government operations. The Government, through the DSDILGP is encouraging Councils to follow the Government's initiative and take the steps necessary to support the State's drive for decarbonisation. This Project has identified strategic actions that will position Councils to achieve carbon neutrality by 2050.

The Queensland Government has set a target of zero net emissions by 2050, with an interim goal to reduce emissions by 30 per cent below 2005 levels by 2030. The Government through the Department of Environment and Science (DES) is actively implementing projects that will support a transition to a zero-carbon economy. Through the identified action plans projects will be identified that will see job creation and economic stimulus through construction activities.

Queensland Government goals and targets are currently aspirational and are not legislated, however rising commitments from the public, private sector and other governments (such as Australian Government with legislated targets and United Nations Climate Change Conference of Parties (COP) Agreements), may contribute to these goals becoming binding in the future.

Ultimately, the Australian and Queensland Government vision and target is to progress towards a zero GHG emissions society. Council hence has a role to play not just with council activities but also local businesses and households, as about 20 per cent of Australia's carbon footprint comes from household emissions[1]. SWQROC councils are likely to have a more direct impact on household emissions via waste and water practices and knowledge sharing.

The Queensland Government's Department of State Development, Infrastructure, Local Government and Planning (DSDILGP) has provided financial assistance to the South West QLD Region of Councils (SWQROC), through their Remote Area Board funding, to undertake a zero-carbon strategy.

All Energy Pty Ltd was contracted to engage with SWQROC Councils to develop strategic plans considered for implementation towards a potential goal of being carbon neutral (referred to as 'Project'). As part of the Project, All Energy produced a report for each Council to consider in consultation with DSDILGP. The SWQROC Councils specifically engaged in the Project include the councils of Bulloo, Paroo, Balonne, Murweh, Quilpie, and Maranoa.

This Project will also support Action 3.5 in the Queensland Energy and Jobs Plan (Plan) which is aimed at reducing emissions in remote communities (https://www.epw.qld.gov.au/energyandjobsplan). The Plan outlines how Queensland's energy system will transform to deliver clean, reliable and affordable energy to provide power for generations. It leverages Queensland's natural advantages to:

- Build a clean and competitive energy system for the economy and industries as a platform for accelerating growth.
- Deliver affordable energy for households and business and support more rooftop solar and batteries.

[1] https://www.abc.net.au/news/2021-05-30/carbon-neutral-households/100165072, accessed 7 Dec 2022.

- Drive better outcomes for workers and communities as partners in the energy transformation.

1.2 Project Scope

All Energy produced individualised results for each Council detailing:

- A carbon emissions estimate for FY2022/23,
- Rapid payback, relatively simply and comparatively low CAPEX energy efficiency and PV solar projects ("low hanging fruit").
- Formulation of "low hanging fruit" into a format suitable to support a submission for Fed Govt funding via the Community Energy Fund (round 1 closing 30th April 2024; Round 2 in 2025).
- Long list of direct abatement opportunities (i.e. more complex, longer payback, strategic).
- Council specific large scale opportunities e.g. energy from waste, green fertilizer.
- Indirect abatement options to achieve Carbon Zero after Scope 1, 2 and 3 have been addressed.

Quotations from Solahart Darling Downs were used as the basis of the economic analysis. These quotations were accurate at the time of creation (Q1 2024), however were valid for 30 days only hence must be updated at an appropriate time. Solar panels are continuing to drop in price, however STCs are also dropping in price whilst labour and materials are generally increasing, however it is expected that into the future quotations for solar should remain relatively similar with the main changes being due to foreign exchange (i.e. the strength of the Australian dollar to procure overseas manufactured equipment) and site specific requirements such as if a main switch board requires upgrading.

1.3 Specific SWQROC Motivation: Power Cost and Power Reliability

Two key motivations for organisations using power on the Ergon grid are:

(1) The high cost of ergon power, and

(2) The reliability of Ergon power.

Ergon power is expensive: in FY24/25 a house hold expects to pay 34 c/kWh compared to 17.71c/kWh in Melbourne[2] or 25.74 in Brisbane[3].

[2] https://compare.energy.vic.gov.au/, Welcome - Victorian Energy Compare, accessed 17th Sept 2024.
[3] https://www.energymadeeasy.gov.au/plans/results, Plans Results - Energy Made Easy, accessed 17th Sept 2024.

Ergon power for a small business is at 36 c/kWh compared to 26.62 c/kWh in Sydney or 28.16 c/kWh in Brisbane[4].

On power reliability, the SWQROC area is poor power quality. Data on power quality for individual meters is very limited, however Ergon does make available 30min interval data on substations which provides an opportunity to analyse periods of very low (<5% average load) or no flow. The following table summarizes the substation availability for each major town.

Table 1: Zone Substation Data Analytics of Ergon Data FY21-22: <5% of average MW.

Substation	Hours <5% average load	Information
St. George Town	255 hrs	66 kV via Roma East
Quilpie	138 hrs	66 kV via Charleville
Cunnamulla	6 hrs [FY23/24: 97.5 hrs]	66 kV via Charleville
Charleville	2 hrs	66 kV via Roma West
Roma West	2 hrs	132 kV from Miles
Roma East	0	132 kV from Miles
Thargomindah	No specific zone substation (power is via Cunnamulla substation).	22kV HV line via Cunnamulla
Townsville Port	0.5 hrs	

For FY23/24, there was 68 hours of no power at the Cunnamulla substation which mostly occurred in two large blocks on 19th and 20th Dec 2023 and 28th and 29th June 2024 and with some other short periods.

The effects of these black and brownouts that was reported in every SWQROC town during site visits was that household and commercial equipment prematurely fails, resulting in increased costs, downtime, and impediments to existing and prospective business in the area.

1.4 Direct Abatement - Introduction

Direct abatement refers to actions done by Council on an asset or activity where Council has operational control. An example of direct abatement is installing energy efficient equipment or solar PV within a council building (as opposed to buying a carbon credit which is indirect abatement).

By implementing direct abatement opportunities, it is estimated that emissions can be reduced to 65% to 80% of the current GHG emission levels. The direct abatement options, in order of priority should include:

- Energy efficiency.
- Renewable power generation.
- Waste management; and
- Mobile fleet / transport opportunities.

[4] https://www.energymadeeasy.gov.au/plans/results, Plans Results - Energy Made Easy, accessed 17th Sept 2024.

There is a strong trend amongst industrial companies to pull back from short term carbon zero targets that would have required large and ongoing purchases of carbon abatement credits, but rather investing those funds into direct abatement projects to reduce directly Scope 1 and 2 emissions within operations. Projects routinely are energy / materials efficiency projects or “behind the meter” power and thermal energy projects. Specific opportunities for direct abatement are outlined in the following sections.

1.5 Indirect Abatement - Introduction

Indirect abatement opportunities are difficult to estimate without detailed analysis, however land-based abatement projects that may be suited to semi-arid pastoral grazing lands include soil carbon (e.g. changing practices to perennial pastures; legumes) and native forest regeneration (e.g. which could align with mine rehabilitation, in particular for areas with higher rainfall). SWQROC LGAs could consider collaborating with local land holders (e.g. supporting local projects via abatement credit off-takes or purchase agreements) then retiring credits to indirectly abatement council emissions (e.g. for fugitive emissions from water and landfilling operations).

To become carbon neutral would then require procurement of offsets from third parties for any emissions that cannot be eliminated via direct and indirect abatement.

1.6 Project Methodology

The project methodology is summarised in the following flow diagram where for each council:

(1) emissions were estimated upon requested data (e.g. Ergon metering data, fuel consumption, landfilled tonnages) and publicly available information (e.g. council financial reports, reporting on potable water and wastewater, staffing numbers).

(2) Actions internal to the council were defined for councils to reduce emissions via direct abatement such as energy efficiency, PV solar, landfill avoidance, etc.

(3) Indirect abatement i.e. projects external to council that they could support such as local soil carbon projects, plantings, managed plantation and beef cattle herd management.

(4) Offset options where abatement credits are procured by a third party.

(5) Pathway towards Carbon Zero where the amount of abatement by each of (1) to (4) above were defined.

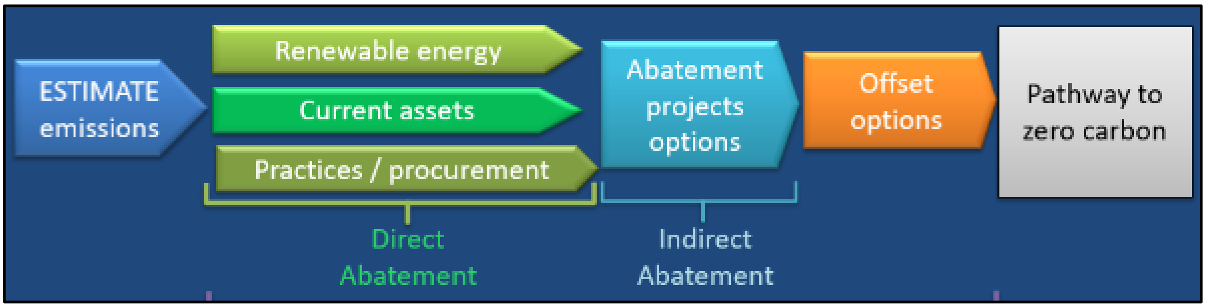


Figure 1: Pathway to carbon neutrality

The emissions inventory and carbon zero strategy factoring direct and indirect abatement opportunities along with required purchased offsets was completed for each LGA – **the detailed reports and documentation of findings of direct consultation with the six (6) Councils are provided in the Appendices.** The summarised consultation approach was as follows:

1. General introduction to the "Towards Carbon Zero" for the Project Control Group.
2. For the first "Pilot Council": Stakeholder consultation, requests for information (RFIs), data collection, data quality review and analytics for emissions estimation.
3. Follow up requests for information for identified data gaps, and fill with heuristics / defining of assumptions where data was unavailable (i.e. diesel consumption)
4. Discovery and utilisation of publicly available information, specifically financial reports, water reports and waste management strategies.
5. Data analytics to produce emissions inventory.
6. Options analysis for direct abatement opportunities
7. Options analysis for indirect abatement opportunities
8. Options for purchase of offsets for residual emissions.
9. Discussion / transmission of results to council.
10. Formulation of results into a final report.
11. Presentation of completed results at the next Project Control Group.
12. Repeat stages (2) to (11) for each council.

LGA South Australia provides the following pathway to emissions reduction for local governments as part of their Net Zero Accelerate program[5]

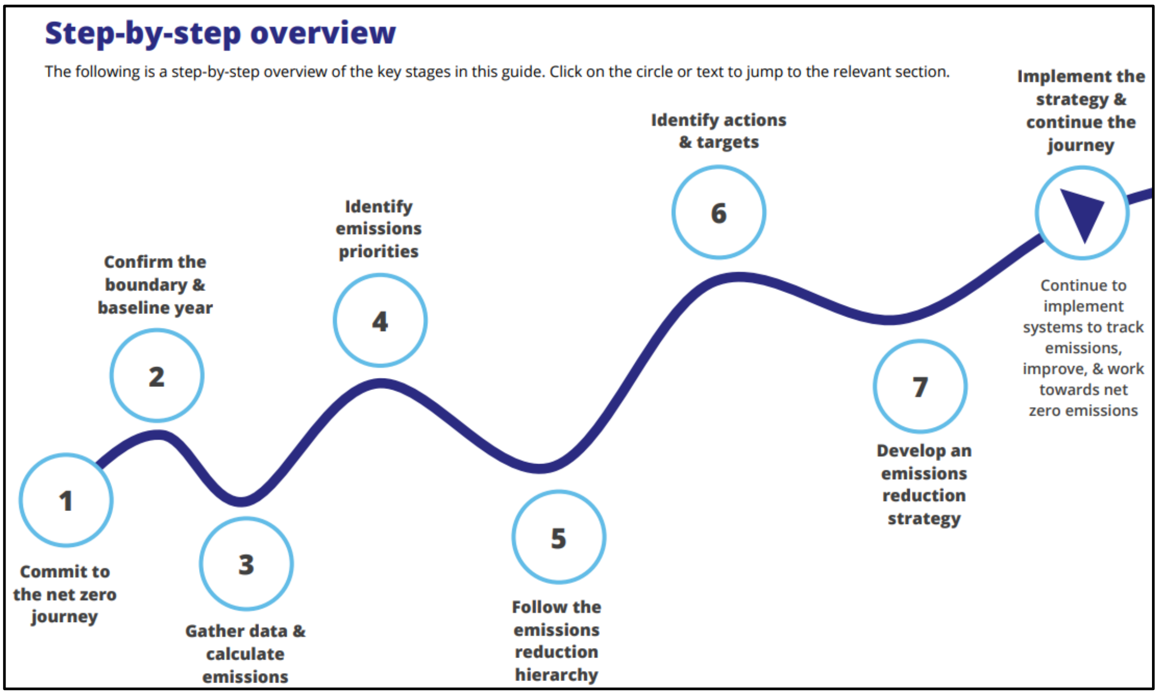


Figure 2: Local government pathway to emissions reduction

[5] dsquared_A4 Report_ Executive summary (lga.sa.gov.au)

1.7 Why Should SWQROC Councils Receive Funding For Energy Projects and Emissions Reduction

This section highlights some points of difference for SWQROC councils compared to other (more southerly) councils with specific reference to making submissions to the Community Energy Utility Fund submissions more competitive.

(1) **Smaller regional councils have a much higher burden of emissions** due to the transient or enumerated population (i.e. tourists, FIFO/DIDO resource workers and seasonal agribusiness workers) compared to urban areas. This puts a much higher load onto potable water pumping, sewerage treatment, landfilling and other council infrastructure. Using 2021 data the transient / enumerated population can be compared to the ABS permanent population.

- Bulloo had an enumerated population 60.5% higher than the resident population (541 v 337; difference of 204 people).
- Quilpie 24.1% (866 v 698; difference of 168 people).
- Paroo 21.1% (2034 v 1679; difference of 355).
- Murweh 8.9% (4326 v 3971, a difference of 355 people).
- Maranoa 8.1% (13,870 v 12,825, a difference of 1,045 people).
- Balonne 7.7% (4654 v 4320; difference of 334).

These results can be compared to urban centres like Townsville with an enumerated population being 0.7% higher than the resident population or Rockhampton and Toowoomba where on Census nights the enumerated population was lower than the resident population. Even taking a tourist destination like Noosa Council, the enumerated population was 3.7% higher than the resident population; or the Gold Coast City Council with 0.4%. Source: profile.id

(2) **South west Queensland is an area of high solar radiation** and a high percentage of sunny days resulting in very high PV productivity with actual solar production exceeding most other geographic areas and routinely exceeding solar modelling (metered data from pilots deployed in the Balonne Shire Council are operating at an average of 5.0534 kWh / kWp). High solar radiation also leads to hotter days and associated requirements for HVAC and water consumption.

(3) **Regional areas in Queensland have an extremely distributed and comparatively expensive grid power network** which at times has low reliability and is simultaneously expensive to operate and maintain. This monopolistic environment results in relatively expensive power with the FY23/24 small business rate at 37.75 c/kWh and residential rates at 33.25 c/kWh; compared to highly competitive energy markets like Melbourne with residential offers as low as 12.24 ¢/kWh (first 15kWh/day; Ref: https://compare.energy.vic.gov.au/offers); or Brisbane with residential offers of 25.74c/kWh (ref: www.energymadeeasy.gov.au).

2 Murweh Shire Council GHG Emissions Estimate

2.1 Carbon Footprint Introduction & Boundary

A carbon footprint calculates all of the Scope 1, 2 and 3 emissions for an operation. Scope 1 emissions are direct in that they come straight out of a tail pie or boiler stack. Indirect Scope 2 emissions are most commonly emissions associated with using electricity. Scope 3 emissions are everything else, where generally the upstream Scope 3 emissions (i.e. all good and services used by an organisation) are included in a carbon footprint whilst downstream Scope 3 emissions (e.g. emissions associated with the use of a product) are excluded.

For example, diesel has direct Scope 1 emissions from combustion in an internal combustion engine and the upstream Scope 3 emissions due to the emissions associated with exploration, extraction, refining and transport.

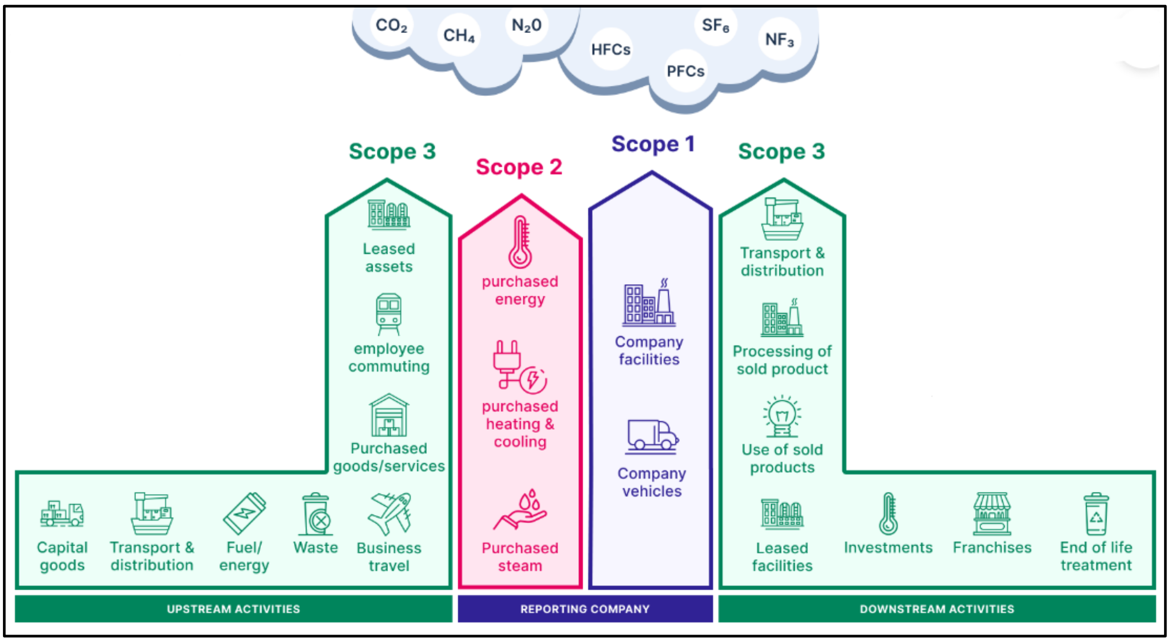


Figure 3: Scope 1, 2, and 3 emissions sources

Boundary: to maintain consistency, **Scope 1, Scope 2 and upstream Scope 3 emissions have been included in the council carbon footprint.** Downstream Scope 3 have been excluded, an example for a council being emissions from cars using council roads, TMR contracts, emissions associated with recycling of materials (e.g. recycling of steel collected at landfills). The approach utilised for this project is in keeping with the carbon accounting principles as per the GHG Protocol[6] and ISO 14064. A key area for discussion is the emissions associated with TMR funded works untaken by council.

[6] ghg-protocol-revised.pdf (ghgprotocol.org)

2.2 Carbon Footprint Results for Murweh

The GHG emissions for MSC are summarised in the following table then presented graphically as a pie chart, with the main emissions being landfilled waste followed by emissions associated with building and facility maintenance (including roads). It must be emphasized that this table is an estimate based upon best available data.

Table 2: Murweh Shire Council emissions inventory estimate

Murweh Emissions	Scope	Emissions Intensity t CO_2-e/Unit	tonnes CO_2-e pa	% of total emissions	Notes
Total Emissions [t CO_2-e pa]			12,958.2		
Landfilled Waste	1	0.751	7,175.9	55%	Estimated from population
Electricity	2	0.88	1,656.1	13%	Ergon data
Diesel	1 & 3	87.71	411.3	3%	Estimated from population
Potable Water	3	0.0005	128.7	1%	Public report
Waste Water	1	0.0020	509.4	4%	Multiplier
Building & Facility Maintenance	3	0.0002	2,641.5	20%	Annual council report FY22-23
Professional services - Banking and Investment ["Bank charges, Finance Costs", etc].	3	0.00003	6.5	0%	
Accounting services (A-G audit and internal audit)	3	0.00013	9.6	0%	
Business services ["Consultants, Contractors"]	3	0.00009	105.0	1%	
Professional services - Insurance	3	0.00016	64.6	0%	
Office equipment and supplies - Office Equipment ["Admin supplies and consumables"]	3	0.00027	102.6	1%	
ICT Services and Equipment - Computer and Technical Services ["Communications and IT"]	3	0.00017	137.4	1%	
Advertising and promotion ["Advertising and marketing"]	3	0.00013	9.6	0%	

Compared to other SWQROC LGAs, the proportion of emissions coming from grid electricity consumption is relatively low due to the efforts of MSC in installing solar on council assets.

2.3 Electricity, Efficiency and On-site Generation

Electricity is consumed in council-owned buildings and assets frequently dominated by council administration buildings, swimming pools, works depots, water treatment plants, and potable water pumping. For each LGA, meter consumption data was transmitted by Ergon in its raw form and processed by All Energy Pty Ltd.

Table 3: SWQROC LGAs electricity consumption 2022/23

	LGA MWh pa	MWh per Capita
Bulloo	248	0.7
Paroo	505	0.3
Balonne	1,487	0.3
Murweh	1,882	0.4
Maranoa	6,296	0.5
Quilpie	637	0.9

As above, the per capita power consumption follows a weak exponential trend towards an asymptote of 0.3 MWh per person per annum. This is compared to the QLD average of 10.6 MWh per person, or the NEM average of 15.6[7]. The discrepancy in these figures is obviously distorted by the level of heavy industry covered in the NEM and QLD, but can be used indicatively.

Purchased grid electricity is a scope 2 and 3 emission source and is calculated at 0.88 tCO2-e per MWh in QLD as per the Federal Department of Climate Change, Energy, the Environment, and Water *National Greenhouse Accounts Factors*[8]. Note that for the Community Energy Upgrade Fund Program, a blanket 0.31 t/MWh Scope 2 and 3 GHG figure is used to compare emissions reductions across states with varying levels of renewables in the grid.

For the majority of SWQROC LGA registered meters, particularly single phase 240V meters, the data resolution was monthly at best, sometimes quarterly. Detailed 30min data tended to only be available for the largest three phase 415V meters. Hence, detailed analysis of power quality, power factor, time of use, and variability of peak power consumption is lacking for the most part.

To reduce power consumption from the grid:

- Efficiency measures are the most viable direct abatement options as the paybacks are routinely in months rather than years. Options are outlined throughout this report, in particular section 3.
- PV Solar routinely has a payback of 3 to 5 depending upon the tariff and solar utilisation.
- Other generation options such as energy from waste or anaerobic digestion tend to provide better economics at scale, with specific options outlined throughout this report.

[7] https://www.aer.gov.au/wholesale-markets/wholesale-statistics/annual-electricity-consumption-nem
[8] https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-accounts-factors-2022.pdf

2.4 Landfilled Waste and Energy From Waste

As for most Australian councils, landfilled waste by SWQROC LGAs is one of the key sources of GHG emissions and is routinely the largest source of Scope 1 emissions. The estimation of emissions from landfill is highly complex. The estimate of landfill emissions was simplified for this project via the use of the "AusLCI Published Processes", "waste treatment, municipal waste average, at landfill" kg CO2-e using the figure for "Carbon Neutrality" which excludes biogenic carbon but includes infrastructure emissions (as well as all fossil fuel usage and biogenic methane; i.e. includes upstream Scope 3 emissions)[9]. The tonnes of "Municipal Waste Average" was assumed to include MSW, C&D, C&I (and excluded asbestos, segregated inerts, recycled materials and recycled organics) and had an emissions factor of 751.326 kg CO2-e per tonne landfilled waste.

The complexity of landfill emissions is due to the time it takes for materials to decompose and the different types of materials in complex waste streams, which is impacted by the geographic location, climatic conditions, and exact compositions. For simplicity, it was assumed that landfills have reached a "steady state" in that the rate of addition of materials over a long period of time is constant and hence the generation of GHG emissions is constant. Hence, the emissions for the landfill in FY22/23 are presented as the emissions associated with the material sent to the landfill for the same time period.

The reality is much more complex, for example, a detailed analysis utilising the National Greenhouse Emissions Reporting Scheme (NGERS) calculator[10] shows emissions peaking one (1) year after delivery of material to a landfill, with GHG emissions continuing until the year 2209; that is, materials landfilled now will impact the next nine generations or more.

Data on landfilling was available for only some of the SWQROC LGAs; where data was unavailable linear extrapolations were done based on the population of an LGA. Depending on the structure of waste management contracts in each LGA, these may be counted as Scope 1 if managed directly by the Council (assumed the case for SWQROC), or Scope 3 if subcontracted to a third party waste management company.

Table 4: FY21-22 SWQROC LGA landfilled waste production

	Estimated Landfill t/yr
Bulloo	759
Paroo	3,714
Balonne	9,555
Murweh	9,551
Maranoa	28,976
Quilpie	1,544

The following table provides a guide on the organic and inert fractions of Australian waste. Of the inerts, approximately 33% is glass/construction materials, 19% is metal, and 48% is polymer (suitable for Energy from Waste).

[9] AusLCI Carbon Emissions Factors, www.alcas.asn.au/auslci-emissions-factors, accessed 25 Jan 2023.
[10] NGER Solid Waste Calculator 2021-22, Clean Energy Regulator, Australian Federal Government, accessed 20th Dec 2022.

Table 5: NGER determination guide on organic and inert fractions of Australian MSW, C&I, C&D wastes

NGERS Determination Waste Composition DATA	% of Domestic MSW	C&I	C&D
Food	35	21.5	0
Paper and cardboard	13	15.5	3
Green waste	16.5	4	2
Wood	1	12.6	6
Textiles	1.5	4	0
Sludge	0	1.5	0
Nappies	4	0	0
Rubber and leather	1	3.5	0
Inerts	28	37.5	89

Considering the potential for waste to energy, a good solution for mixed heterogenous, highly variable, high moisture, and varying particle size solid wastes such as the above is gasification in a moving injection style gasifier[11].

Rather than allowing waste to degrade anaerobically over a long period time with associated fugitive emissions of methane and NOx (plus potential leaching of waste into surrounding waterways), energy can be derived via thermo-processing at high temperatures in a low oxygen environment to create syngas (a mixture of carbon monoxide, hydrogen, methane and other gases) which can be cleaned and used to make power (e.g. in a reciprocating generator).

[11] One such technology manufacturer that All Energy is familiar with and has done due diligence using red meat processing wastes is Wildfire based in Brisbane Wildfire Energy

2.5 Liquid Fuel and Associated Options

Diesel consumption was estimated based upon the ATO Fuel Tax Rebate, and hence could have a high level of inaccuracy due to the large number of assumptions (uses for the diesel and hence the credit applied, cost, etc). From an energy perspective, in the SWQROC region, 2.8 times the amount of diesel energy was consumed as electrical energy which shows the huge need for transport for regional councils.

With diesel engines often operating at 15 to 20% efficiency plus emitting particulates, NOx and SOx in addition to GHGs, there is a strong motivation to look to higher efficiency, lower emissions solutions to replace or reduce diesel which include:

1. Electrification of main power drive.
2. H2 fuel cell power vehicles (electrical platform)
3. Higher efficiency and lower emissions engines (e.g. Euro VI).
4. Electrification of auxiliary loads e.g. PTOs.
5. Hydrogen dual fuel systems via on-board electrolyers (10 - 14% fuel saving).
6. Use of biofuels such as ethanol and biodiesel (from waste cooking oil)
7. E-fuels: low emissions fuel based upon methanol produced from green hydrogen and bio-genic CO2; may require further processing to be “petrol drop in”.

Options 1 – 3 would require procurement of new vehicles, whilst options 4 – 7 are relatively minor modifications or “drop in fuels” that would require no modification.

Diesel consumed in trucks and equipment owned by each respective Council are counted as Scope 1 emissions.

Table 6: FY21-22 SWQROC LGA liquid fuel consumption

	Estimated L Diesel per Year
Bulloo	181,725
Paroo	37,124
Balonne	628,686 (FY19-20 data)
Murweh	467,356
Maranoa	1,417,869
Quilpie	75,548

Liquid fuel consumption is the line item where the greatest gains in accuracy can be made with respect to emissions inventories (i.e. diesel consumption was estimated upon historical data or correlations based on populations with similar remote communities for which data was available).

2.6 Water and Associated Options

Emissions associated with the water sector can contribute a significant portion of an LGA's total emissions inventory. For the purposes of this project, water was split into potable consumption and the subsequent treatment of produced wastewater. Where available, volumes of potable and treated water were reported in each LGA annual utilities performance report, otherwise linear extrapolations were completed based on population using the SEQWater average of 169 L/person/day. It was assumed that 97% of incoming water consumption is discharged as wastewater.

Table 7: FY21-22 SWQROC LGA potable water consumption and waste-water treatment volumes

	Potable Water kL pa	Waste Water kL pa
Bulloo	21,158	20,523
Paroo	103,569	100,462
Balonne	266,479	258,485
Murweh	266,356	258,365
Maranoa	808,074	783,831
Quilpie	43,056	41,764

Options to reduce emissions include:

- Efficiency measures such as variable speed drives. Options are outlined throughout this report.
- Load shaping and PV Solar to move loads to when solar is available (and when grid power is cheap) which is routinely 9am to 4pm; using "gravity batteries".
- Re-design to low energy systems. Due to long life of plant, opportunities are few and far between however avoiding anaerobic ponds (rather using aerobic or in-vessel systems), low energy treatment such as trickle beds, reducing pressure drop or vacuum systems (such as at Thargomindah).

2.6.1 Potable Water

Embodied emissions associated with potable water consumption can include the electricity in pumping from a bore or other reservoir, maintaining pressure along a supply network, and any pre-treatment.

2.6.2 Wastewater Treatment

Likewise, there are embodied Scope 2 emissions associated with treating waste water in electricity consumption, however a significant Scope 1 emissions associated with waste water treatment is the production of GHGs (e.g. methane or nitrous oxide) by various bacteria species bacteria as they consume organic carbon compounds in an anaerobic environment.

AusLCI Published Processed report a figure of 1.97 kg CO2-e per kL of wastewater treatment, excluding infrastructure.

2.7 Repairs and Maintenance (Scope 3)

Another significant contributor to total emissions inventory is building and facility maintenance and repair services for Council assets (excluding diesel and power), which is represented predominantly in roads, however this also includes parks and gardens, admin building, public halls, libraries etc. The method here to estimate emissions utilised dollar figures reported in each LGA annual financial statement, and a multiplier of 0.18 kgCO2-e / $ spent as per Federal Government Climate Active[12] emissions inventory multiplier guidelines. Hence, the simplest option for reducing these Scope 3 emissions is to develop a procurement strategy where zero carbon materials and services are procured. Councils can target procuring zero carbon services and materials by the same year that the council wishes to achieve overall carbon neutrality.

2.8 Professional Services

Similar to repairs and maintenance, amounts spent on professional services including accounting, advertising and marketing, public administration costs, consultants and contractors, office equipment and supplies, and banking and investment costs. Respective multipliers published by Climate Active range from 0.03 kgCO2-e / $ spent for light duty professional services to 0.27 kgCO2-e / $ spent for expenses including hardware. Likewise, council can target procuring zero carbon professional services by the same year that the council wishes to achieve overall carbon neutrality.

2.9 Opportunities to Improve Data Quality and Accuracy of Estimate

The following were identified as either lacking from the current available data, or opportunities to improve accuracy

1. Employee accommodation and travel – flights, road travel, accommodation
2. Construction materials and services, including asphalt, concrete, fuel, steel, electrical wiring
3. Available wastes tonnages by type (green waste, inerts, MSW, C&D etc)
4. Separate accounting of professional services aggregated in annual report into:
    a. Postage, courier, and freight
    b. Food and catering
    c. Cleaning services
    d. ICT services and equipment
    e. Office equipment and supplies
    f. Consumables
    g. Granularity into type of professional services
5. Consumable gases such as refrigerants and acetylene
6. Consumption of fuel for stationary energy i.e. backup generators
7. Working from home data

[12] https://www.climateactive.org.au/

3 Murweh Shire Council (MSC) Energy Cost Reduction, Energy Efficiency and Direct Abatement Opportunities

3.1 Solar Pumping e.g. MSC Bores or Park Irrigation

As evidenced by the extensive uptake of off-grid solar pumping in rural applications, there exists a strong economic opportunity to replace pumps on grid power with solar pumping. The challenge is to oversize the pump to ensure sufficient kL of water is pumped within the available sunlight hours (as opposed to having pumping available 24/7). For an indicative park or garden sprinkler irrigation system, budget pricing was sought for a ~0.5 kW solar pump:

- 3", 500W Stainless Steel Solar Pump, helical screw motor; 13kg.
- 2 x 200W Mono Crystalline A grade Solar Panels (Dimension: 1580 x 808 x 35mm. Weight: 16Kg each)
- 1x Auto Control Box (of tank level with battery input option).
- 1x Spare Helical Screw Rotor
- 2 x MC4 Extension Cable for Solar Panels Connect to Control Box
- 1 x 40m & 10m Combined Water Sensor (for bore and water tank)
- 1x User Manual
- 24 months warranty
- Delivery included.
- Max 23LPM/800kPa
- 10m (at 18 L/min) to 40m (at 8L/min).
- 7 hrs in winter and 9 hours in summer.
- Excludes: PV supports (i.e. suited to installation on a shed), piping, steel wire safety cable.

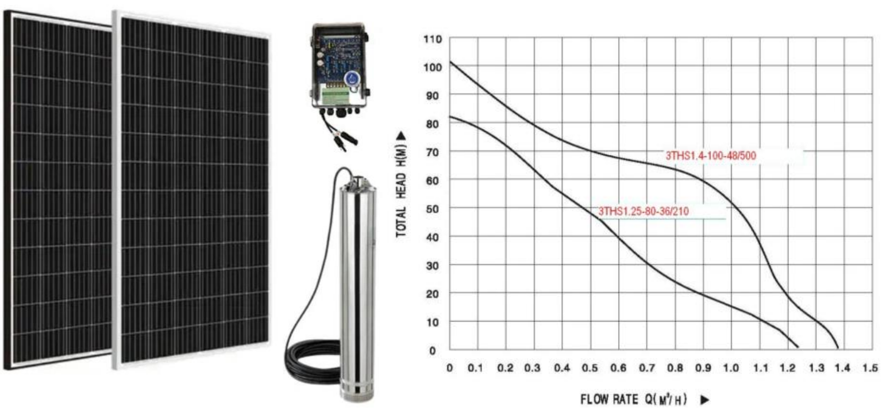


Figure 4: Example solar pumping setup

Solar pumping could be utilised for any asset where water transfer is required including water treatment and potable water.

3.2 Summary of Specific Shortlisted Assets & Opportunities

Table 8: Submission to CEUF grant for solar on MSC assets

Address	NMI	Peak kW	kWh/day	MWh/yr	% of Murweh Total
Forest St Augathella Water Pumping	3044473826	94.4	536.0	195.6	10.4%
Warrego St Charleville Pool	3044467401	29.8	360.4	131.5	7.0%
Airport Dr Charleville	3045115311	42.2	308.7	112.7	6.0%
Lot 53 Warrego Hwy Morven	3044474920	38.4	299.4	109.3	5.8%
Bore 5 Lot 53 Partridge St	3050450239	67.9	280.7	102.5	5.4%
Burke St Charleville Bore	3044452616	Not recorded	276.1	100.8	5.4%

Address	Solar kWp	CAPEX	Offset kWh[13]	Simple Payback
Forest St Augathella Water Pumping	13.3	$21,900	24,272	3.1
Warrego St Charleville Pool	13.3	$21,900	24,272	3.1
Airport Dr Charleville	13.3	$21.900	24,272	3.1
Lot 53 Warrego Hwy Morven	6.7	$14,700	12,227	4.1
Bore 5 Lot 53 Partridge St	13.3	$21,900	24,272	3.1
Burke St Charleville Bore	13.3	$21,900	24,272	3.1

All Energy assisted with preparing a submission to the *Community Energy Upgrade Fund (CEUF)* for the above suggested low hanging fruit projects. At time of writing in October 2024, the outcome of this grant is not currently known.

Energy efficiency measures to improve solar effectiveness at the above facilities include:

- Digital timers on hot water circuits to run during 9am – 4pm period when solar available: $420 cost with payback period <6 months
- Digital timers on HVAC systems to prevent being left on outside of opening hours: as above
- Proximity and motion sensors for lighting and HVAC to transition to "as needed" basis when building is physically occupied: ~$400 with payback period <2 years

The intent of the above energy efficiency measures is to shape demand to match the availability of solar as much as possible, along with minimising non-essential demand outside of this period.

[13] Based on a solar installation by All Energy at the Dirranbandi pool, 86% of solar used onsite offsetting 29% of grid draw with a 13.3 kWp array and extrapolated to larger draw for MSW bores. Assumed 100% of solar consumed by bores with little to no export

3.3 Example Images of Indicative Solar Installations by Scale

3.3.1 13.3 kWp Charleville Pool

The large curved roof on the shade structure enables a NW facing solar array adjacent to the main switch board (small white shed in SE corner), with a flat roofed shed to west of MSB also facing NW.

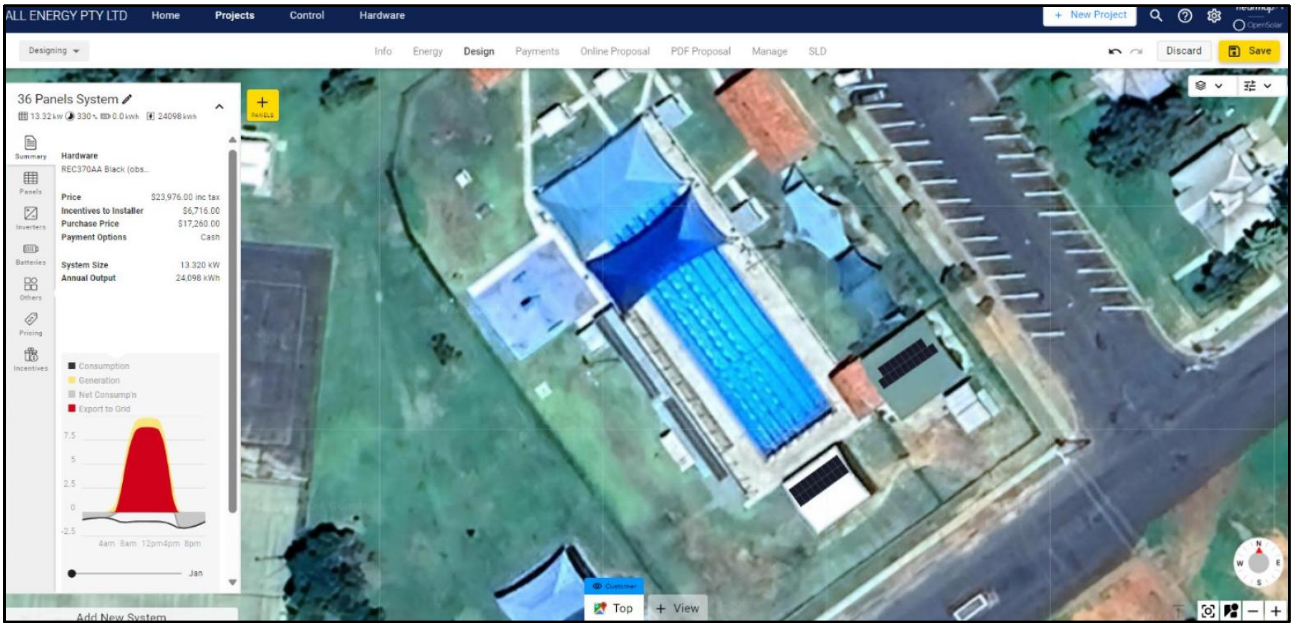


Figure 5: Indicative layout of 13.3 kWp solar array at Charleville pool

A 13.3 kWp array is estimated to be well sized to minimise quantity of power exported to the grid, maximising the value of produced kWh. The peak recorded demand at the Charleville pool was 29.8 kW, with an average calculated of 15.0 kW.

Energy efficiency measures to improve solar effectiveness at the pool include:

- Digital timers on pumps to schedule operation between 8am – 4pm (assuming sufficient over capacity of pump rating(s) to shape load to as closely follow solar curve as possible. May require additional investment in VSDs depending on sizes of pumps, series/parallel configuration, and individual performance curves.

3.3.2 6.7 kWp Lot 53 Warrego Hwy Morven Bore

The roof space is limited at this facility, hence 6.7 kWp is recommended unless a structure is wished to be invested in.

Figure 6: Indicative layout of 6.7 kWp solar array at Morven bore

3.4 Diversion of Waste from Landfill – Mulching / Composting

As shown in the plot below, key options other landfilling to reduce GHG emissions are:

- Mulching
- Composting with associated offsetting of fertilizer,
- Waste to energy,
- Waste to energy with composting of digestate then offsetting fertilizer.

Inert and recyclable materials have no Scope 1, 2, or upstream 3 GHG emissions hence, the primary targets to keep out of landfill with respect to reducing emissions that could be used as solid fuel are, in order:

- Cardboard (1.68 t CO2-e / tonne)
- Paper (1.56 t CO2-e / tonne)
- Food waste (1.01 t CO2-e / tonne)
- Wood (0.79 t CO2-e / tonne)
- Green waste (0.75 t CO2-e / tonne)

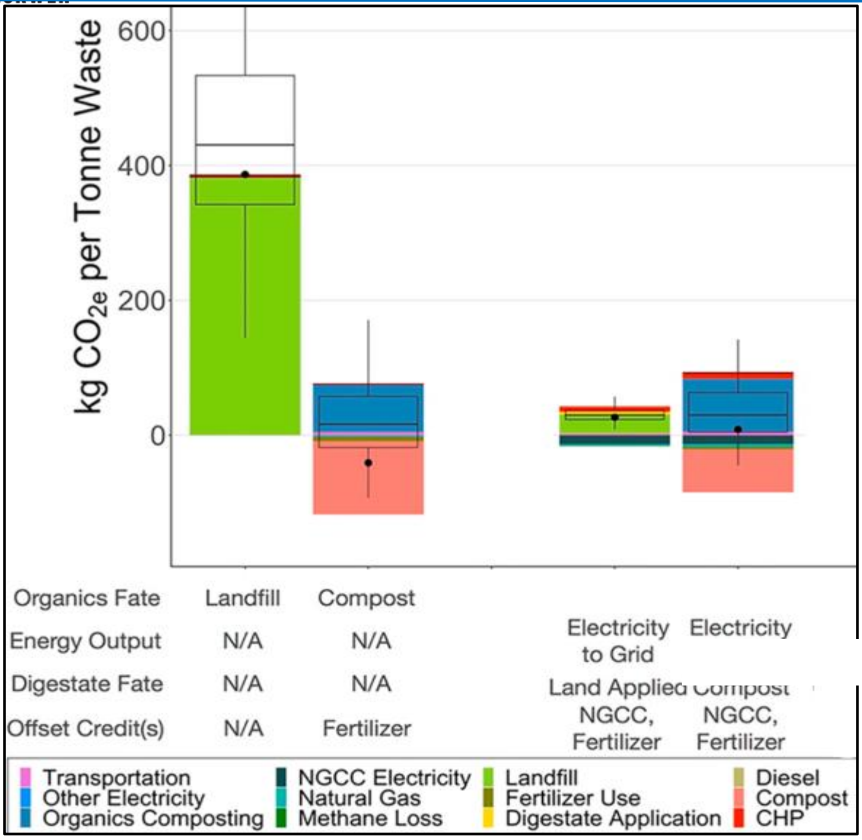


Figure 7: GHG intensity of landfill or nutrient/energy recovery

A key limitation of mulching / composting is that the overheads (grinding, temperature control, moisture control, windrowing) may exceed the value of the compost and/or segregation of materials may be too difficult to create a saleable compost. Hence waste to energy, outlined below, may offer higher value end products.

3.5 Diversion of Waste from Landfill – Biomass

One option for diversion of waste from landfills is the creation of biomass for use to generate power / energy. Whilst mulching / composting may only utilise clean organics, biomass for energy may be able to include pallets, construction wood and any other combustible materials. Whilst Murweh may have a smaller tonnage, as the equipment is mobile it could be shared between the SWQROC councils.

Figure 8: Example biomass grinding and screening mobile plant

CAPEX:

Grinder with metal removal (e.g. Vermeer HG6000TX): $1.71mil

2-deck screen (e.g. TESAB 2600): $520k

Total: $2.23 mil.

OPEX: $200k pa.

Value of avoided landfill for SWQROC councils: $2.04 mil pa (i.e. for Maranoa Regional Council to avoid state based landfill levies; other councils have no state based levy) but equipment can be shared between councils.

Simple payback for SWQROC: 1.2 years (due to Maranoa avoided landfilling costs). Additional value can be generated via the ERF ACCU method for landfill avoidance, but this value has been excluded for this analysis.

Biomass with a particle size of 2 to 50mm would then be suitable for use in energy systems such as gasifiers for power generation and boilers.

The demand for woodchip would be driven by having a use for the biomass in the SWQROC area. For example, a Green Fertilizer Facility requiring large (11.5 MW) and continuous power. Such a facility would utilise solar power as the main energy source, but by way of example, such a facility would require 164 kt pa of biomass if running 24/7 off biomass gasification.

The wastes outlined in Section 3.6 would be well suited to supporting a facility to produce fertilizer as such a facility requires 24/7 power. Excess heat could be utilised in an adjacent grain processing facility. All Energy Pty Ltd is working through detailed requirements for a 7,300 tpa anhydrous ammonia facility, funded by a Qld State Government grant in collaboration with Balonne Shire Council.

3.6 Landfill Emissions Reduction: Small Scale Energy from Clean Wood.

A scenario was analysed where a 140 kWe power output gasifier utilising ~2000 tpa dried wood was considered. Such a system would generate value from power offsetting existing loads and LGC credits. With a total installed capital of $1.4 mil, this system could provide a 6.7 year payback if providing power to the sewerage vacuum system. Such a system would not be suited to taking general wastes (e.g. plastics, etc).

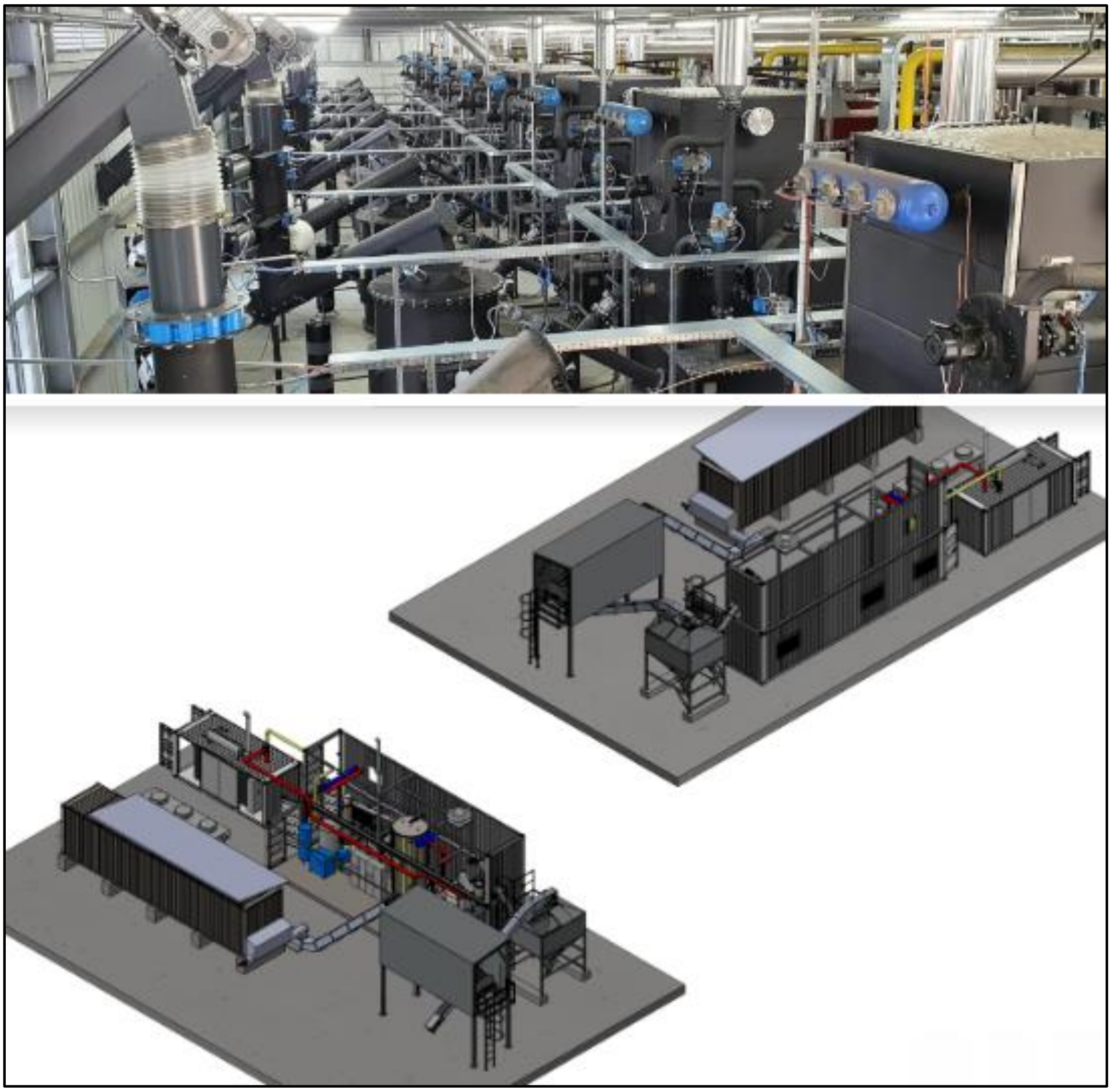


Figure 9: Low cost biomass gasification to electricity recovery system 2000 tpa / 140 kWe (FORTES)

A system of this size providing 140 kWe of continuous power is calculated to be a good fit for the Charleville goat plant. As part of the extension of this project, All Energy will aim to develop this opportunity further in collaboration with MSC.

3.7 Landfill Emissions Reduction: Large Scale Gasification of All Wastes

The following technology is a robust gasifier where the gasification front moves through the bulk material, hence is well suited for mixed wastes where there is no or minimal waste sorting and/or waste sorting is not possible. It would be recommended to remove inert materials in order that these materials do not take up space within the system.

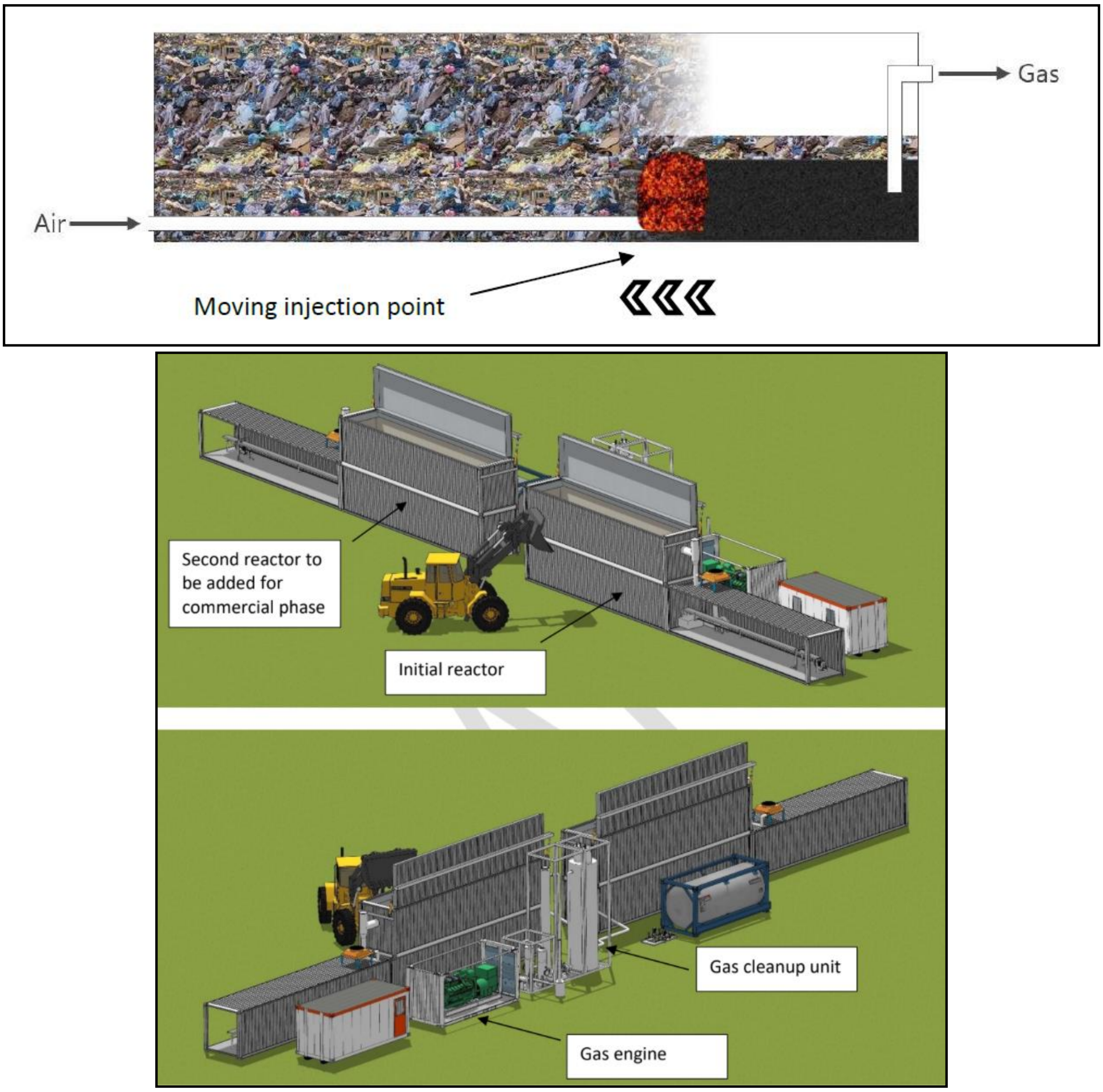


Figure 10: Gasification option for mixed heterogeneous MSW (Wildfire Energy)

The following table provides an analysis for a gasifier capable of processing 9450 tonnes per annum of mixed wastes.

Table 9: Wildfire MIHG basis of design and business case

Parameter	Data
Hours operated per annum	8,000
Annual feedstock 9,450 tonnes, equivalent per day processing rate	25 tpd
Electrical MWh/day recovered	25.4
Electrical MW equivalent – continuous 24 hr	0.8 to 1.06
Equivalent LPG tonnes per day offset	0.6
Plant total installed CAPEX	$7,200,000
Power offset value	$1,946,000
LPG offset value	$100,000 / assume $0 for this project
Avoided landfill	$888,300
LGC generation value – only to 2030	$460,000
OPEX: Wages and maintenance	$340,000
Net revenue p.a.	$2.96
Simple payback period - years	2.9

3.8 Wastewater treatment

The long term aim to progress towards minimising emissions for a wastewater treatment system is to:

- have 100% biogas capture and utilisation where anaerobic digestion is employed,
- "managed aerobic treatment" for polishing (or as the main treatment system),
- Utilisation of renewable energy either from onsite biogas engines or from a 100% renewable grid.

The Intergovernmental Panel on Climate Change methane emissions default values for different treatment systems are:

- managed aerobic treatment: 0
- unmanaged aerobic treatment: 0.3
- anaerobic digester/reactor: 0.8
- shallow anaerobic lagoon (<2 metres): 0.2
- deep anaerobic lagoon (>2 metres): 0.8.

That is, an aerated system must be "managed" (e.g. with continuous dissolved oxygen monitoring and control) to completely avoid methane emissions. As can be seen, the most emitting system is an anerobic lagoon >2 meters with no biogas capture.

Of note, even a very well managed system is expected to have:

- Minor N_2O and CH_4 emissions associated with combustion of biogas,
- Minor CH_4 emissions associated with leaks from digesters, flanges, valve steams, etc.
- N_2O emissions associated with organic treatment.
- Emissions associated with sludge management.

Sludge management also has emissions associated with it in terms of if it is treatment onsite aerobically, treated onsite anaerobically, landfilled (emissions then come under the operational control of the landfill) or transferred elsewhere. According to the NGERS Determination, the lowest emissions option for sludge for a council may be onsite aerobic treatment or to be transferred off site for a facility other than a landfill (e.g. composting or land application).

4 Cultural Changes to Reduce Energy Usage

The six aspects that influence building energy consumption include:

1) climate,
2) building envelope (e.g. insulation),
3) building services and energy systems,
4) building operation and maintenance,
5) occupant activities and behaviour, and
6) indoor environmental quality / set points.

Studies show that changing energy use behaviour can significantly reduce energy consumption by up to 30% and hence can be the most critical factor to achieve energy efficiency[14].

Technology alone will not achieve energy conservation goals. With the total kWh costs being ~$200k pa, a small incentivisation (e.g. celebration BBQ, prizes for efficiency ideas) will have a payback period of a few days.

[14] Su, S. *et al.* Journal of Building Engineering, Volume 58, 15 October 2022, 105011

5 Conclusions and Future Opportunities

Some steps in achieving carbon neutrality could include the following actions:

1) Table this report at a suitable council meeting.
2) Decide upon an acceptable economic hurdle rate for renewables and GHG emissions reduction projects (e.g. less than 5 year simple payback period) and a suitable budget amount (e.g. up to $100k per annum) to implement "low hanging fruit" projects e.g.
    a. Energy efficient equipment (e.g. solar hot water, insulation, light responsive window films).
    b. Timers / automation (e.g. on pool pumps; HVAC; hot water).
    c. Cultural changes:
        i. Data tracking with associated incentivisation for staff / asset users for reducing energy usage to guide cultural changes e.g. publicly report energy usage for different buildings / assets with associated celebration BBQ.
        ii. Incentivisation for energy efficiency ideas e.g. hamper for best energy saving initiative.
    d. PV solar and batteries.
3) Consider larger CAPEX / longer payback options as part of strategy e.g.
    a. Extensive PV solar with batteries where it makes sense.
    b. EV fleet (biofuels as an interim measure)
    c. Diversion of wood / FOGO from landfill
    d. Maximum recycling.
    e. Energy from Waste
4) Procurement of carbon zero good and services.
5) Abatement of remaining emissions.
6) Annual calculation of Scope 1, 2 and 3 emissions and associated verification of carbon neutrality.

Into the future, some areas for collaboration (which could include knowledge and/or equipment) across the SWQROC include:

- Energy from waste: extracting value from waste by making energy, metals, road base/construction materials and renewables credits. With a power value of $80/MWh, 8GJ/t waste has a value of ~$48 to $67 /tonne (depending upon % system efficiency etc).

This value plus value in recycling metals/LGCs/road base could drive waste collection, sorting, compaction, baling and transport from the regions to an EfW facility. This could include a mobile sorting and baling facility with trucks bringing road base from the plant to councils then backloading with baled waste.

- All councils: Common infrastructure for mulching / composting: transportable equipment (grinder/chipper/mulcher/3-way screen + specialised operations FTEs).
- Green Ammonia: best suited to broad acre irrigated cropping rather than dry land grain (e.g. well suited to Balonne/Surat/Muckadilla areas).
- Nanogrids: mobile 50kW EV / township power (festivals, shows, emergency, EV charging).
- Pilots / Trials: PFC, VO, lagging, pool system control / load shaping; DATA LOGGING; automation (e.g. turning pumps on and off to match power costs); building design (All councils)
- Biogas from food and organic waste in AD: at the Roma sale yards; CO2 plant (industrial / food grade).
- Waste management / Landfill avoidance: mobile sorting equipment. Metals pays for the sorting. Energy value pays for the transport. All councils.
- Future Made in Australia Act: food grade CO2 from EfW / asphalt plant; H2 for transport; ammonia; making asphalt locally (tyre and plastic pyrolysis) rather than being imported.
- Hydrogen: fuel cells for off grid power; for farm equipment.
- TMR:
  - Towards a Net Zero Emissions Economy: understanding the cross over between Scope 1, 2, & 3 council emissions with road building / TMR activities. Then how to collaborate on emissions reduction.
  - Comparison of Scope 1 and 2 carbon footprint (i.e. areas with carbon costs) for:
    - Traditional Fossil Based Bitumen with new aggregate / sand.
    - Bio-bitumen (from Solid Municipal Waste)
    - Biochar
    - Plastic Waste Modified Bitumen
    - Tyre-Based (Crumb Rubber) Modified Asphalt & Bitumen
    - Waste Wood Fast Pyrolysis-Modified Bitumen
    - Waste Oil & Fats-Based Bitumen
    - Microalgae-Based Bitumen
    - Printer-toner Waste-modified Asphalt & Bitumen
  - Design and pilot trials of SWQROC derived low carbon road construction materials:
    - fly ash, bottom ash and clinker from “Energy from Waste” facility.
    - asphalt utilising tar oils from “Energy from Waste” facility asphalt extender from tyre crumb (Fulton Hogan / Tyre Stewardship Australia).

    - "recycled sand" from waste glass recycling.
    - "recycled road based" from crushed concrete and inerts (from materials sorting).
    - retaining wall bricks from fly ash, bottom ash and clinker (from primary and secondary combustion).
    - utilising excess heat from EfW: asphalt + tyre mixing plant.
    - asphalt utilising oil/gas industry residues.
  - Onboard H2 electrolysers for heavy vehicles / road construction equipment: test claim of 10 to 14% less fuel and less maintenance; torque improvement.
  - Fully electric / H2 construction fleet and equipment; electric asphalt plant / crusher.
  - Life Cycle Assessment: full inputs / outputs / carbon calculation for SWQROC road vs SE QLD etc. Can then model utilising SWQROC derived materials vs "Business as Usual". See below an extract of the calculators All Energy Pty Ltd did for TMR back in 2017.
  - Remote area and portable power generation for road construction and EV charging: H2 fuel cells, PV-battery-H2 hybrids.
  - Access routes for renewables: equipment in, green products out. Specifically A-double transport routes for green ammonia.
  - Linking TMR priorities with SWQROC priorities: jobs, training, apprenticeships; other areas?
  - Easy to use app / calculator to help staff procure lower emissions road materials and road construction.

6 Appendix 1: Detailed Energy Efficiency and Emissions Reduction Options

6.1 Carbon Zero Strategy

Following the review of the SWQROC emissions and analysis of potential direct and in-direct abatement options, the following actions could form the basis of a strategic plan towards carbon zero for each LGA:

1. **Electrical efficiency:**
   - Energy management systems (timers, load shedding, demand management)
   - Voltage optimisation
   - Variable Speed Drive (VSD) motors
   - Power Factor Correction (PFC)
   - Heat pumps (for water heating and space cooling)
   - Microgrids
   - Off-grid streetlights and CCTV (Photo-voltaic (PV) solar)
   - Commence with projects that meet a target payback (e.g. <3 years) / larger loads then roll out for balance of plant.
2. **Renewable power generation:**
   - Roof top PV solar
   - Waste to energy
   - Batteries for storage of excess power
   - Hydrogen fuel cells for storage of excess power (future opportunity)
   - Ground mounted solar for large loads or where there are no buildings: requires more considerations about land utilisation, visual amenity, fencing / security, vehicle movements, etc.
3. **Waste management**:
   - Landfill avoidance for organics. In order of least to most complex (and also lowest to highest potential revenue):
     - Segregate and mulch green waste.
     - Shred / grind then screen green waste for composting.
     - Segregation and collection of food organics & green organics (FOGO) for composting with dedicated collection for large waste generators i.e. commercial businesses, schools, hospitals, nursing homes, etc.
     - Segregation and collection of food organics & green organics (FOGO) for composting with dedicated collection for households.
     - Anaerobic digestion of FOGO.
     - Energy from Waste (EfW) using mixed waste streams.
   - Landfill avoidance for other materials via recycling (to reduce tonnage of generic waste landfilled) and improve usability of mixed waste for EfW:
     - Containers.
     - Recyclable plastics.
     - Inerts for crushing and reuse (concrete, bricks, tiles, etc).
   - Energy from Waste (EfW) to convert all mixed waste streams into energy and other products e.g. collaborating with a third party for all waste to be used to generate energy (e.g. gasification for hydrogen or power, moving grate boiler to generate

thermal energy for a pool; anaerobic digestion of food and green organics) and other products such as ask / clinker for road base.

4. **Mobile fleet / transport opportunities**:
    - Electric Vehicles (EVs) for passenger cars and light commercial
    - Hydrogen-diesel dual fuel for fuel savings
    - 100% hydrogen for heavy vehicles (future opportunity).

5. **Renewable power target**:
    - 70% renewable electricity by 2030 via increasing renewables uptake (i.e. making more renewable energy during the day than what is consumed by over-producing PV to with solar credits retained and retired to progress towards carbon neutrality).

6. **Land-based abatement**:
    - Grazing land management and legumes for soil carbon or rehabilitation and revegetation of cleared or degraded land. Collaboration with land holders in areas with a large area (>5,000 hectares) and rainfall (>500 millimetres per year) to support land abatement projects.

7. **Carbon Neutral Target**:
    - Procurement: procure only Carbon Zero goods and services. In the short term,
    - Work towards certified scheme (e.g. via Australian Government Climate Active Scheme) requiring in-house direct emissions reductions then procurement of credits (via land abatement or other projects) to achieve zero net emissions by 2050.

6.2 Power Efficiency – Voltage Optimisation (PO), Power Factor Correction (PFC), Variable Speed Drives (VSD)

It is estimated that 90% of Australian businesses receive electricity at a higher voltage than required[15]. Near or at the end of power distribution lines, networks may distribute power at a higher voltage to ensure quality at the end of the line, which may mean that equipment at these consumers are receiving power above the voltage required to operate motors, thus impacting efficiency, increasing energy consumption and prematurely wearing plant. Voltage Optimisation can reduce the active power consumed by an equivalent magnitude of voltage reduction and reduce reactive power by a ratio of 1:1.7 or more. The best life and most efficient operation usually occurs when motors are operated at voltages very close to the nameplate ratings. High voltage reduces power factor, thus increasing the losses in the system. High and low voltages can cause premature motor failure, as will voltage imbalance. For DC loads, VO will have no effect, and AC savings ranging from 3-5% reduction in kWh for VSD driven motors, to 9-15% for motors operating at partial load, oversized motors, and HVAC[16]. Typical VO installations deliver paybacks between 4-8 years.

Very low power factors (PF) have been observed in regional areas on the Ergon grid, with the average PF sat at approximately 0.6 - 0.7 but can drop to as low as 0.4 at times. A low PF means that a consumer is potentially paying significantly more than necessary, either in excessive $/kVA costs, or significantly overrated kVA gensets and fuel consumption, for a given kW peak load.

[15] http://energywise.net.au/voltage-optimisation/

[16] https://www.captech.com.au/case-study/energy-savings-through-voltage-optimisation/

By increasing PF closer to unity (1.0) with reactive circuitry (inductors and capacitors), apparent and reactive power (kVA / kVAr) is reduced for a given kW demand. Note that for most Ergon tariffs without a kVA charge, or for DC loads, there is no motivation for PFC outside of improving motor life. For loads with a low PF and high kVA charge, PFC can deliver paybacks in less than 1 year.

A large portion of aging motors can be direct-on-line (DOL) or star-delta starting, which can draw from seven to more than ten times the normal running current during starting. As such, these starters are best suited to motors that run full speed all of the time; if this is not the case, variable speed or frequency drives (VSD / VFD) are much better suited and have potential to save from 25 – 60% of kWh[17]. Loads best suited to VSD are generally rotating equipment with fractional load capability, including pumps, fans, conveyors, elevators, and augers. Typical VSD payback periods are in the order of 2 years.

6.3 Microgrid / Green Ammonia Renewable Energy Hub

A microgrid is defined as a localised energy system comprised of distributed (as opposed to the conventional centralised model) energy sources and loads[18].

Microgrids generate, store, use, and manage electricity in a closer proximity to the point of use, which allows greater efficiencies through reduced transmission losses and costs. An attractive feature of microgrids is the ability to operate in isolation or parallel to the macrogrid, meaning that during periods where demand and tariffs are low, a microgrid can draw from the macrogrid (or main grid), and when demand and tariffs are high during peak periods, can switch to generating all power.

A specific opportunity defined as part of the SWQROC is conversion of landfilled wastes (which in Maranoa would enable avoidance of the state base landfill levy) to generate 24/7 power to support an anhydrous ammonia fertilizer manufacturing facility. Such a facility could utilise towards 11.5 MW of continuous power (in practice, the system is turned down to ~20 to 40% load during the evening and run on continuous power supplemented by PV solar stored in batteries).

[17] compressed-air-savings; carbontrust.com
[18] https://www.generalmicrogrids.com/about-microgrids

Figure 11: 3D preliminary layout of a 3000 tonne per annum anhydrous ammonia plant using energy from waste and solar.

6.4 Load Shedding, Load Shaping and Demand Management

Load shedding, load shaping and demand management should be considered before implementation of onsite power generation. Load shedding is where non-critical plant during peak billing periods are turned off or motor speeds are reduced. Load shaping is where operating plant harder during off-peak billing periods (i.e. on the Ergon grid outside of 4pm to 10pm) or during low cost solar availability. Demand management is turning equipment off/reducing speeds, staggering ramp-up, staggering turning on or operating variable motors closer to their actual / optimal required load in order to achieve specific demand levels (e.g. to not exceed a specific kVA demand to avoid kVA spikes and associated costs when on the grid, or for off-grid to avoid tripping a plant by having too high a kVA load).

The ultimate goal is to shape the power load to match the availability of lower cost power such as PV solar, stored PV solar, and off-peak power, whilst avoiding kVA associated costs for grid power. For example, this could be a staggered ramp-up of larger motors, peaking at the middle of the day, and staggering ramp-down as solar generation wanes in the afternoon. Conventional embedded generation (e.g. diesel gensets) when paired with an energy management system to enable rapid response times can be strategically used to help shape loads.

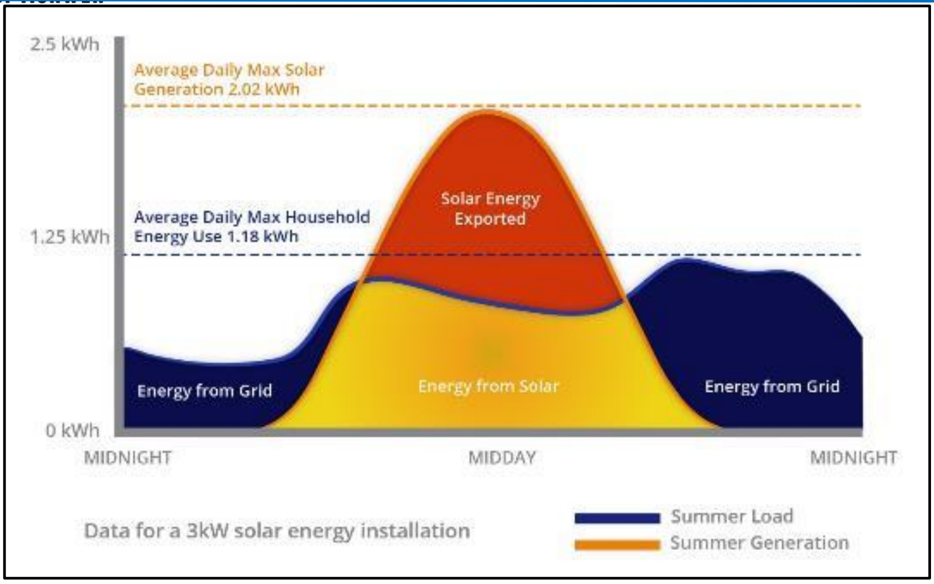


Figure 12: Indicative diagram of the intent of demand management. The goal here is to concentrate loads to within daylight hours, peaking with solar production at midday, and minimising the blue area where power is consumed from the grid.

Demand management may also be achieved by considering how electricity is consumed, and how excess power can be stored. For example, instead of a water pump running at night, this can be run during the day on free solar power, and pump into a reservoir to draw off at night. Likewise, energy can be stored for either heating (e.g. water or thermal oil) or cooling (water / glycerol.

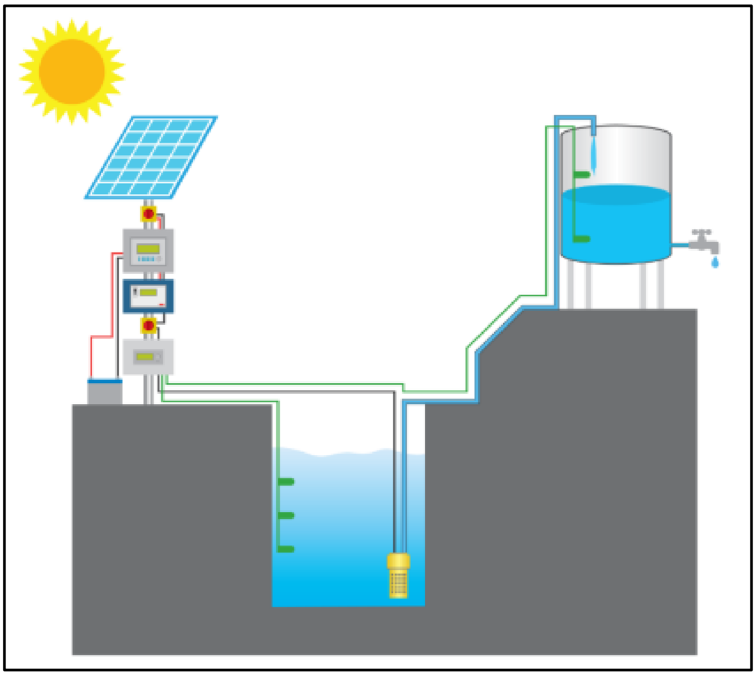


Figure 13: Schematic of a "solar battery" for a pumped water system

6.5 Solar PV

Ergon generally limits installations to 10 kW inverter per phase. Clean Energy Council rules state that the inverter capacity must be at least 75% of array kWp unless batteries are installed. Thus, for a single-phase meter, up to 13.3 kWp solar array should be easily approved by Ergon. Therefore, 13.3 kWp of panels per phase tends to be the key external limiting factor on sizing of solar systems. Assuming larger arrays can be installed on 3 phase assets, up to 40 kWp arrays with export limitation to 15 kWp are assumed to be the maximum viable size. From an "economies of scale" perspective, there is an optimum scale of solar at 99 kWp per NMI as this is the maximum system for which up-front small-scale STCs can be claimed as a rebate off the capital cost hence the economics of systems of this size are excellent. Otherwise, large generation certificates LGCs must be claimed at the end of the financial year by recording total MWh generated (which may require working with a broker). Capital costs of solar arrays are approximately linear, with calculated payback periods ranging from 1 – 4 years depending on tariff and feed in credit; however for smaller systems sizing is routinely defined by the size of inverter offered by manufacturers (i.e. 5, 7.5, 10, 13.3 kW etc).

The Levelised Cost of Electricity (LCoE) for a 6.6 kWp / 5 kW system accounting for solar credits and assuming a 10 year life of plant (this is a typical warranty period, with systems able to operate longer than this) is estimated at ~$0.037 / kWh. Hence as the LCoE (cost of making power) is lower than the cost of power and lower than the feed-in-tariff, there is an economic incentive to install the largest solar system possible for any given NMI. The main disruptor to this scenario would be a future drop in the feed in tariff.

The asymptote of electricity emissions that are offsetable with solar is the % utilisation of each meter during the daylight hours, which is routinely ~50-75%. **Therefore a key assumption is that utilisation can be concentrated to within daylight hours and allow a large portion of kWh offset with solar.** As discussed in the section previous, shaping the demand schedule to maximise utilisation during daylight hours will improve the potential impact of solar, hence it is recommended to investigate load shaping prior to investing in solar.

The small amount of kWh that are unable to be offset with daytime solar generation is likely to be able to offset by additional investment in load shaping via storage.

PV solar is complex in terms of matching a suitably sized system to the load whilst being economically viable whilst also obtaining approval. Some high-level discussion points:

- For all locations with a daytime "Solar array size kW" as per the above tables, install a solar system at the calculated array size or larger, up to 10 kW per phase as such system should be automatically approved (as of Nov 2022).
- For larger systems, open communications with the distribution network as to whether export protection or a grid stability analysis is required. Generally, systems up to 99kW have excellent economic viability as the credits are received upfront to offset the CAPEX.
- Develop a large-scale array with a PPA for SWQROC members.
- How to bring the distribution network into the conversation.

6.6 CASE STUDY FROM The U.S.A.: Impact of Batteries + Solar.

A number of energy records were broken in Texas (USA) during a heatwave in mid-August 2024[19]. Demand was high throughout the day, setting a new record for total load, but solar generation was also high, and this helped to keep prices under control for much of the day. As the

[19] https://www.linkedin.com/posts/gavinmooney_batteries-solar-energy-activity-7234329697407410176-6ot8?utm_source=share&utm_medium=member_desktop

sun set and solar output tailed off, a new record was set for net load (i.e. the dispatchable generation needed). Prices increased - sending a signal that more power was needed - and batteries responded in a big way. At nearly 4 GW, they peaked 20% higher than the previous record, which was only set the day before.

Prices remained off the cap (i.e. government mandated maximum pricing, as per in Australia) and despite the high demand, prices and ancillary deployments, ERCOT (Electric Reliability Council of Texas) did not issue a general call for conservation (i.e. load shedding), indicating its operators were confident that the grid had sufficient resources to make it through the net load peak. Compared to 5 years ago (August 2019), ERCOT declared emergencies in the afternoon twice: peak demand was less than 75 GW (about 11 GW or ~12% lower than the 2024 peak) and prices were prolonged at the cap over two days.

But in 2024, with peak demand above 85 GW there were no emergencies declared and prices barely reached the cap. What's the difference? In 2019 Texas had about 2 GW of solar capacity. Today it has over 23 GW. **In hot and sunny places, solar matches well with peak load. Pre-cooling of buildings can bring that peak forward to align even better with the solar generation**. As the sun sets, batteries take over to ease the peak load into the evening.

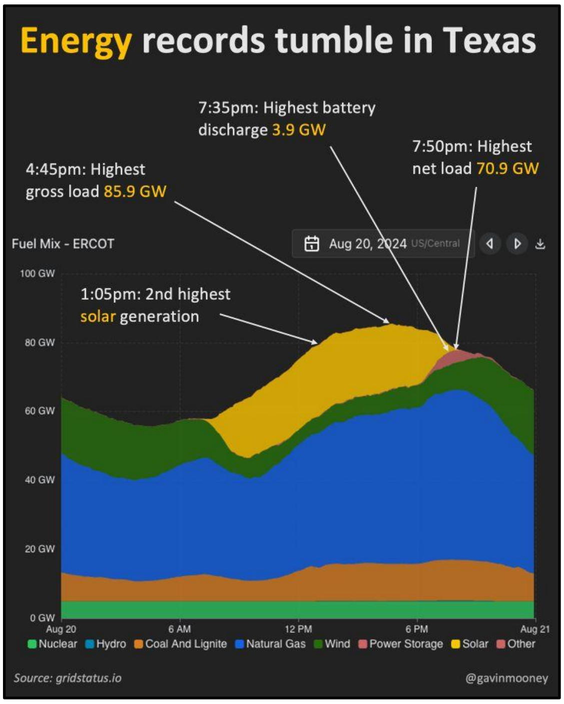


Figure 14: Effect of solar in hot sunny areas in addressing peak load and mitigating wholesale price spikes

6.7 Goods and Service Procurement

To address residual Scope 3 emissions for maintenance, building, and professional services that are subcontracted to third parties, SWQROC LGAs may consider either investigating new carbon neutral businesses or amending existing contracts to require carbon neutral services.

An example of widely acknowledged certification is the federal Climate Active program, where businesses must rigorously account for all Scope 1, 2, and 3 emissions as part of their product or service supply chain, demonstrate reduction initiatives, and record offsets of residuals. This certification demonstrates that the business is committed to emissions reduction and is a visible differentiator for consumers to inform their spending.

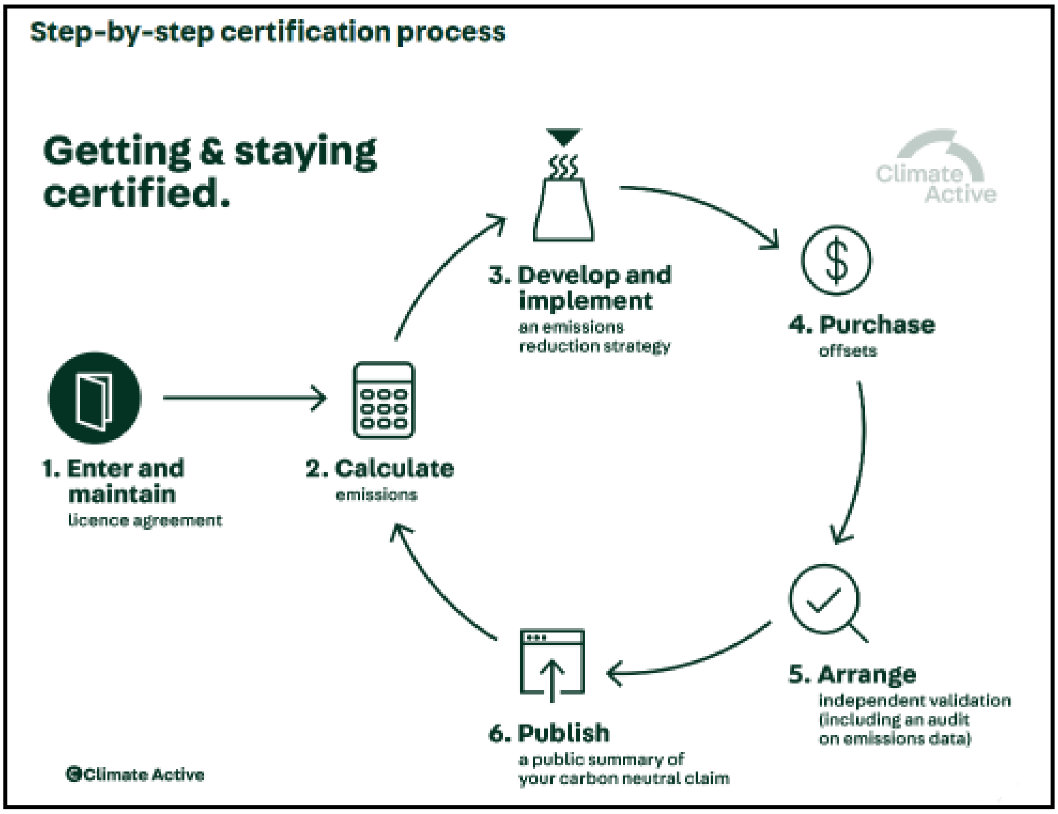


Figure 15: Climate Active carbon neutrality certification method.

The City of Sydney was the first LGA to be certified carbon neutral by Climate Active; an archive of public disclosure statements dating back to FY 2009-10 can be accessed[20] to give an idea of the reporting requirements for certification.

[20] https://www.climateactive.org.au/buy-climate-active/certified-members/city-sydney

6.8 Electrification of Mobile Fleet

A range of economically viable EV options for passenger vehicles and light commercials exist. Further, EV chargers are available at reasonable pricing to enable rapid charging and there is a strong and growing network of charging stations as displayed in the map below. The following panels summarise some options which show strong economic viability, especially where roof top solar can be utilised:

7-seater Passenger Vehicle

KIA EV9 @ $AUS 89,500, 418km range. $6.21 to charge on PV Solar (77.4 kWh)

Assuming 100,000km pa, fuel saving of $13,814 @ $1.70/L.
Payback versus 7-seater AWD SUV @ $AUS56,527: 2.4 years.

Fuel saving of $17,064 @ $2.10/L.
Payback versus 7-seater AWD SUV @ $AUS56,527: 1.9 years.

5-seater Passenger Vehicle

KIA EV6 (528 km range): $91,583 Total cost of ownership first 5 years versus $94,930 for Kia Sorento (~60,000 km pa). Source: RACQ

Light Commercial: 7.3 t GVM EV Truck

4x2 tray / tipper with ~200km range with 114.5 kWh battery.

CAPEX: $150,000 versus $80,000 for a 2023 Hino 300 series.

Assume: 150km per day, 255 days per annum.

Diesel: $1.59/L after rebate, ~18L/100km.

Hyundai Mighty electric truck is powered by a 120kW, 320Nm traction motor

EV:

(1) Grid at $0.1622/kWh fuel cost savings per annum: $7,395.27

Payback: 9.5 years.

(2) Solar at $0.04/kWh fuel cost savings per annum: $10,071.22 (10,947.15 – 875.93)

Payback: 7.0 years.

Figure 16: EV options for passenger vehicle and a light commercial truck.

6.9 EV Infrastructure

The EV recharging infrastructure, when both public and privately owned is considered, is generally good throughout the SWQROC.

As a specific case study, the following route from Brisbane anticlockwise around the SWQROC was developed (refer map). Quilpie and Thargomindah have not received electric superhighway chargers, however the 3P, 32A sockets owned by councils could provide ~20 kW charging points (with the right adapter).

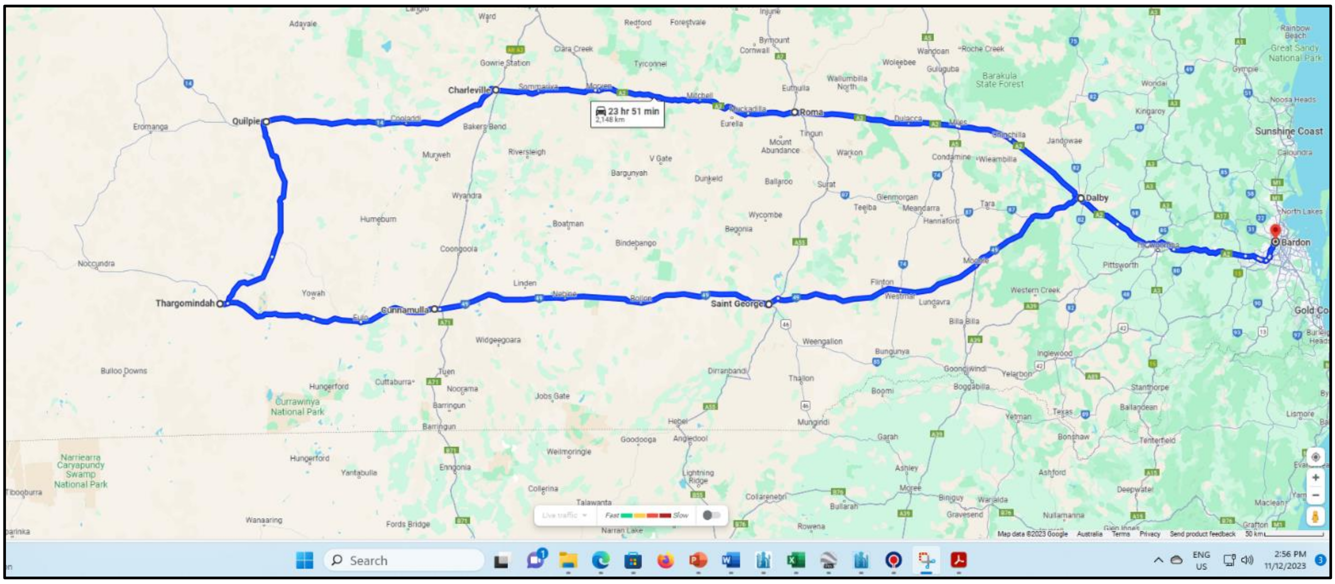


Figure 17: Brisbane-SWQROC round trip feasible done on electric super highway fast chargers and supplemented by 3 phase facilities owned by Councils in Quilpie and Thargomindah

The route can be completed via the following stops assuming 4 km / kWh:

Table 10: Charge itinerary for Brisbane - SWQROC EV journey

Start Location	End & Charge Point	Start Charge	Km driven & End Charge.	kW	Time to recharge to 100%
Brisbane	Toowoomba Charlton; [Aldi]	90%	208; 38%.	50 kW 22 kW [350kW]	1hr 14 mins 2 hrs 49 mins [11 mins]
Toowoomba Charlton	Dalby, Bell Park	100%	73; 81%.	22 kW	50 mins.
Dalby, Bell Park	Roma (Explorers Inn)	100%	268; 33%.	11 kW 2.2 kW	7 hours 30.5 hours
Roma (Explorers Inn)	Charleville, Graham Andrews Park.	100%	267; 33%.	75 kW 22 kW	0.9 hours 3.1 hours
Charleville, Graham Andrews Park.	Quilpie (Hotel) [3P, 50A council outlet]	100%	211; 47%.	2.2 kW [20 kW]	24 hours. [2hrs 25mins]
Quilpie (Hotel)	Thargo (Hotel)	100%	195; 51%.	2.2 kW	23.3 hours

Targo (Hotel)	Cunnamulla (52 Stockyard St)	100%	196; 51%.	75 kW 22 kW	0.7 hours 2.3 hours
Cunnamulla (52 Stockyard St)	St George	100%	293; 27%.	75 kW 22 kW 2.2 kW	1.0 hours 3.3 hours 33 hours
St George	Dalby, Bell Park	100%	303, 24%.	22 kW	1.5 hours
Dalby, Bell Park	Toowoomba Charlton	57%	73; 39%.	50 kW 22 kW	1.25 hours 2.75 hours
Toowoomba Charlton	Brisbane	100%	208; 48%.		

A saying from the EV industry is that EVs are only as good as the recharging network supporting them, hence consideration needs to be given to charging both for council vehicles and for the public (both current and future EV users).

Figure 18: Existing EV charger network in central QLD

There is the option of AC / DC operation, with the primary difference being DC chargers having much greater capacity and charging speed due to not requiring on-board rectification, at a much greater price point.

The cost for "fuelling" an EV is 14% that of liquid fuel when using a public rechargers (~30c/kWh) or 3.3% of the cost of liquid fuel when using roof top solar to recharge the EV (~7c/kWh).

The low operating cost of EVs is a strong argument for electrification, not including the resilience and other advantages of using energy created locally and not dependent upon international supply chains. Single phase chargers which utilise readily available existing power infrastructure can be procured off the shelf for less than $6,000, with the installation costs often being the most expensive part, depending predominantly on length of cabling, trenching, and any required switchboard upgrades / extensions. Some EV charging infrastructure options are summarised here, from low CAPEX / ~2 hrs to 80% charge options (Level 2) to high CAPEX / ~15 minutes to 80% charge options (Q3 2022 data).

Item	Cost $AUS
Billing and operating status system	$281.50 per annum
Internet / Wifi	$0 if able to use local ethernet connection. $208 per annum if via 3G/4G Wifi modem.
Painting / signage	$350
Installation	$21,222.65 (including switch board upgrade, pedestal install and 30m of cabling but ***excludes power system upgrade***)
Level 2: 22kW AC charge point [~70 to 150km in an hour, noting some cars limit recharging rate hence would increase recharge time].	$4948.90
Total for 22kW AC	$27,011.05
Other options:	
Level 3: 50 to 75kW (DC) [~300km in an hour, noting first kms are charged very fast then charging rate slows down]	$25,000 to $35,000; excludes upgrading costs to power system infrastructure. *Many cars are limited to 50 kW.*
Level 3: 150kW (DC) [to 80% of capacity in ~20mins]	$75,000; excludes upgrading costs to power system infrastructure.
Level 3: 550kW (DC) [to 80% of capacity in ~10mins]	$140,000; excludes upgrading costs to power system infrastructure.

6.10 Solar Production in South West QLD

A solar pilot by All Energy at the Balonne Shire St George Depot was operational from 11am on 6th June 2023. Data through to 11:16pm 7th March 2024 has the system at a lifetime of 18.39 MWh, for a 13.3 kWp array. This equates to 5.046 kWh/kWp (274 days); the Bollon Town depot has displayed 16.02 MWh for 238 days of production from 12th July 2024 equating to 5.061 kWh/kWp. This averages to 5.0534 kWh / kWp.

7 Appendix 2: Greenhouse Gas Emissions Intensity per Capita

Table 11: *Summary of FY21-22 SWQROC LGA emissions inventories*

	GHG Emissions per Annum tCO2-e/yr	GHG Emissions per Capita
Bulloo	2,797	8.2
Paroo	5,535	3.3
Balonne	15,649	3.6
Murweh	12,926	3.0
Maranoa	35,638	2.6
Quilpie	2,670	3.8

Totalised emissions for each LGA including Scope 1, 2, and 3 emissions are shown in the table above and Figure below, with breakdowns between emissions sources, and potential offsets by implementing direct abatement opportunities discussed below in the recommendations and strategic plan. To become 100% carbon neutral would then require the purchase of third-party emissions credits or implementing indirect land-based offsets as discussed later.

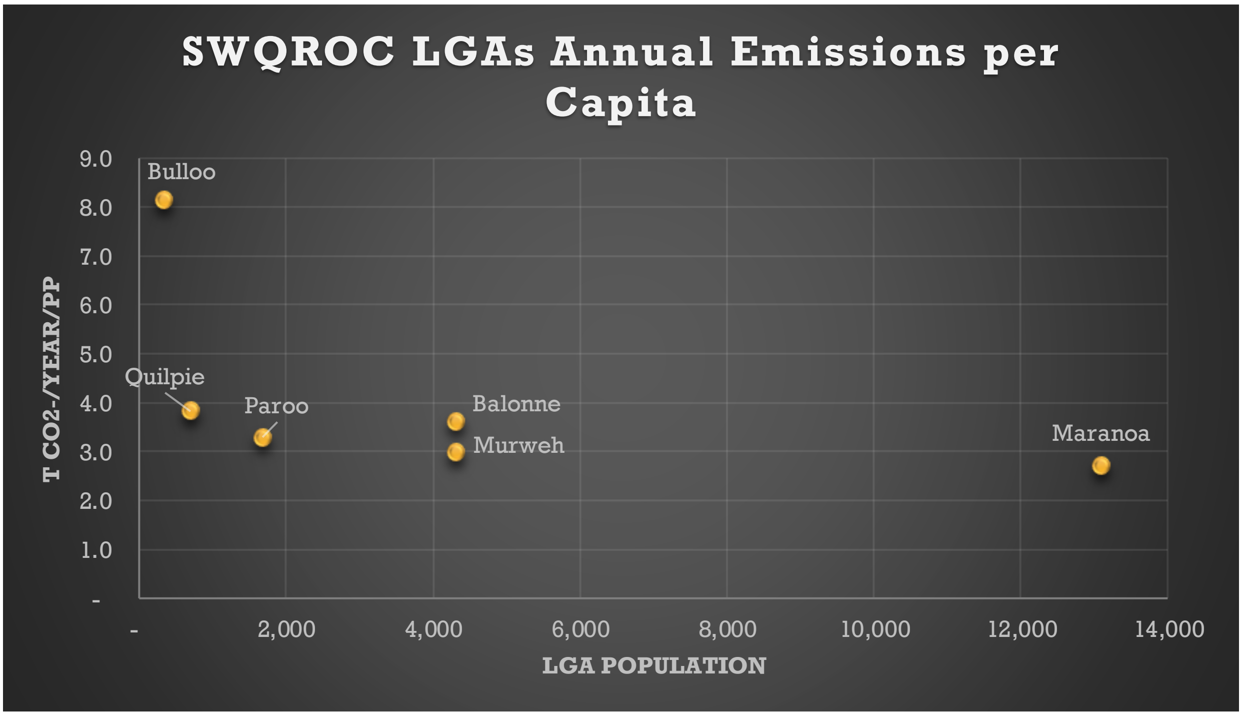


Figure 19: *FY21-22 emissions inventory by SWQROC LGA*

Figure I above shows the per capita emissions in SWQROC LGAs asymptote at around 2.5 tonnes of CO2-e per person, contrasted to large urban hubs of ~0.4 to 0.7 tonnes per person[21].

[21] For reference, Brisbane City annual per capita emissions are 0.46 t/pp

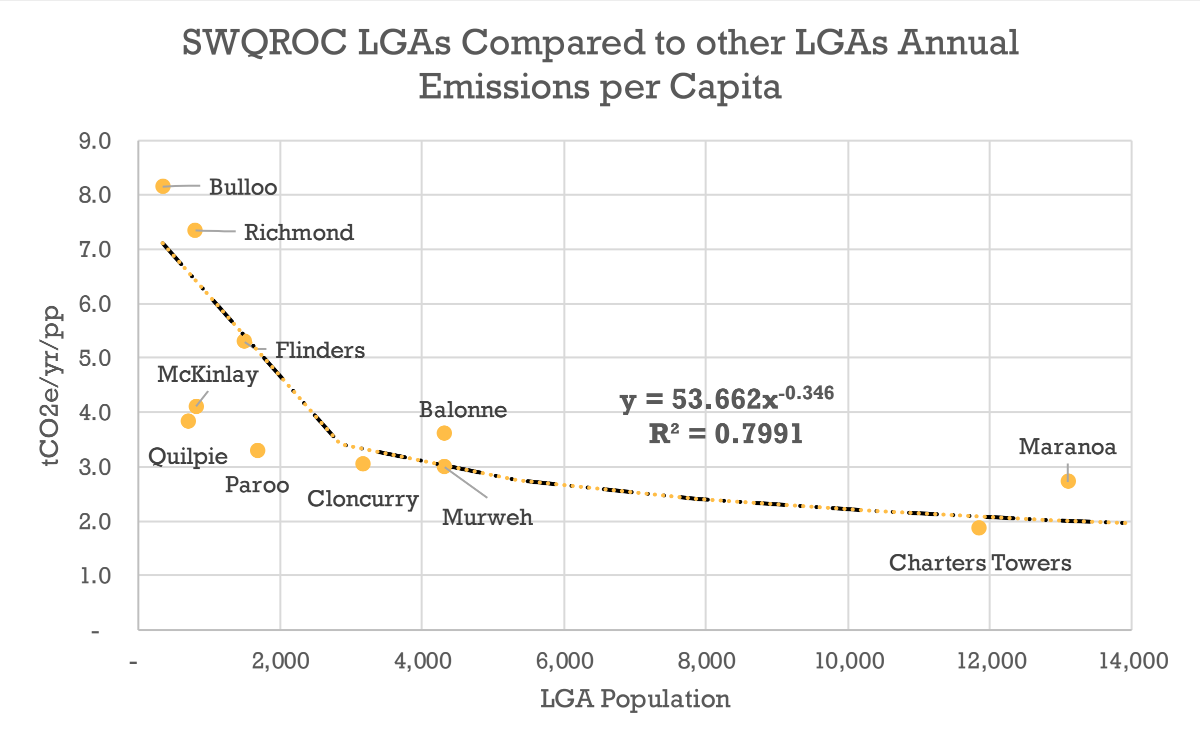


Figure 20: SWQROC per capita emissions relative to MITEZ

It can be seen that per capita emissions in SWQROC LGAs average to 4.1 tonnes of CO2-e per person, contrasted to Brisbane of 0.448 and Townsville of 0.604 tonnes per person. Within the SWQROC region, less-populated councils will unavoidably have a higher per capita emissions intensity, due primarily to the high transient or enumerated population relative to the permanent population and the geographic spread of operations for maintaining roads and other capital equipment (or subcontracting to third party professional services).

Smaller councils have a higher percentage of the enumerated population as transient visitors (tourists and itinerant workers) which drives up the per capita emissions intensity when considering the permanent population (i.e. ABS permanent population data). Further, councils covering large geographic areas have relatively large emissions for maintaining roads and other capital equipment sized for transient populations with seasonal spikes (i.e. tourist events).

The key emissions sources for each SWQROC LGA are electricity consumption (Scope 2), landfilled waste (Scope 3), fuel consumption (Scope 1), potable water and water treatment (Scope 1 and 2), repairs and maintenance (Scope 2 and 3), professional services (Scope 3), and staff commute (Scope 3).

To improve the accuracy of future GHG inventories, the following suggestions can be implemented:

1. More detailed recording of landfilled materials by type including household MSW, green waste, construction & demolition (C&D), commercial & industrial (C&I), with specific recording of segregated green waste and inerts (e.g. brick, concrete, glass), and recycling.

2. Detailed recording of materials consumed per annum, including asphalt, road aggregate, construction materials.
3. Detailed records of third-party goods and services.