Armidale Regional Council Renewable Energy Action Plan

Completed by Constructive Energy Pty Ltd

June 2022

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Contents

Disclaimer

This report documents the results of preliminary observations and analysis of material provided to Constructive Energy Pty Ltd. In preparing the report, we have relied upon information provided by Armidale Regional Council, retailers and Azility Energy Management through referral to form our conclusions. Whilst we have reviewed this information to assess its reasonableness and internal consistency, we are not able to consider specific and/or abnormal circumstances that may impact your energy use.

The findings, conclusions and recommendations and all written material contained in the report represents our best professional judgement based on estimated and generic data and visual inspection where appropriate. Recommendations have assumed average conditions and historical usage.

Executive Summary

Armidale Regional Council (ARC) is taking a proactive stance in relation to climate change, seeking to address emissions both within the organisation and through leadership within and support of the community. Constructive Energy (CE) have been engaged to identify opportunities in relation to renewable energy and consistent with the objectives of Project Zero30. Outcomes of the study are captured in this Renewable Energy Action Plan (REAP).

Constructive Energy completed a review of strategic documents including the Armidale City Activation Plan, the ARC Local Strategic Planning Statement 2020, and 2020 Climate Emergency Working Group Report. ARC has an ambition to adopt Renewable Energy and a clear pathway towards a carbon-neutral future.

The NSW Government announced the Electricity Infrastructure Roadmap setting out a plan to deliver 5 Renewable Energy Zones (REZs) delivering affordable, reliable energy to replace the NSW's existing carbon intensive generators as they retire.

The New England REZ encompasses the Armidale Local Government Area and surrounding councils. The region has been identified as one of the leading locations for Renewable Energy resources (wind and solar) receiving State Government support and private investment for the development of large-scale solar PV and wind farms. The region also has the possibility for other RE options including pumped hydro storage and biomass generation.

As the renewable energy market evolves new energy storage options are emerging at competitive cost – these include large scale battery banks and hydrogen. Council has an overarching objective to drive operations to 100% renewable energy by 2030. This goal necessitates examining building and facility energy consumption (both electricity and gas) and vehicles, plant and equipment.

It is already possible for Council to be powered by 100% renewable energy through selective energy procurement. Further, being in the REZ is likely to see Council well positioned to bargain for good pricing with local generators via an energy retailer. However, this approach does not form the bulk of this report which instead examines how Council may benefit from participating directly in the ownership and/or management of renewable energy technology.

While a full range of renewable energy technologies are explored, CE finds the most obvious opportunity in solar PV, following essentially one of two pathways; Behind the Meter (BtM) distributed energy or Distributed Energy installations across a number of Council and possibly partner assets. These options are discussed in detail throughout the Plan.

Energy Storage should be considered as part of the evaluation for every project for its ability to provide flexibility and adaptability in energy management in the future. This is particularly true if Council elects to follow the distributed energy route.

The retailing sector is changing dramatically, and ARC is well positioned to take advantage of emerging models in valuing and sharing renewable energy. Capacity now exists for ARC to effectively operate as a 'generator-retailer' and to use excess energy to underpin services or affordable energy to local business and industry.

Energy efficiency measures should not be forgotten as this both reduces the Capital Expenditure (CAPEX) required to achieve 100% renewable energy and, if the right generator-retail deal is brokered, will result in additional value for Council.

Vehicles, plant, and equipment represent a challenge which can be managed basically through offsetting or substitution depending on financial factors, the appetite of Council for innovation/leadership and the practicality of developing alternative fuels in Armidale.

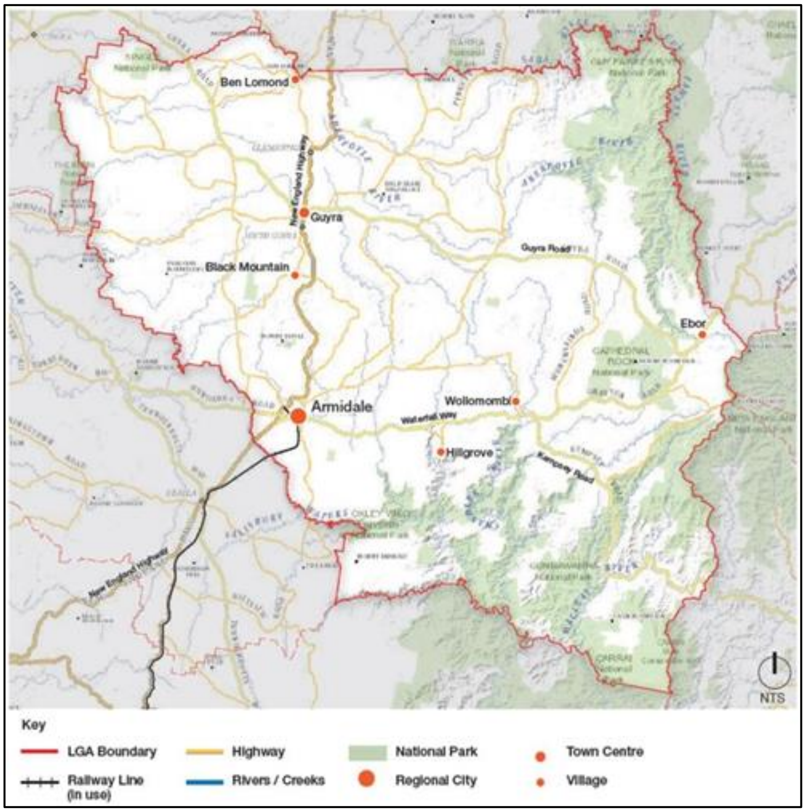
Constructive Energy are of the opinion that transitioning to 100% renewable energy is not only achievable, but also makes economic sense and to do so and will improve the fitness of council for the future on multiple levels. We recommend that Armidale Regional Council adopt this Renewable Energy Action Plan, use it to gain or leverage government and private investment, and start soon to meet Council's 2030 target.

Constructive Energy is passionate and dedicated to the integration of renewable energy in Regional Australia for the advantage of local communities. As such, we are available as a 'critical friend' to Council on an ongoing basis at no charge. Constructive Energy can assist in grant submission, business case development and project delivery that ARC may require.

1.1 Armidale Regional Council (ARC)

Armidale Regional Council (ARC) located in the New England region of NSW. The Armidale region has a population of around 30,000 and just over 12,000 dwellings (Australian Bureau of Statistics, 2016 Census).

The Local Government Area covers approximately 8,621sqkm and is located within the Essential Energy distribution network.



Map 1. Armidale Regional Council boundary (Map Source: Local Strategic Planning Statement A Plan for 2040 (Final October 2020))

1.2 Purpose Statement

ARC declared a Climate Emergency in 2019 and this has provided the imprimatur for further engagement and planning aimed at both netting out emissions and building adaptive capacity. This applies to both council as an organisation and to the entire LGA.

Council has an active role in collaborative initiatives including Project Zero30, a partnership between ARC, UNE and the community which has set goals in relation to making the LGA net zero for carbon emissions by 2030.

Council's approach is wholistic, embracing the Planetary Boundaries Framework developed by the Stockholm Resilience Centre and developing leadership capacity within the organisation and Councillors.

The Renewable Energy Action Plan reflects Armidale Regional Council's desire to engage with renewable energy and identify options for projects that benefit Council and the Armidale community.

ARC supports innovation in energy use and delivery for the purpose of supporting Project Zero30 goals, improving cost control, demonstrating leadership within the community and preparing for any future carbon price. Specifically in relation to renewable energy, Council is supporting the following goals:

- Be a net renewable energy exporter and have 50% of its industry and homes exporting solar energy to the grid
- Generate power using biochar power generation technologies
- Be a model for carbon transitions and adaptation
- Winter air quality levels below the Department of Health's guidelines

(Source Project Zero30)

The previously developed Armidale City Activation Plan also points to areas of focus related to this REAP.

- **Green** Active Transport Network
- **Attract startups** with low-cost energy
- Celebrate **Sustainability**
- **S.E.A –** New England's energy centre – exporting to state
- **Smart Regional Cities Project** – Power for data centre – IT Hub
- **HEX NE** – New England Horticulture Centre of Excellence – power for greenhouses and water pumps
- **Sun Train** – Energy conservation

(Source Armidale City Activation Plan 2018)

In context of the above, the purpose of this Plan is to provide strategic direction into the specific opportunities and pathways for Council to transition to 100% renewable energy sources by 2030 and to support the entire region in achieving the same.

Of note is the alignment of this Plan with the UN Sustainable Development Goals, specifically; 7 Affordable and Clean Energy, 9 Industry, innovation, and infrastructure, 11 Sustainable cities and communities, 13 Climate Action and 15 Life on Land.

1.3 Armidale Regional Council Objectives

Armidale Regional Council has developed this Renewable Energy Action Plan with the following objectives:

- To play its part in mitigation for, and adaptation to, climate change.
- "Increase use and innovation of renewable resources and decrease the use of nonrenewable resources" (source, ARC, sustainability strategy 2018-2023)
- To reduce the cost and uncertainty of future energy supply to Council infrastructure and transport.
- To attract and retain people and businesses to Armidale Regional Council.
- To support residents and local businesses suffering financial stress or discomfort due to energy affordability.

1.4 Decision Making Framework

The following framework was developed in consultation with Armidale Regional Council staff and Councillors to assist in evaluating the relative importance of projects identified through the Renewable Energy Action Plan:

- Carbon reduction – does the project contribute to Project Zero30
- Benefit/Cost – does the project have positive financial impact?
- Community benefit – how does the wider community benefit from this project?
- Logic – is the project practical, defensible, sound, ethical, enduring?
- Leadership – will the project stimulate positive change in others?

1.5 Desktop Analysis

Given that Council intends to power the entire organisation operations using 100% renewable forms of energy, we start by quantifying where energy is consumed, how much and in what form.

Electricity

The first task in developing this action plan was to complete a desktop analysis of all metered sites to create a general profile of how ARC uses electricity. Then further, to understand how contracts and energy supply arrangements are structured with various energy retailers and the network provider.

Armidale Regional Council engages E21 to provide a bill validation service and this portal was used to collect and verify site data.

The analysis was for a 12-month period for all sites was the up until May '22. Both negotiated 'Contract' sites and general 'Tariff' sites were analysed. In NSW consumers are entitled to negotiate or 'contest' a cheaper electricity retail charge if they consume more than 100,000 kWh per annum (100 MWh p.a.).

Only limited, bulk consumption data has been available for Council's tariff sites. E21 and the Energy retailers were contacted to obtain interval data where possible but most sites do not have this capacity. Raw data tables and analysis are not included in this report however further analysis follows in the appendixes.

Table 1. Contract site VS Tariff site summary

	No. of Sites	kWh	MWh	% usage	Cost $	% cost	c/kWh	GHG (tonnes)
Contract	12	2,913,558	2,914	82%	$ 642,112.95	76%	$ 0.22	2360
Tariff	102	648,907	649	18%	$ 200,823.52	24%	$ 0.31	526
Total	114	3,562,465	3,562		$ 842,936.47			2886

In the 12-months, the 12 Contract sites consumed 2,913 MWh of electricity compared to 650 MWh consumed by the 102 tariff sites as is shown in the Table 1.

While the major contract sites represent 82% of energy usage, they represent 76% of the overall energy costs. This reflects the marginally lower electricity c/kWh rates available for higher demand sites and is within the band of charges anticipated.

Scope 2 greenhouse gas emissions have been calculated referencing the National Greenhouse Accounts 2021 and show that Council emitted approximately 2886 tonnes via indirect emissions from consumption of purchased electricity.

Vehicles, plant and equipment

ARC own and operate a significant register of machines required to execute the various operations of Council. Ignoring workshop and landscaping tools, there are approximately ~56 pieces of minor plant/special equipment, a further 27 items of heavy plant and just under 60 vehicles.

The vast bulk of fuel consumed is diesel and petrol. It has been difficult to establish an average year for calculating consumption estimates but ARC appears to consume around 220 to 250,000 L of liquid fuel each year. Based on the split of diesel and petrol this equates to approximately 2,240,000 kWh of energy and leads to associated emissions in the order of 600 tonnes per annum. See Table 2 below.

Table 2. Annual fleet and plant fuel and energy demand with emissions.

Financial year	Approximate Litres consumed p.a.	Approximate kWh p.a	Approximate kWh p.m	Total Scope 1 GHG emissions (tonnes)
FY20	212,174	2,239,614	186,634.46	577.4
FY19	244,628	2,582,185	215,182.12	665.7
FY18	248,800	2,626,222	218,851.85	677.1
Average	**235,201**	**2,482,674**		

These figures become the working numbers for planning how to reach 100% renewable for vehicles, plant and equipment. The theoretical conversion of embodied energy in liquid fuels to kWh is useful to approximately indicate the quantum of energy required to move plant and people around for a year. That is, about 2.4 GWh compared to the 3.7 GWh required to power buildings and facilities.

However, there is wide variation in the efficiency of converting energy into 'work', or motion, between Internal Combustion Engine vehicles, Battery Electric Vehicles, Hybrid vehicles and Hydrogen Fuel Cell vehicles. For example, Battery Electric Vehicles (BEV's) make more efficient use of energy than Internal Combustion Vehicles (ICE) cars. (Around 90% conversion of energy to motion for BEVs compared to around 40% for ICE). Hydrogen varies again depending on the use of energy required to create hydrogen but is shaping up as a suitable fuel, particularly for heavy vehicles and plant. (It takes ~54kWh of electricity to make 1 kg of hydrogen which can then deliver ~33kWh of electrical energy)

A detailed mobile energy plan is beyond the scope of this report however we raise these figures because they are important in the context of Council becoming 100% renewable across all operations. A key implication of electrifying fleet and plant is that the energy to operate them can be produced locally. If Council chooses to invest in self-generation to meet carbon/energy targets, then consideration should be given to future electrification of fleet and plant and the capacity to create up to 2.4GWh locally from renewable energy. Section 4.7 below provide more dialogue around this.

Gas

In terms of reduced carbon emissions and increasing expense, ARC is in the fortunate position of having virtually no reliance on gas for heating or transport. While Armidale produced its own town gas up until late last century, it is not connected to a national or regional distribution network.

The absence of town gas, a legacy of poorly insulated homes and the rising cost of electricity has resulted in the proliferation of wood combustion heaters in many homes. Given that the city is situated in a valley and conditions are often calm, this results in significant air pollution.

There is growing interest and examples internationally of biogas being generated for municipal supply. While not core to recommendations in the REAP, Council may do well to 'keep a look out' for developments in this space. Being a region of primary production, it may be feasible to establish a biogas plant as a source of renewable gas for residential heating via distribution within the existing decommissioned infrastructure.

Energy Approaches

Constructive Energy has examined the entirety of Council's assets and operations with the view to becoming 100% renewable. We have considered the following broad approaches.

Stationary Energy

1. **Seek 100% renewable energy from suppliers.**

   Simply seek renewable electricity suppliers. Proximity with the New England Renewable Energy Zone (NE REZ) may be advantageous for this approach.

2. **Make your own energy.**

   Establish Council with sufficient renewable energy generation capacity to meet demand. This could occur in a literal sense with storage to dispatch energy as needed 24/7, or as an offset mechanism utilising the National Energy Network to absorb excess energy when ARC doesn't need it and provide energy when it does.

Mobile Energy

1. **Find alternative fuels and technologies**

   Electrify where possible and supply 'green' energy, seek biofuels for older heavy plant and move to hydrogen fuel cells over time.

2. **Offset energy use and emissions.**

   Quantify and offset fleet and plant emissions. Transition to alternative low-carbon technologies over time.

It should be noted that the NEREZ could ultimately supply around 1/3 of the energy needs for all of NSW, meaning that any smaller local loads, such as the city of Armidale, are effectively supplied with 100% renewable energy. Despite this reality, the National Energy Market does not distinguish between parts of the grid that are more or less renewably powered.

With the various REZs and other renewable energy projects in the pipeline, the Australian Energy Market Operator and many industry commentators expect the national grid to be 50% renewably powered by 2025 and 90% renewable around 2030. It is currently about 20% on a national scale but much higher in South Australia and Tasmania.

In effect, if carbon neutrality is the key driver, this results in Council having a legitimate 'do nothing' approach – simply purchase 'green' electricity for buildings and facilities and purchase offsets for the non-renewable energy associated with liquid fossil fuels.

This strategy however renders ARC as a 'price taker' only. This report examines opportunities for Council to become investors and long-term financial beneficiaries of energy infrastructure in the process of transitioning to 100% renewable energy.

ARC has already invested in on-site solar for several facilities and has other projects 'in the pipeline'. Constructive Energy did not seek to replicate this work, rather to aggregate and examine the overall energy consumption story for contract and tariff sites.

2.0 Contract Site Analysis

All contract sites were analysed in detail and summary findings are included in Appendix 1 of this report.

2.1 Contract Site Overview

The following table lists all contract sites with their usage and annual cost per kilowatt hour (c/kWh), to help identify which sites might be the most important to focus on. The summary table represents the rolled-up costs (i.e., supply and consumption) and will change between bills and years, however it does help identify expensive sites and sub-optimal contract terms.

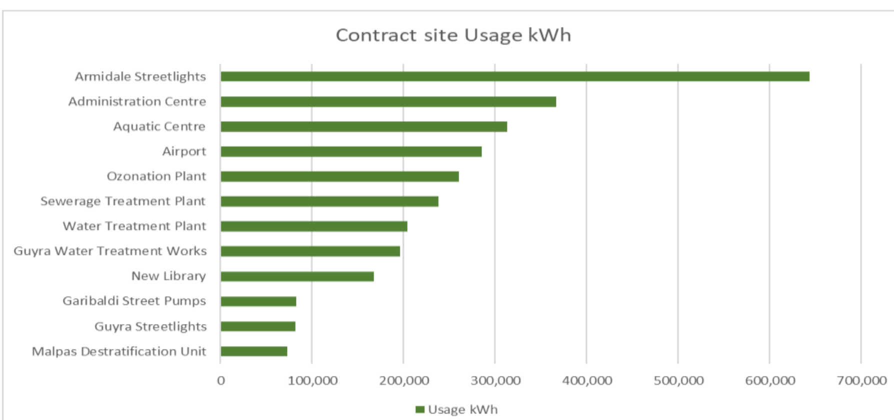
Table 3. Armidale Regional Council usage and costs for Contract sites

Site Name	Usage kWh	GHG tonnes	Cost $	c/kWh
Malpas Destratification Unit	73,247	59	$ 14,001	$ 0.1912
Guyra Streetlights	81,838	66	$ 16,391	$ 0.2003
Garibaldi Street Pumps	82,840	67	$ 15,388	$ 0.1858
New Library	167,508	136	$ 34,308	$ 0.2048
Guyra Water Treatment Works	196,499	159	$ 62,867	$ 0.3199
Water Treatment Plant	204,426	166	$ 48,133	$ 0.2355
Sewerage Treatment Plant	238,085	193	$ 55,589	$ 0.2335
Ozonation Plant	260,779	211	$ 64,907	$ 0.2489
Airport	285,181	231	$ 65,726	$ 0.2305
Aquatic Centre	312,622	253	$ 61,254	$ 0.1959
Administration Centre	367,004	297	$ 74,271	$ 0.2024
Armidale Streetlights	643,529	521	$ 129,277	$ 0.2009
	2,913,558	**2,360**	**$ 642,113**	$ 0.2208

On the face of this information, one might focus on sites with the highest c/kWh rate or those with the highest consumption however, more detailed analysis can often move the priority elsewhere.

The following Chart 1 relates to the same data but provides a clear visual indication of which sites consume the most electricity.

Chart 1. Contract site usage



The two largest consumers of energy were the street ighting and the Administration Centre. While Chart 1 reveals the relative total consumption, hidden within these figures are existing behind the meter solar installations and variable daily and seasonal usage profiles. These profiles provide important insights into optimising management, technology interventions and retail arrangements for each site.

2.2 Billing Structure

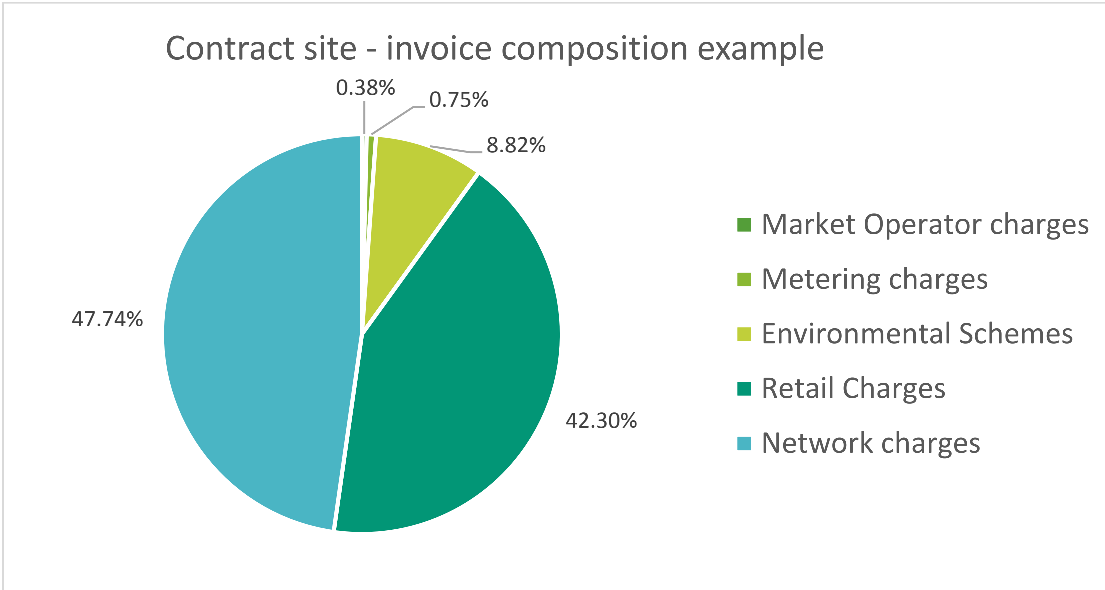
The billing structure becomes important when considering the potential of on-site renewable energy to reduce costs and drive operational changes. The following table is an excerpt of a bill for the Armidale Regional Council Administration Centre and provides a detailed breakdown of the charges for electricity supply to this site.

Example Invoice for Administration Centre

Energy Charges	Consumption		Unit cost c	Total charge
Peak Energy	5,736.30	c/kWh	9.421	$540.42
Shoulder Energy	12,174.20	c/kWh	9.421	$1,146.93
Off Peak Energy	18,735.00	c/kWh	6.583	$1,233.33
Losses {DLF =6.640; TLF = -3.29; Rate = %}		%	3.1315	$91.46
Sub-Total				$3,012.14
Market Charges				
Ancillary Services Charge	39,078.00	c/kWh	0.0327	$12.78
ESC	39,078.00	c/kWh	0.1876	$73.31
LRET	39,078.00	c/kWh	0.2966	$115.92
SRES	39,078.00	c/kWh	1.1233	$438.95
NEM Fee	39,078.00	c/kWh	0.0368	$14.38
AEMO FRC Operations	31	c/day	0.3643	$0.11
Sub-Total				$655.45
Network Charges				
Network Peak Energy	3,134.00	c/kWh	4.2784	$134.09
Network Shoulder Energy	14,776.60	c/kWh	3.7133	$548.70
Network Off Peak Energy	18,735.00	c/kWh	2.4364	$456.46
Peak Demand	77.2	$/kVA	9.9526	$768.34
Shoulder Demand	94.6	$/kVA	9.0047	$851.84
Off Peak Demand	80.4	$/kVA	2.1848	$175.66
Fixed Charges - Daily Rate	31	$/meter/d	14.9752	$464.23
Sub-Total				$3,399.32
Associated Charges / Adjustments				
Metering Provision	31	$/meter/d	1.6667	$ 51.67
Value Added Service	31	$/day	0.0656	$ 2.03
Sub-Total				$ 53.70
			Total (inc GST of $712.06)	**$ 7,832.67**

For ease of analysis the charges can be grouped and represented visually as per the chart 2 below.

Chart 2. Contracted sites bill comparison (May 2021)



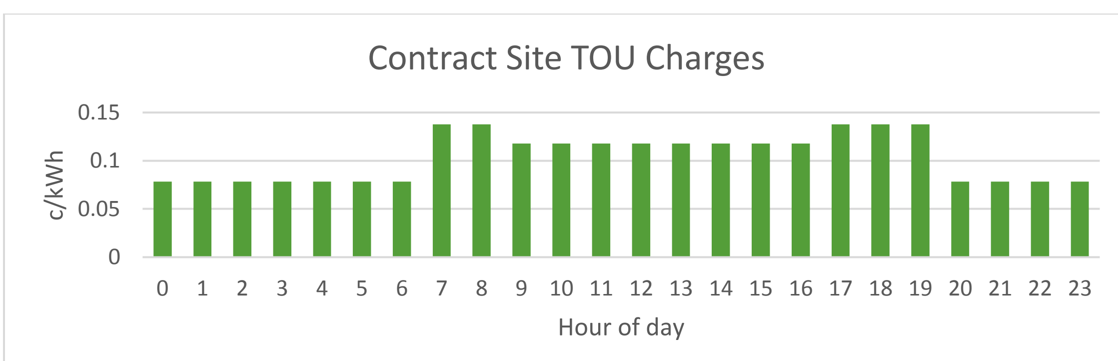
There are important insights to be made from this information.

- Consumers have no bargaining power over the Network, Market, Metering or Environmental charges. The only way to avoid these is to not buy electricity.
- 42.3% of the bill is open to negotiation (retail charges). If, for example, one could halve the retail charge rate, the overall bill saving would be 21.15%, or, in the above example $6,332 vs $7,823.
- The reason that 'behind the meter' (BTM) projects are attractive is because they reduce all elements of the bill through reducing the full purchase of electricity.
- Embedded networks and Microgrids the include generation can also reduce network charges.

Being aware of the charge structure can also lead to simple 'wins' through load shifting. The below chart shows the current retail charge structure for Armidale Regional Council's large usage sites.

The most cost-effective time of day to consume electricity is in the Off-peak period from 8pm to 7am. Shoulder times (9am-5pm) and Peak times (7-9am and 5-8pm) are charged at higher rates.

Chart 3. Contract Sites - Time of Use retail charges



The differential between peak and off-peak charges can provide the economic rationale for battery storage and/or behind the meter load shifting. Most obviously, energy can be purchased at the least expensive off-peak times, stored and then consumed behind-the-meter in the most expensive periods. At the time of writing battery costs remain too high for this approach to be cost-effective however, paired with on-site solar, a battery can make sense to reduce exposure to peak tariffs.

Often there is a more immediate opportunity in load shifting through demand control. A range of technologies now exists to automate devices, from simple timing switches to more complex sensor driven controllers. This already occurs to some extent at ARC where, for example, plant operators seek to lock-out pumps from running during peak times.

2.3 100% Renewable

Combined with low-carbon drivers, understanding the composition of electricity fees and charges can lead to the ideal of going "off grid", however, other than for new installations, this will generally push out a pay-back period compared to a grid-connected solution due to the inability to sell excess energy.

It would be impossible to achieve 100% renewable capacity at each of these sites with on-site solar only, not least because of limited site space and grid connection constraints. An on-site battery can be sized to accommodate the full demand however to effectively 'off grid' the facility requires significant investment.

A third approach would be to integrate a co-generation or hybrid energy plant. Biodiesel cogeneration plants are readily available commercially. Hybrid energy systems with on-site solar and wind generation plus battery and back-up generator are increasingly common for off-grid homes and larger industrial applications.

The key question is 'Is managing these sites in isolation better than a collective approach to the full suite of council assets?'

Considerations include Council capacity/desire to own/operate additional infrastructure with commensurate increase in O&M, insurance, etc.

Recommendation: 1. Improve energy transparency and control at all sites. 2. consider closely the relative merits of creating a situation where a council owned, mid-scale renewable energy generator can be established to, in time, provide energy for contract sites for near zero cost, versus reducing overall consumption with oversized BtM systems and an energy sharing platform.

3.0 Tariff Site Analysis

3.1 Tariff Site Overview

Armidale Regional Council manages 102 facilities with unique connections to the electricity network via a National Meter Identifier (NMI). For this analysis we have grouped these sites into areas of common function as per Table 4 below. As with contract sites, the simple derivative of annual cost divided by consumption gives an indicative c/kWh and provides a metric to prioritise sites that will benefit from a BtM renewable energy installation or efficiency intervention.

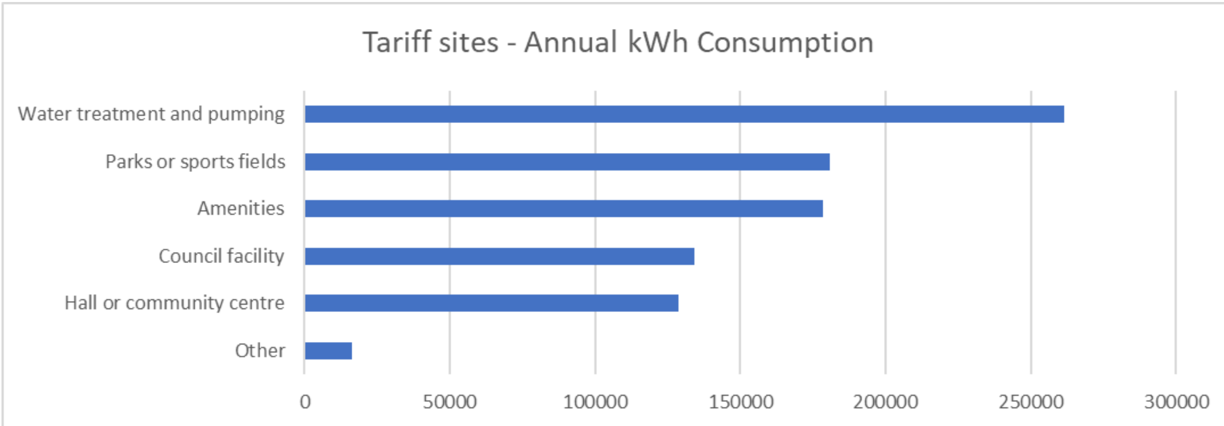
Table 4. Tariff sites cost and usage breakdown

Site group	No. Sites	Annual kWh	GHG tonnes	Annual cost	c/kWh
Amenities: Toilet blocks, lookouts and Mall.	31	178,332	144	$ 54,098.54	30.34
Council Facility: Depots, offices and dog pound.	10	134,147	109	$ 34,328.95	25.59
Community centres: Halls, community centres and libraries.	12	128,772	104	$ 36,247.75	28.15
Other: Any other site that did not fit into the other listed categories.	9	16,286	13	$ 6,931.68	42.56
Parks and fields: Sports facilities, parks and gardens.	23	180,813	146	$ 52,901.05	29.26
Water treatment or pumping: Sewer, septic and water pumps.	17	261,646	212	$ 68,481.04	26.17
	102	899,995	729	$ 252,989.01	30.34

*Indirect emissions from consumption of purchased electricity

Chart 4 below represents the same information in a manner that allows us to see the groupings that draw the most energy. Water treatment and pumping are typically the highest demand group for councils.

Chart 4. Grouped tariff sites annual kWh usage chart



Further insight is gathered by looking into the individual sites that consume the most energy. Table 5, below, displays any sites that consume over 20,000 kWh per year.

Table 5. Tariff sites cost and usage breakdown

Site Name	Annual kWh	GHG tonnes	Annual cost	c/kWh
Swimming Pool	76,930	62	$ 20,294.45	26.38
Depot Mann St.	53,799	44	$ 13,654.23	25.38
Madgwick Pump Station	31,383	25	$ 8,329.65	26.54
Dog Pound	30,177	24	$ 6,332.01	20.98
Ross St. Reservoir	23,625	19	$ 6,730.08	28.49
Dumaresq Dam	21,767	18	$ 6,035.74	27.73
Traffic Education Centre Mann St	20,432	17	$ 5,851.47	28.64
Kent House	20,009	16	$ 5,539.79	27.69
	278,123	**225**	**$ 72,767.43**	**26.48**

*Indirect emissions from consumption of purchased electricity

Our analysis demonstrated that the ARC swimming pool is eligible for contestable tariff negotiation in the next retail contract period. However continual tariff review is also likely to remain of value for this group of facilities, and all others on contestable tariffs, particularly with greater understanding and control of the daily usage profile.

Key questions

- Which of these sites is best suited to BtM solar?
- Which sites can change their energy use through either behaviour change or technology?
- How can we get interval/operational data for these sites?

3.2 Tariff Site Strategy

The c/kWh column in Table 5 above is a relatively blunt but useful metric. Understandably, the sites that appear most expensive are those with low or intermittent use, raising the relative proportion of the fixed connection charges. The highest of these figures point to potential disconnection of certain sites from the grid and replacement with standalone solar-battery systems. As an example, this approach could be cost-effective for some amenity blocks. Certainly, this approach should be considered for all new facilities where connection costs can be redirected into off-grid CAPEX with little on-going outlay.

Of the larger tariff sites, beyond energy efficiency measures, there are three strategies for reducing costs; behind the meter solar installations, self-consumption of export from other Council sites at a reduced fee (see more on this below), and load shifting to optimise tariff structures. While we know there are some sites that are more obvious choices for small roof-top solar, it would be better to make decisions based on data and again, we are limited by the lack of energy consumption interval data at the tariff sites.

Behind the meter renewables

It is likely that rooftop or on-site solar opportunities exist at most of the tariff sites and there may be an argument for behind the meter battery installation at some sites to avoid peak tariff charges and participate in emerging demand response opportunities.

This approach is analysed below in section 4.3.2 Distributed Solar Installation.

Internal energy sharing

Over recent years the capacity has emerged to pool several solar sites, managing them as a Virtual Power Plant (VPP), and/or to specify pathways of energy sharing between customers/sites – known as Peer-to-Peer trading. Examples already exist in Australia and conceptually this could be a useful model for ARC. There is a financial advantage in paying ones-self for energy or, in time, supplying excess from site A to site B for free (although network charges still apply).

The establishment of internal energy trading will necessitate both upgraded metering devices, a cooperative retailer and identifying a hierarchy applied to sites. The hierarchy will be based on factors such as consumption profile, overall load/cost and social benefit. This hierarchy enables Council to optimise the excess summer export from a Council owned and operated 'Virtual Power Plant'.

Later in this report we take this approach to an extreme and investigate the opportunity to consume energy at every ARC site with electricity which has been generated at a single large site. This enables the pay-off of an array to be made with funds already budgeted to operate multiple sites. As is the case for the distributed generation approach, once the single large array is 'paid back' Council can choose to supply to itself for a very low marginal cost.

Load shifting

There are advantages in having the ability to control when and how energy is consumed. Most obviously the ability to avoid peak charge periods and optimise lower fee windows, however there are also emerging markets for Demand Response. This is where network operators (retailers or network providers) make payments to consumers for decreasing load or providing/choking supply in response to issues managing the entire network. An example is asking Council to turn off non-essential loads in heatwaves to avoid overloading the network and causing blackouts.

This capacity is contingent on equipment installed at the switchboard, a software interface with embedded control logic and a participating retailer. There are several suppliers in the market and more emerging with devices ranging from "Super smart meters" which report to retailers and have load control capacity embedded, through to multiple sub-circuit controllers.

As of October 2021, it has become easier for retailers to offer demand response payments and Councils that can aggregate larger amounts of energy to verifiably and easily control, will be well positioned to participate in this new market mechanism.

In time, and as the level of available site data improves, it will be possible to implement and accurately measure energy saving initiatives such as retrofits and behaviour change programs.

Recommendation: Regardless of the direction chosen in regard to strategies for tariff sites, we recommend that all installations of solar and/or electrical upgrades now be accompanied with a smart meter installation, preferably with embedded load control functionality.

4.0 Priority Renewable Energy Options

As with most things in life, it may be that there is no silver bullet solution and in-fact we are looking for 'silver buck-shot' with multiple strategies. For this reason, it is important to be clear on core objectives and the decision-making framework in evaluating alternative options.

In this section of the report Constructive Energy have highlighted the projects we feel stand out given our understanding of ARC objectives.

4.1 Energy Efficiency Measures

Before investigating alternative sources of energy, maximising energy efficiency should be a primary objective. To reinforce this the following measures are recommended (and to some extent already evident at ARC):

- **Monitor consumption**: Engineering and/or Finance are responsible for reviewing energy usage at all sites and of key equipment/assets.
- **Reporting and performance**: Energy use for sites/assets is reported in regular section meetings and efficiency forms a component of staff Position Descriptions and Performance Reviews.
- **Procurement policy**: Energy consumption rates are considered in the procurement of any new equipment or servicing and maintenance of existing items. This includes new buildings and vehicles.
- **Retrofit strategy:** Building modifications will be carried out at least in part for the purpose of reducing energy consumption.
- **Education**: Armidale Regional Council makes it easy for staff and constituents to reduce energy consumption through promotion of strategies and materials that facilitate energy efficiency.

- **Planning**: Armidale Regional Council promotes energy efficiency in design through the planning phase where applicants are encouraged to adopt Guidelines for factors including – insulation, glazing, orientation, primary equipment, water use, etc.
- **Product broker**: Armidale Regional Council applies knowledge and purchasing power to support residents and businesses with products that reduce their energy consumption.
- **Street lighting**: Armidale Regional Council continues to work with other councils/programs to replace existing lights with efficient alternatives.
-

Recommendation: That ARC integrate the above strategies into ordinary operations.

4.2 Smart metering and load control

Australia is in transition from a centralised, 'dumb', monopolistic grid with fixed central generation and regional distribution, to a dynamic, integrated and distributed network of coordinated generation and load at varying scales. With the privatisation and corporatisation of generation and transmission assets, and the opening of retail markets in NSW to competition, the sector is experiencing unprecedented growth in the number and type of generation assets and innovation in technology and retail mechanisms. The days of simply looking for the best kWh price from a limited pool of options, and then forgetting about it, are over.

In this context, data is increasingly important along with the old adage, "*what we inspect we improve, what we measure we manage*".

Retailers are now reluctant to send people into the field to read meters when the automated alternative, digital meter, is less costly and more accurate. So called "Smart Meters" can measure consumption in intervals, usually of 30 or 5 minutes, and these can be used to create a usage profile, as has been completed for this report, but also to enable billing on a cost-reflective basis. Beyond this functionality, a new range of 'super smart' meters are also able to control a number of devices by sending signals to relays on the basis of pre-defined logic. These meters can report to a portal or mobile device for instantaneous reading of energy consumption.

Load monitoring and controlling devices may or may not also be equipped with appropriate approvals to act as the network meter. In other words, there is a choice to either seek a meter that does everything, or to separate the network meter for billing, and the monitor and control device that provides operational intelligence and control. Both devices usually exist at the switchboard. It is critical that the metering

Recommendation: ARC invest in the roll-out of meters with monitoring and control capacity across all assets with both significant consumption and, ideally, the potential to move or modify loads without adversely effecting operations. It may even be possible to leverage retailer relationships so that the cost is borne, or at least shared, as part of the energy supply contract. Although all sites could be monitored, we suggest that there are about 40 priority sites which would benefit from smart meters.

platform can be used to provide close to real-time data through an accessible dashboard which may also eliminate the need for bill-validation platforms.

4.3 Solar

Solar Photo-Voltaic (PV) cells are a proven technology capable of delivering on-site electricity for immediate consumption and/or export. While panel efficiency has improved in recent years, the major factor driving an increase in solar installations has been dramatic reductions in panel costs, combined with government subsidies. The subsidies for systems less than 100kW (Small Technology Certificates or STCs) are reducing year on year until being completely phased out by 2030. Subsidies for systems larger than 100kW exist in a market mechanism (Large Generation Certificates or LGCs) that has been volatile and oversubscribed to date resulting in uncertain and low values, also declining to zero by 2030.

Currently the greatest economic impact from solar is to consume locally and avoid purchasing from the grid – known as Behind the Meter (BtM). This works particularly well when the demand pattern of solar use closely matches the intensity of the sun.

In the context of becoming 100% renewable, these circumstances lead to 2 principal approaches; several sub-100kW systems distributed over multiple sites and larger mid-scale single site systems in the order of 500kW to 5 MW. These two approaches are detailed below.

4.3.1 Medium Scale Solar Arrays

The reasons to consider investing in a mid-scale generation asset include:

- Reduced complexity in number of installations to install and maintain
- Capacity to reach 100% renewable energy target
- Acceptable financial performance
- Leadership and useful practical experience

And in the context of the REZ

- Potential for financial or material assistance from REZ suppliers and stakeholders

When identifying a potential location for standalone medium scale renewable energy installations, it is important to consider proximity to suitable power lines, transformers and electricity substations; close range of a substation or appropriate 'feeder' can lead to more cost-effective grid connection for larger arrays.

Larger solar installations require more research and modelling than those installations below 5 MW because they can have a disruptive and damaging impact on the network. Facilities under 5MW require an intermediary licenced market participant to sell into the National Energy Market but currently avoid extensive Australian Energy Market Operator (AEMO) reporting requirements. Once the 5MW threshold is broken, these additional costs, along with increased implementation costs such as network fault protection works, typically result in systems of around 8MW or more to stack up financially. It is likely that the 5MW threshold will change in time as the Market Operator recognises the value in increased mid-scale generation across the network.

There is another threshold within the Essential Energy distribution network at 1MW, below which the potential network impact, and hence approval process, is usually significantly easier and less costly. Solar installations below 1MW may not be regarded as High Voltage customers whereas arrays over 1MW require Connection Investigation Services Agreements that will incur fees in the order of $25,000 to $250,000, not including detailed engineering and High Voltage design.

In the Armidale Regional Council LGA there is an obvious opportunity for mid-scale solar adjacent to the Sewerage Treatment Plant. Our understanding is that land to the east and south of the facility is Council owned. In the image below we have marked a ~6 ha area that would readily accommodate a 5 MW solar array and which has the advantage of advantageous topography and relative seclusion from view. Sites near STPs have the added advantage of being situated on land that is otherwise 'sterile' from a development perspective.

Also positive for this location is proximity to the regional zone substation (directly south over the highway) which typically results in easier and less expensive network connection and augmentation costs.

Map 2. Potential mid-scale solar site (Six Maps, June 2022)

There will be other suitable sites available within the distribution network within the LGA which may support smaller arrays than those over the 1MW threshold and which, depending on strategy, would be required for Armidale Regional Council to become 100% renewably powered and to offset carbon emissions. Ideally Council would own land or assets for solar and battery installations, however this is not critical as, for example, site lease costs can be integrated into the business plan.

Financial considerations

The commercial development appetite for medium to large solar arrays has varied over time in response to government policy uncertainty and trends in the daytime market price. Despite the surge in wholesale market pricing at the time of writing, there are now periods where solar supply exceeds market demand and this is pushing the pool price down, resulting in the so-called 'duck curve' already evident in some parts of the NEM (National Energy Market) particularly during Spring and autumn months. In the past, the market price average was reliably above the cost of production and may well remain there for some time making solar projects profitable, but there remains a risk of a revenue shortfall. This issue has been exacerbated by network constraints resulting in Market Operator curtailment of export from large solar farms. In our view this reinforces the case for more, smaller, solar arrays within the Distribution network – provided that there is a customer 'locked in' at an appropriate rate.

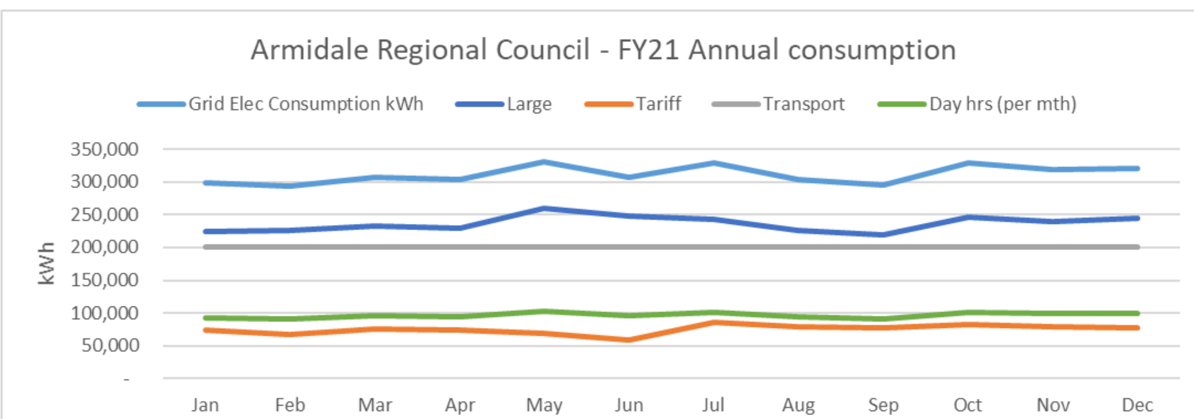
Developers usually seek to secure revenue by locking in customers with a fixed price Power Purchase Agreement, however for Councils the opportunity exists to create alternative models that value self-generation matched to self-consumption – effectively being your own customer. There are 2 broad retail mechanisms to achieve this: a floating wholesale market process and a hedged offtake agreement.

With supply matched to demand and a floating market price, the Council is less concerned with what the energy price is at any point in time and more concerned about the transactional cost. That is; if the NEM price is high then increased costs of consumption are offset by increased revenue for the array. Equally, low prices reduce revenue to the array but save on expenditure at Council sites. To avoid excess export at low value it is important to match the solar array size to demand, noting that the opportunity exists to increase the pool of customers by signing up local Commercial and Industrial facilities. Of course, once the array is paid off, Council has access to electricity at negligible cost (refer to the section "Council as energy retailer" below).

Understanding this model is critical to the decision for Council to invest in a mid-scale array as without it, CE would not currently advise Council to proceed with a mid-scale solar project. Indeed, it will be difficult to secure finance if a project is totally exposed to market or merchant risk. See more about this in section 4.4 Council as Energy Generator/Retailer.

Modelling was completed to examine what the options might be for ARC to progress a mid-scale array. Local climate data was used to project solar generation and aggregated to monthly figures. These were mapped against actual usage for the 2021 financial year. The following chart represents annual consumption in aggregate and the percentage of usage likely to currently occur in daylight (solar production) hours. It also includes the approximate equivalent electrical demand for substitution of transport fuels.

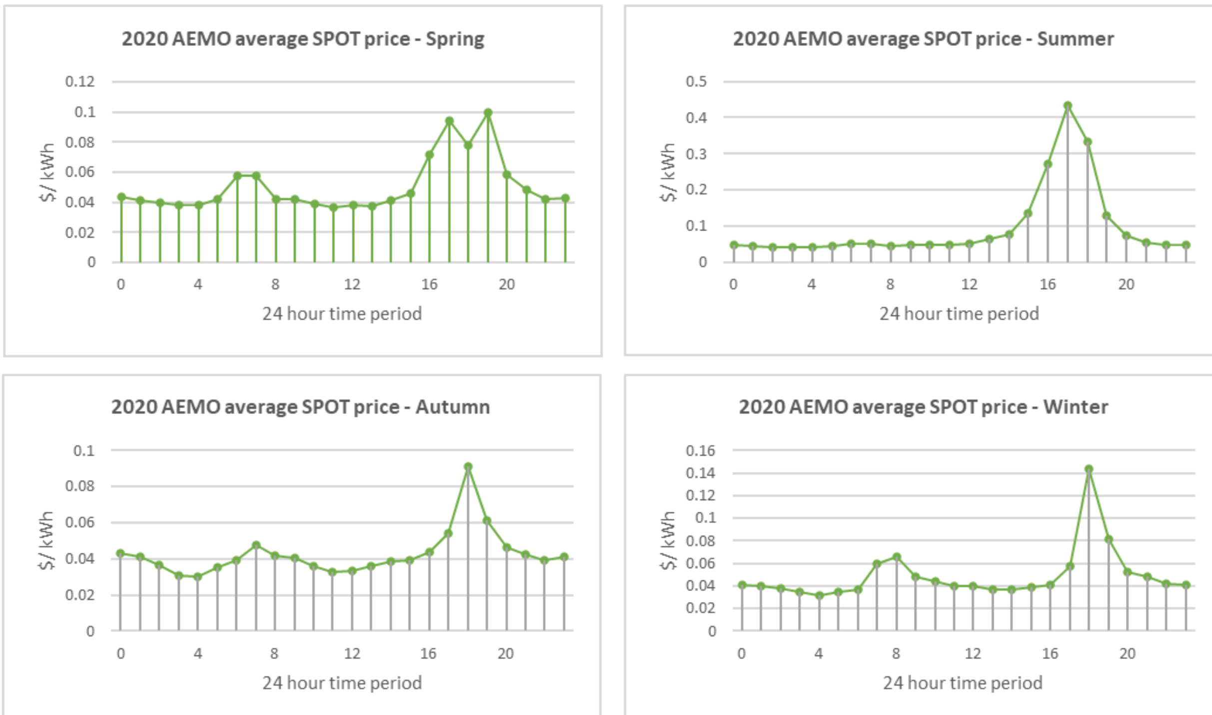
Chart 5. Armidale Regional Council Annual electricity consumption



The profile is interesting as it visually represents two important factors relevant to solar generation; minor peaks for consumption occur over winter and early summer months and consumption during daylight hours is around 1/3 of total consumption.

We now need to understand how this profile interacts with the wholesale or spot price on the National Energy Market. The charts below indicate that, on average, summer is a good time to be selling solar energy into the spot market at the end of the day as the price is relatively high compared to other seasons – particularly in the peak heat of mid-afternoon. However, in winter 2020 the evening spike, while shorter in duration, was higher in value than summer. In shoulder seasons daytime export is of lesser value than the morning and evening peak periods.

Chart 6. Seasonal average AEMO (Australian Energy Market Operator) NEM Spot electricity price charts



Care should be taken in drawing too many market inferences as these curves change from month to month and year to year and future changes in the energy sector are uncertain, particularly over the multi-decade lifespan of a renewable energy generator. For example, what impact will closure of coal fired power plants have? If a carbon price returns, what will this do? As batteries and EVs enter the mainstream, will the evening peaks diminish?

What we can say though is that people are still likely to use more energy at the beginning and end of each day, winter and summer will require more energy for heating and cooling than autumn and spring and retailers will still need to apply a risk margin to offer stable pricing.

As coal-fired plants close down, new generation and storage enters the market, and there is increased electrification of everything, it is very difficult to predict the market. We anticipate that the continuing influx of solar into the market will further depress daytime spot prices at times until the point that storage becomes an obvious choice, creating demand for this cheaper energy and thereby pushing the price back up. Similarly, as more and smarter generation and demand control enters the market, it is easy to imagine the price curves flattening out.

Project scale

We now investigate factors that would influence the size of a stand-alone solar array that would enable council to be a 100% NET renewable energy consumer. For the sake of illustration, the scenario assumes that ARC is happy to pay itself 8c/kWh for solar energy which represents a saving of approximately 6c off small site retail and 4c for large sites, and that export is also purchased by a third party for 8c. We have also modelled the array install cost at $1.45 per watt which is inclusive of all project costs.

Our analysis indicates the improved financial case for Council self-consuming the energy vs finding a consumer willing to enter into a Power Purchase Agreement (PPA) for 8c (more likely around 6.5c at present) or relying solely on the energy spot market. Not surprisingly, the key variables for financial return are the install cost and sale/purchase price per kWh.

Table 6. Summary table of generation and revenue (FY21 Consumption figures)

Council consumption								$ 0.08	$ 0.04	$ 0.08
Month	**Large**	**Tariff**	**Gas**	**Transport**	**Combined**	Day hrs (per mth)	**Export**	**Int'l rev.**	**retail saving**	**Exp. rev.**
Jan	223,669.98	74,351.68	-	200,000.00	298,021.66	92,387	452,051	$ 7,391	$ 3,695	$ 36,164
Feb	226,632.65	66,929.00	-	200,000.00	293,561.65	91,004	357,681	$ 7,280	$ 3,640	$ 28,614
Mar	232,421.02	75,351.78	-	200,000.00	307,772.80	95,410	273,832	$ 7,633	$ 3,816	$ 21,907
Apr	229,183.26	74,922.35	-	200,000.00	304,105.62	94,273	173,585	$ 7,542	$ 3,771	$ 13,887
May	260,367.19	69,697.56	-	200,000.00	330,064.76	102,320	91,353	$ 8,186	$ 4,093	$ 7,308
Jun	248,830.22	59,058.31	-	200,000.00	307,888.53	95,445	56,427	$ 7,636	$ 3,818	$ 4,514
Jul	243,342.62	85,157.36	-	200,000.00	328,499.98	101,835	71,409	$ 8,147	$ 4,073	$ 5,713
Aug	225,844.20	78,677.63	-	200,000.00	304,521.83	94,402	138,611	$ 7,552	$ 3,776	$ 11,089
Sep	218,950.55	76,732.30	-	200,000.00	295,682.85	91,662	223,174	$ 7,333	$ 3,666	$ 17,854
Oct	245,687.69	83,111.96	-	200,000.00	328,799.64	101,928	308,688	$ 8,154	$ 4,077	$ 24,695
Nov	240,328.61	78,836.58	-	200,000.00	319,165.19	98,941	352,711	$ 7,915	$ 3,958	$ 28,217
Dec	243,987.78	77,168.28	-	200,000.00	321,156.05	99,558	421,686	$ 7,965	$ 3,982	$ 33,735
Totals	2,839,246	899,995	-	2,400,000	3,739,241	1,159,165	2,921,207	$ 92,733	$ 46,367	$ 233,697

Scenario – 100% Renewable Energy generation offset matched to ARC's stationery energy consumption.

In this scenario, we have matched an array to meet energy consumption on the basis of creating a revenue stream to offset unavoidable usage in non-solar-producing hours and to reach 100% renewable status in terms of carbon abatement. The size of an array to achieve this is approximately 2,500 kWp.

Chart 7. Solar generation matched to consumption

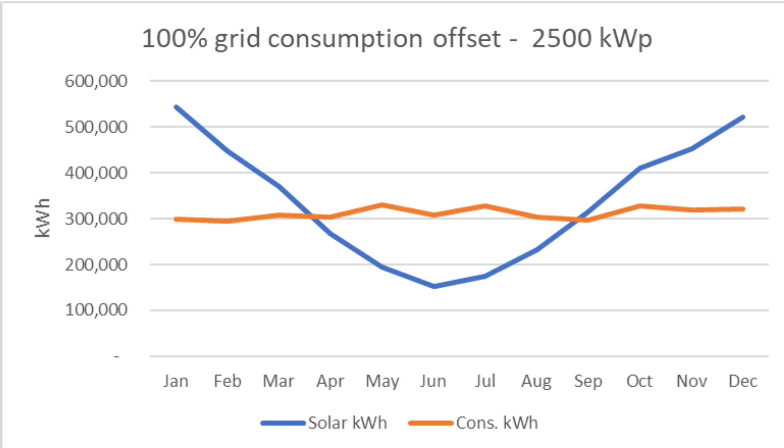


Chart 7 indicates that the bulk of all energy consumed, 24 hours per day, both exceeds and is less than the amount generated depending on the season. In terms of annual volume however the curves are equivalent. The corresponding revenue charts are displayed below.

Chart 8. Intersection of monthly revenue/value curves

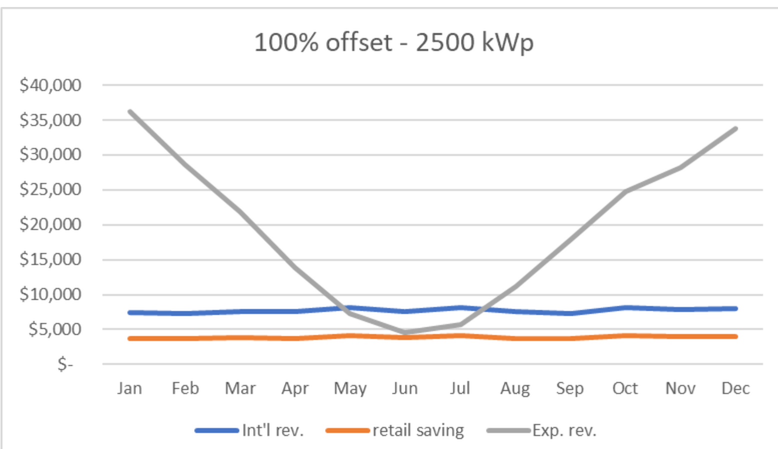
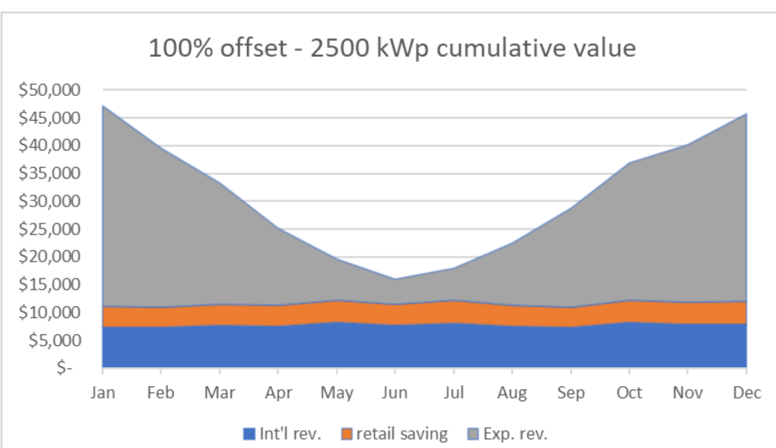


Chart 9. Cumulative value



The above analysis has been undertaken to illustrate concepts, highlight risks and demonstrate the impact of alternative approaches to becoming active in the renewable energy generation space. We have been careful to be realistic and conservative in our analysis however detailed modelling, costing and analysis will be required before investing in a project. For instance, if Council plans to electrify fleet and plant, or expand operations in the future, this demand should be estimated and the array size increased correspondingly.

That said, our analysis reveals that it is possible for an investment in a single site array of around $3.75 million to create annual value of about $373,000, with Council paying off their own solar farm in around 10 years instead of paying a retailer. After this point, council can decide what to do with ~4 GWh of free energy each year.

Clearly there is also value in being able to vary consumption to be within solar producing hours or in least-cost market hours.

Further consideration is required into final sizing of a mid-scale array for Council. Because of a certain level of fixed project costs, it usually makes better financial sense to maximise the 5MW connection threshold to the network. This would result in the array creating an additional 4GWh of energy per year. Council may choose to establish a PPA or find local customers to value this energy, creating a revenue stream.

Given that the minimum effective life of a solar array is the warranty period, i.e., 25 years, and in-fact usually more like 40 years, Council have the capacity to structure finance over a longer term to deliver increased cash flow now, or as-short-a term as possible to pay off quickly and create an effectively free energy supply. Aside from whatever advances in technology are available at that time in the future, including electric vehicles, there are a wide range of social impacts that could be supported with this low-cost energy.

Constructive Energy has completed detailed modelling for other Councils who have elected to proceed with this approach based on favourable economic and social returns. The project will reduce current outgoings for energy in the medium term, pay off an array in just under 10 years, engage local business with lower cost local renewable energy and deliver a financial dividend of ~$9 million over 25 years.

If Armidale Regional Council elects to further investigate this concept CE can facilitate the necessary system design and Network Enquiries and work with Council to develop the detailed business plan.

A final point of note is to consider that there may be city-based local governments that would welcome the opportunity to partner with a 'country cousin' that can generate renewable energy for them, to offset their usage. This could be another way of locking in price certainty and revenue to de-risk the business plan.

4.3.2 Distributed Solar Installation (+ Virtual Net Metering/Virtual Power Plant)

ARC has previously investigated Behind the Meter (BtM) solar for multiple facilities and installed a total of 393kW on 7 out of 11 identified potential sites as shown in the table below. These installations have successfully lowered Council's grid consumption and operational costs.

Table 7. Existing on-site solar installations

Site	Town	Size (kWp)	Comments
Civic Administrative Building	Armidale	0	Not suitable roof structure
Visitor Information Centre	Armidale	4.58	Roof
Airport	Armidale	99.6	Roof
Armidale STW	Armidale	99	Ground Mount
Armidale Mann Street Depot	Armidale	29.9	Export limit 30kWp
Malpas Dam	Armidale	0	Export limits
Streetlights	Armidale	0	Replacement of 724 lights with energy efficient LEDs
Armidale Cycleway	Armidale	0	Solar lighting - installation of 49 new solar lights (funding through the Safer Communities Fund)
Kolora Aged Care Facility	Guyra	99.9	Roof
Guyra Works Depot, Ryanda Street	Guyra	30	Not sure on exact installed amount
Guyra swimming pool	Guyra	30	Swimming pool.
Total		393.0	

Constructive Energy have investigated the potential for additional on-site solar across Council operations in terms of both economic impact and the capacity to reach 100% renewable.

BtM solar arrays obviously generate electricity during daylight hours which, when there is a load on the facility electrical circuits, stops the need to import energy from the grid, thus avoiding power costs charged on a per kWh basis. If the solar is generating more energy than is currently required, this excess energy generation is sold into the network at a negotiated feed-in tariff or shared with other consumers. An ideal site for this type of installation (where a faster return on capital investment can be achieved) should present the following characteristics: -

- High, regular electricity consumption, with most of the usage occurring during the daylight hours.
- Large suitable roof structure, preferably north facing and not shaded, or suitable nearby space for ground/frame mounted solar.

Important Considerations

- Identify project drivers as cost, energy-sharing and carbon offsetting will all lead to different answers
- Size and design individual systems correctly to meet the identified objectives
- The Small-scale Renewable Energy Scheme currently offers significant discounts on solar systems smaller than 100kW. The scheme reduces in value on 31st December each year until it ends in 2030.
- Systems larger than 30kW require additional costs associated with network connection studies and permission from the network provider to connect to the grid.

There are currently new technologies and market-place arrangements being developed that allow peer-to-peer solar energy trading between properties, known as Virtual Net Metering (VNM) and the ability to collectively manage multiple installations, known as a Virtual Power Plant. At a small scale, a household can trade their excess solar generation to a property of their choosing at a negotiated price. This system usually requires both parties in the transaction to be with the same retailer and arrangements can be put in place for one-off transactions or longer-term periods.

Using this concept, it is possible for Armidale Regional Council to develop a Rooftop Solar Virtual Power Plant large enough to power a major portion of Council sites and other businesses and residences in the LGA. This collective approach is consistent with the objectives of Project Zero30 and may see, for example, Council subsidise or facilitate the installation of solar and battery systems at selected third party/community sites. This approach would also require a shared retailer.

Important Considerations

- All properties/customers operating within the network would need to have a supply contract with the same retailer. The retailer would also need to be involved in setting up and operating the system.
- A specific meter/device is required to monitor and acquit energy usage.
- The project may require a significant effort to recruit customers (which could include customers outside of the LGA if desired).

To illustrate this opportunity CE considered the impact of existing/augmented solar systems and new BtM installations as part of a holistic program. The system sizes include actual existing installations and an estimate of what might be practical and/or permissible on some additional sites. The sites would be 'oversized' in terms of optimal financial return for any given site on the basis that Council is seeking to optimise renewable generation for self-consumption.

Table 8. Example distributed solar BtM installations

Site Name	Annual Site cons kWh	BtM System	On site gen /yr	Self cons kWh	Avoided GHG tonnes (Scope 1)
Airport*	323302	100	154,905	80,551	65
Sewerage Treatment Plant*	312364	100	144,553	75,168	61
Water Treatment Plant	205222	100	138,048	71,785	58
New Library	170825	60	92,588	48,146	39
Aquatic Centre	145051	300	414,141	75,427	61
Guyra Swimming Pool*	148712	30	41,413	21,535	17
Depot Mann St.*	87012	30	46,823	24,348	20
Depot Ryanda Street*	56308	30	46,823	24,348	20
Kolora Hostel*	21327	100	136,437	7,296	6
Malpas Dam	12449	30	46,471	6,474	5
Guyra Showground	11878	10	14,593	7,588	6
Visitors Info Centre*	15540	5	7,296	3,794	3
Town Hall	8309	15	20,707	4,321	3
Wicklow Playing Fields	3777	30	46,294	1,964	2
Totals	1,518,297.80	940	1,351,092	452,742.72	367

*Pre-existing solar installation

CE integrated the capacity for a virtual network and imagined that Armidale Regional Council charged themselves 8c/kWh for energy consumed at other sites. Subtracting a transactional cost of 1c/kWh this leads to an effective 7c feed in tariff. The avoided purchase is valued at 24c/kWh. Table 9 below is a summary of the collective financial impact if these projects were to proceed.

Table 9. Example distributed solar BtM collective financial impact

Council consumption	BtM solar generation		CapEx	Revenue	GHG	Payback and Yield	
Total combined consumption kWh (across all sites)	Daytime consumption (selected BtM sites)	Export kWh	Inst cost *	Tot revenue p.a. (including VNM)	Avoided GHG tonnes	Payback (simple)	Yield
3,739,240.56	452,742.72	898,349.28	$ 1,998,000.00	$ 180,526.20	367	11.07	9.0%

* Inst cost includes CapEx already sunk into existing installs

While these figures are general, it is evident that there is an economic case for roof-top solar when viewed holistically under a virtual network. However, this approach does not account for the complexity of the multiple solar installations at separate locations. Detailed project and financial planning will be required to firm up actual figures for investment readiness.

Each site location would require detailed network applications, structural and electrical assessments, and may be subject to export limitations or unforeseen wiring upgrades, which would financially impact the project. Furthermore, connection limitations make it very difficult to realise the full Council self-sufficiency figure of 3,739,240kWp.

It may be desirable for Council to facilitate the involvement of other organisations and individuals in a Council-wide virtual network and in fact this is the only way it would be possible to generate the additional 2,388,240kWh required to fully offset Council energy use. The Virtual Power Plant approach is further discussed in Section 5.3 Virtual Power Plants below.

Prior to progressing the case for BtM solar installations, it is important for Council to acknowledge that the broadscale implementation of BtM roof-top solar systems potentially cannibalises the case for a mid-sized solar array. Installing multiple BtM solar installations reduces the amount of solar energy that Council can sell to itself in order to secure revenue for the larger project (which may be likely to provide a more significant pay-off in the longer term).

That said, BtM solar is readily achievable and delivers an immediate financial return and it may be that a hybrid of the two approaches is acceptable.

There are essentially three options for progressing BtM installations (further outlined in section6.0 below): -

1. Armidale Regional Council Capital investment – ARC self-funds projects from cash reserves or internal loans and directs savings to reducing operating costs
2. Project finance – ARC secures third-party funding and directs savings into repaying the debt
3. 'Rent to buy' – A third-party installs and operates for a reduced until nominated hand-over

Constructive Energy can provide oversight or facilitation of each of these options if desired.

Recommendation: There is a strategic choice to be made between implementing distributed BtM solar and a mid-scale solar project. If the key project driver is return on investment, then distributed solar is likely to win out, however it is more challenging to deliver 100% renewable status itself by 2030 so ARC may also require a retail agreement to purchase renewable energy from an existing generator to fill the balance of demand.

Distributed Storage

Storage in association with BtM solar can create value through back-up capacity, improved power quality, optimised consumption and export in relation to tariff charges, enhanced demand control capacity and improved monitoring/reporting.

Batteries

Battery technology has now reached the point where there is an economic argument to include them in the hybrid power generation mix. Many commentators contend that the payback for batteries is too long, however when viewed holistically there are many cases where the yield of a combined solar + storage installation is above 10%. Given the high potential Internal Rate of Return (IRR) for distributed solar it would be remiss not to consider the opportunity to incorporate energy storage where advantageous.

Table 10. Example distributed solar + battery collective financial impact

Site Name	Qty Batteries	Battery Capacity kWh per yr	Avoided purchase	VNM kWh	VNM revenue	Tot revenue p.a. (including batteries)	Solar + battery Payback (simple)	Solar + battery Yield	Avoided GHG tonnes
Airport*	4	19,710	$ 4,730	54,644	$ 4,372	$ 28,434	8.16	12.3%	81
Sewerage Treatment Plant*	-	-	$ -	69,385	$ 5,551	$ 23,591	9.75	10.3%	61
Water Treatment Plant	2	9,855	$ 2,365	56,408	$ 4,513	$ 24,106	10.62	9.4%	66
New Library	-	-	$ -	44,442	$ 3,555	$ 15,110	5.96	16.8%	39
Aquatic Centre	2	9,855	$ 2,365	328,859	$ 26,309	$ 46,776	15.31	6.5%	69
Guyra Swimming Pool*	-	-	$ -	19,878	$ 1,590	$ 6,759	7.99	12.5%	17
Depot Mann St.*	1	4,928	$ 1,183	17,548	$ 1,404	$ 8,430	7.95	12.6%	24
Depot Ryanda Street*	-	-	$ -	22,475	$ 1,798	$ 7,642	7.07	14.2%	20
Kolora Hostel*	-	-	$ -	129,141	$ 10,331	$ 12,082	19.04	5.3%	6
Malpas Dam	2	9,855	$ 2,365	30,142	$ 2,411	$ 6,330	15.01	6.7%	13
Guyra Showground	-	-	$ -	7,005	$ 560	$ 2,382	6.30	15.9%	6
Visitors Info Centre*	1	4,928	$ 1,183	-	$ -	$ 1,822	10.43	9.6%	6
Town Hall	1	4,928	$ 1,183	11,459	$ 917	$ 3,136	12.75	7.8%	7
Wicklow Playing Fields	-	-	$ -	44,330	$ 3,546	$ 4,018	17.17	5.8%	2
Totals	**13**	**64,058**	**$ 15,374**	**835,717**	**$ 66,857**	**$ 190,619**	11.37	8.8%	**417**

Our analysis of solar only BtM installations reveals a collective yield on investment around 9%. The table above indicates that the functionality of multiple batteries can be added to the project within similar financial parameters as the 'oversized' solar-only example above. Of note is that while many individual installations achieve 'pay-back' within a standard 10-year warranty period for chemical batteries, several do not. This is probably not a 'show-stopper' as lithium battery life is well beyond 10 years (though diminished in performance) and there are also different batteries which will last 20+ years, such as Vanadium redox flow batteries, hydrogen or flywheel inertia systems.

It is important to know that batteries are not all made equal and different technologies suit different load characteristics. Battery modelling is very complex and relies on assumptions including pricing structure, demand response capability, technical constraints such as depth of discharge and performance at different temperatures, system integration with existing equipment and control interface.

The core objectives of Council are also critical. For example, if leadership is important, it would be useful to trial a range of energy storage technologies on a site-by-site basis through providing detailed site consumption data and running open market Request For Quote RFQs. Knowledge gained can be shared with the community and local suppliers can be upskilled. If carbon emissions are most critical, then simply choose an acceptable financial performance threshold and 'back-fill' as much solar and storage technology as will fit within the parameters.

This analysis is not provided to give an answer to ARC around where to install certain battery capacity, but rather to point out the need for a carefully considered approach. The price of storage is also in rapid decline and the market itself is still immature, increasing the risks of encountering technology that does not deliver as promised and providers who are not around for the long run.

None-the-less, if managed collectively, a number of distributed batteries can not only assist with individual sites, but also enable participation in market and network 'events' for which network operators will pay in order to reduce difficulties in managing the grid. This is the basis behind the Simply Energy Tesla VPP project in South Australia and other examples where management of the battery is given over to the retailer. AGL have a similar offer in the market at the time of writing where low-cost battery and solar are provided to a household in return for a longer-term contract and permission to control the battery.

Another emerging approach is that of community batteries at a block or suburb level. These units are larger than household batteries but allow solar households to 'bank' their export locally to draw down against later in the day. Council may choose to take a leadership or supportive role in the community if there is sufficient interest in establishing a community battery project.

Hydrogen

Advances in on-site production and safe storage of hydrogen see this technology as a reliable and cost-effective way to store energy. Added benefits include the ability to distribute the hydrogen, use it to refill Hydrogen Fuel Cell Electric Vehicles (HFCEV) and consume it in Hydrogen Fuel Cells to power Council facilities. Hydrogen production also creates oxygen through the electrolysis process and this has benefits in water treatment and even in hospitals. Hydrogen technology is worth 'having on the radar' as it becomes increasingly commercialised and demonstrates benefits, particularly in rural/regional contexts.

Recommendation: ARC should consider the case for battery storage in association with any BtM solar installation and especially for sites with energy quality or security requirements. Retailer provided batteries and community battery schemes should also be explored.

4.4 Council as Energy Generator / Retailer

Armidale Regional Council has the land access, load and grid capacity to install and operate a medium scale solar power plant in the order of 3-5 MW. The inevitable question regarding this option is how to consume the generated energy in local assets and how to maximise financial benefit from selling the excess. As a Council owned and controlled asset, a solar PV facility has the potential to generate both energy for self-consumption and a revenue stream to off-set unavoidable consumption costs such as street lighting.

Clearly, if it were not possible to consume renewable energy 'behind the meter' then the next best thing would be to supply the excess energy to other Council sites and other larger consumers such as local industry. As described in 4.3.1 above, Power Purchase Agreements (PPAs) are the most common mechanism for this to occur to date. However, if this is done, it is still necessary to pay for the "poles and wires" either by paying the network owner-operator a fee or through owning the network. It is unclear at this point if discrete rural energy networks will ever be 'for sale', however, an embedded network constructed and owned by Council, such as for a new greenfield development or an industrial estate, already has precedent.

Power Purchase Agreements have been established and tested in the Australian context and are a feasible option for ARC to consume energy from their own solar generation, or any other arrays for that matter, however they do require integration with a 'friendly' retailer and monthly reconciliation of estimated versus actual generated/consumed electricity. For simplicity, it may be possible to find a local large consumer that agrees to purchase all energy generated from an Armidale Regional Council array.

A third option as indicated above would be for Council to effectively operate as a generator-retailer, choosing to purchase energy from its own solar array at an agreed price, but also to purchase energy from the National Energy Market (NEM) and then choose the level of price mark-up on-selling to themselves (see Chart 25 below). While there are benefits in removing the retailer's margin through purchasing wholesale, the risk of this approach is that the pool price may, or will at times, be higher than the relevant standard tariff. Our modelling has shown for previous years that wholesale consumers tend to be better off overall, but this is not guaranteed. To mitigate against this risk, the ability to control loads automatically would limit exposure to any price spikes. In other words, if the price is high outside of solar production periods, then we switch things off! The other key mitigating factor would be integration of battery storage which could be used as an economic tool to arbitrage market prices or to load shift (see below).

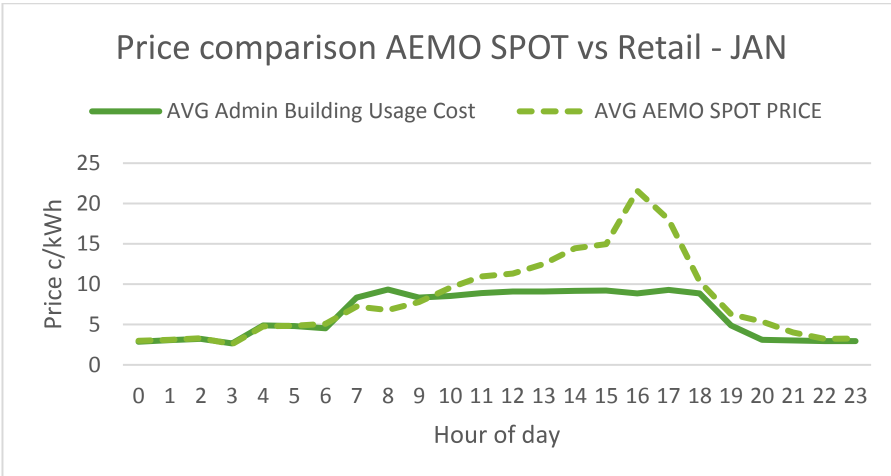
It would be possible for Council to apply for its own licences to be formally recognised as a retailer however this carries cost in establishment and on-going compliance overheads that are, in our view, prohibitive. While the Local Government Act carries the capacity for Councils to supply energy (as per County Councils of last century) in the current competitive and innovative environment it may be smarter to partner with an existing retailer willing to provide the mechanism.

There are several retail organisations currently delivering cost-reflective pricing and facilitating sale of energy into the NEM. Linked to a solar array of course Council would be exposed to purchasing energy from the market for the times outside of solar production hours. (Wind power and energy storage would change this.) The degree to which Council is exposed to the volatility of pricing in these periods versus having the retail partner set a fixed price to 'hedge' the risk depends on the ability to negotiate a deal.

To further illustrate the concept, we have prepared the charts below comparing the amount ARC actually paid to power the Admin Building, a high yet consistent usage tariff site, versus what would have been paid at the market spot price.

Chart 10 displays each 1-hour interval averaged over a month (Jan) and extrapolated over a 24-hour period. We have then overlayed the corresponding electricity SPOT (wholesale) prices from the NEM for the same period. AEMO refers to the Australian Energy Market Operator which is the entity that operates the Network and publishes market data including the instantaneous, or 'spot', pricing.

Chart 10. Comparison of Council Admin Building cost by hour versus equivalent spot market cost Jan-21



Based on this analysis it can be seen that if ARC paid wholesale price for energy during January, this would have been more expensive that paying the pre-agreed retail tariff. In other words, the retailer took a hit in supplying ARC!

Chart 11. Comparison of Council Admin Building cost by hour versus equivalent spot market cost Jun-21

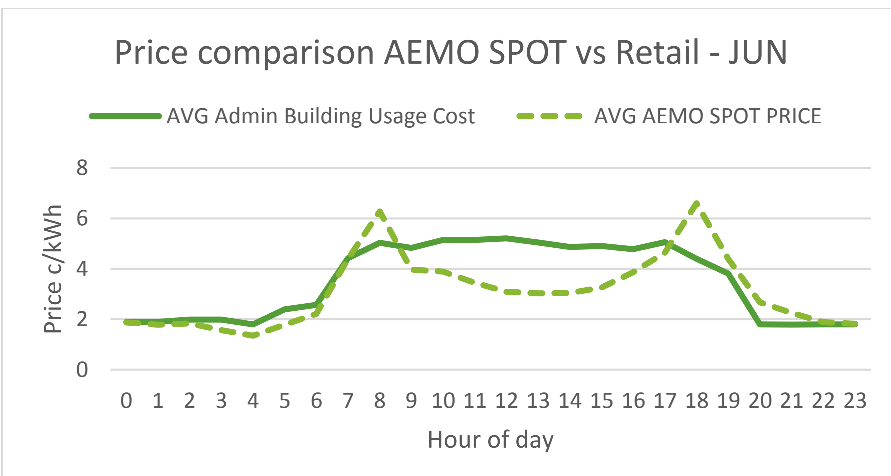


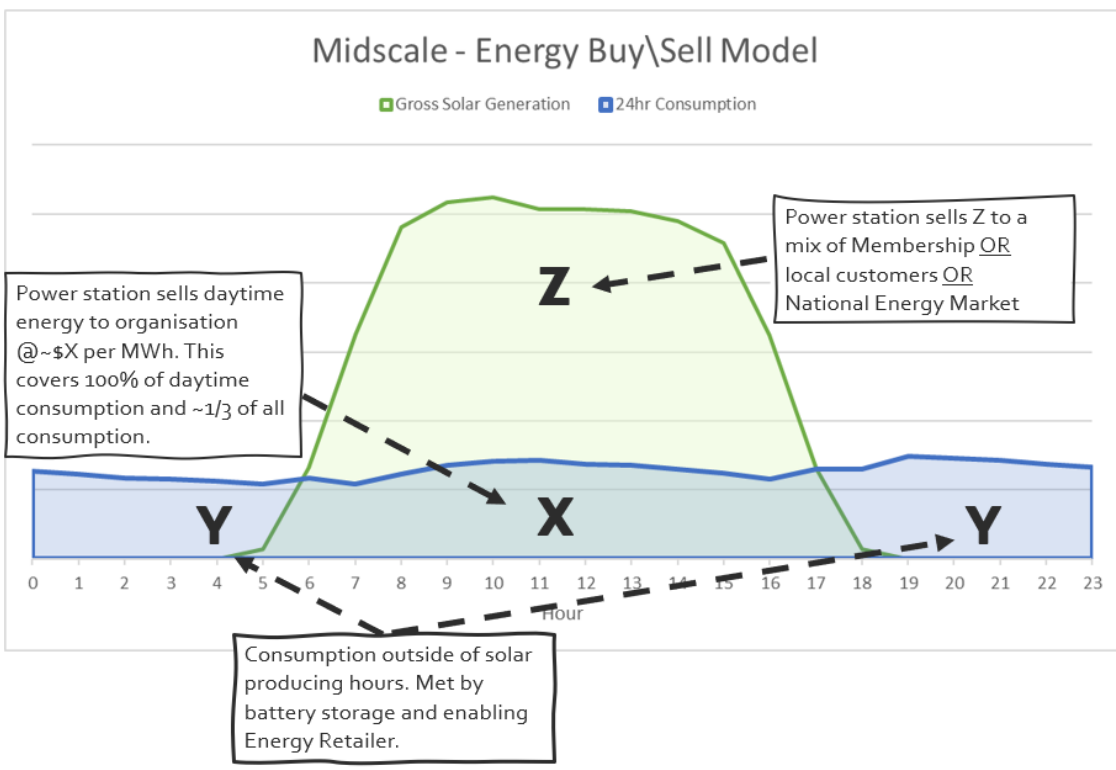
Chart 11 above indicates a period when ARC would have made a saving purchasing energy at wholesale prices, even considering peaks at the beginning and end of the day. This chart also indicates the obvious opportunity in load control and energy storage – maximising energy consumed from 09:00 to 17:00, avoiding consumption in morning and evening peak periods and aiming to sell stored energy into the market at its highest price.

The primary purpose of bringing this to the attention of Armidale Regional Council is to be aware of both the opportunity and consequence of 'stepping into' the generator - retailer space. While there are costs in establishing Councils as generator-retailers the savings and potential revenues are significant. However, even with automation, there will be a requirement for human oversight and this would need to be in the form of internal staff responsibility or outsourced services. Essentially ARC needs someone 'in their corner' to ensure that the generator is performing as expected, the retail structure is delivering value, and that the load controlling logic is optimising self-consumption and minimising external energy purchase.

Part of the role of Constructive Energy is to guide and support Council decision making, in regard to establishing projects, negotiating deals and managing renewable energy assets to optimise benefit. Should ARC wish to follow the generator-retailer pathway, after securing the opportunity to deploy or own energy generation assets, the next step would be to identify suppliers willing to engage in this manner. We have previously received positive responses from Enosi/Energy Locals, Simply Energy, Energy Australia, Origin Energy, Tango and Flow Power.

It is important to note that, as identified in 4.3.1 above, sizing a solar array to 100% meet Council demand inevitably leads to an export 'problem'. This requires ARC to find a market outside itself that values this export. Such a market could be a small number of high-demand industrial users, commercial and retail businesses with daytime usage, and/or local residences. This 'solar power station' model is illustrated below.

Figure 1. What to do with solar excess



In reality it is difficult to establish the exact quantum of 'X' in the figure above and to that extent there is a risk in raising the expectations of the last few customers who may never consume much energy from the array. In other words, after 'Z' is fully allocated we can guarantee supply for the first customer but not the last!

The likely management of this issue which is to have a certain percentage sold commercially with the remainder exposed to the wholesale market price.

An ideal agreement would incorporate both elements, so Council is able to negotiate 'certainty' and savings with electricity production and consumption, ultimately benefiting the ARC community, and to underpin affordable local energy to the local community. The retailer would provide customer support and billing facilities and in return the Council could assist the retailer with their brand promotion and customer acquisition in their Local Government Area.

Recommendation: If ARC decide to progress the mid-scale 100% offset option, this should be done in concert with identifying and negotiating with a retail partner. ARC will need to come to a position on how to value the export ranging from simple PPAs to sharing with local customers. E.g., Main street shops to assist in providing affordable, local energy.

4.5 Energy Storage

Small scale distributed energy storage has been addressed in section 4.3.2 above. His section refers to larger scale possibilities. In addition to exploring the various large-scale solar installation options available, it is important to consider integration of energy storage options to bring additional value and benefit to a project. Batteries are an increasingly critical part of optimising the economic and environmental benefits of renewable energy generation and are now affordable to the extent that pay-back periods are usually less than 10 years and can be less than 5 with the right price and market settings.

The battery market is currently in price decline as various providers and technologies vie for market share. In addition, the impact of batteries on the grid is in the early stages of implementation in practice so case studies will have important flow-on impact. Energy storage integration presents the following key benefits to a project-

- Load smoothing: battery storage can buffer solar generation peaks and intermittent or variable demand profiles.
- Load sharing: particularly where Microgrids are implemented, battery storage can provide a power sharing and grid stabilising faculty.
- Load shifting: - supporting the economic case for avoiding purchase of high-cost electricity.
- Load export: smart-meter technology can identify when a system should export onto the grid (when demand and price is high) and when to divert to storage. Under a generator/retailer model, integration of battery technology adds an additional advantage to 'playing' the energy markets.

The enduring problem with intermittent renewable energy generation is reliability of supply, a factor which has been improved dramatically at the time of writing by the improving economics around battery

Recommendation: ARC should model energy storage as part of the business plan in both medium scale and/or distributed solar project options. This modelling should compare a single, mid-scale, grid connected storage device (ideally with the solar array) and multiple distributed devices.

storage. The emergence of technologies that can offer utility scale storage at a price point with a 10 year pay-back is significant. It is now technically feasible to operate 'off grid' at scale, however, taking all ARC's sites off the grid is not desirable for a range of reasons and at present would increase the cost of supply. However respected industry energy analysts suggest that price parity for this scenario could occur in the next 5 years and it will be worthwhile for Armidale Regional Council to consider this scenario with their high use and/or remote sites in the next 5-10 years. There are other reasons to integrate batteries, including energy security/resilience, and with increasing climate volatility this may become a more important driver.

4.6 Retail arrangements

Armidale Regional Council has a variety of sites that have large and consistent consumption and this has provided leverage for negotiations in the past which, through well run tendering processes, resulted in sharper competition between each of the energy retailers and hence better pricing.

As discussed above, as Armidale Regional Council implements the recommendations of this REAP it is possible to become a net generator of electricity which is then sold back to other ARC sites, the community and local industry or other councils and market customers. This changes the relationship with retailers who are already being disrupted by the 'prosumer' revolution affordable solar has created. However, we appreciate that ARC may not wish to develop renewable energy projects themselves and if so, negotiating suitable retail contracts remains important.

Proposed changes to network operating rules will see smaller operators such as Councils able to participate in high value demand responses, such as being paid to reduce demand or produce electricity at times where the network is stressed. Any supply agreements should account for this into the future.

Because the sector is rapidly changing it is difficult to provide definitive guidance in respect to retailer contracts. That said, there is also opportunity emerging in this period of significant innovation so it is important for Council to be clear on wants and needs as, chances are, at least one of the retailers will be eager to attract and retain council business.

In section 4.3.1 above relating to mid-scale solar arrays, CE sought to provide background into the function of energy retailers, which is to reduce the variability and volatility of a spot market into a simple pricing structure. In that sense they manage the risk of price blowouts for a customer and pay for this by making a margin in normal market conditions. Retails use a range of market mechanisms to hedge risk including forward purchase and long-term purchase contracts as well as owning their own generation assets.

Retailers also need to acquire customers and the space for this is increasingly competitive with ~160 retail licenses in NSW at present from a base of 4 retailers at the turn of the century. Retailers set a budget for customer acquisition in the range of $80 to $150 per person and accept that there will be an amount of turnover or 'churn'. Councils can attract competitive pricing because they usually bring a larger number of contracts (sites), signup for longer periods, and use a known bulk of energy.

If, as a result of this Plan, Council becomes an active participant the energy space, it is useful to understand the value that they bring and how this can impact negotiations with a retailer. Where council can reduce market risk and increase customer recruitment and retention, this will have value.

Going forward Council should be increasingly wary of simple bulk purchasing contracts for electricity as these approaches can limit the capacity for Council to save or off-set usage (usually a 20% reduction cap before fees apply) and to gain from participating in the new distributed energy economy. We recommend that Council be careful in engaging with any retailer over a long term and ensure the ability to reduce consumption along with fair exit conditions. Ideally any new retail agreement needs to enable Council to sell excess energy production to the retailer at a market or negotiated price, whilst purchasing electricity consumption at a fixed low price during peak times. The contract should also enable peer-to-peer trading and the operation of a Virtual Power Plant, potentially including distributed storage options.

There is an obvious opportunity for ARC through the New England Renewable Energy Zone. ARC may be able to negotiate supply contracts from 1 or more of the existing or future generators. A retailer will be required to facilitate the transaction and the mechanism may range from a simple retail contract or PPA through to block-chain enabled real-time supply reconciliation contracts.

Recommendation: That ARC does not commit to any long-term retail contracts until Council's own renewable generation strategy is clear.

Council should gain understanding of the selling/retailing strategy of the emerging generators in the REZ and be mindful that retailing energy to Council and/or local customers can be facilitated and negotiated via a participating retailer.

4.7 Transport & plant

4.7.1 Electric Vehicles

Australia lags many other developed nations where electrification of transport is progressing rapidly. With Tesla most prominently spearheading the 'mainstreaming' of fully electric cars, as opposed to hybrid drive trains, all major brands are now developing Electric Vehicles (EVs). Many countries internationally have incentives and targets for EV uptake and China leads the world with development and sales, particularly in the heavy vehicle sector.

As part of the Net Zero Plan, the NSW Government has introduced a NSW Electric Vehicle Strategy "intended to increase EV sales to 52% by 2030-31 and help NSW achieve net-zero emissions by 2050."

Key strategies include:

- $3000 rebates for the first 25,000 EV's purchased under $68,750
- Removal of stamp duty for new EVs and plug in hybrids
- Fleet incentives for local councils and businesses
- Expanded EV charging network
- Fast (T2 and Ts) transit lane access
- Regional EV fast-charger network and 'Tourist Drives'.

The relevance of EVs to this plan is particularly apparent when considering export of surplus generation and the fact that in around a decade, Council will be producing energy for essentially no cost. Even at existing c/kWh prices, the operational savings are clear as illustrated in the table below comparing a basic hatch-back.

Table 11. ICE vehicles Vs BEVs

Internal Combustion Engine (ICE)			Battery Electric Vehicle (BEV)		
Fuel efficiency	7	L/100km	Power efficiency	16	kWh/100km
Fuel cost	$1.80	per L	Electricity cost	$0.30	kWh
Annual km	15,000		Annual km	15,000	
Annual running cost	$1,890		Annual running cost	$720	
			Savings with EV	$1,170	per annum

Accurate granular data on fleet usage was difficult to obtain, however the following generic table is illustrative of the potential positive benefit in electrification of fleet and plant.

Table 12. Electrification of fleet

Description	Total	km per yea	L/100km	L per year	kWh/100	kWh p.a.
Road vehicles	46	15,000	10	69,000	16	110,400
Heavy plant	19	15,000	15	42,750	20	57,000
Minor plant	85			5,000		22,833
				116,750		190,233
			Unit cost	$ 1.80		$ 0.30
			Total cost	$ 210,150		$ 57,070

However, because the fuel costs are marginal in the context of greater CAPEX, even considering reduced servicing costs, at present the financial case for EVs may not be compelling. That said, ARC may value other factors, such as research, leadership, etc and these may outweigh the reduced financial case. With the continued fall in EV costs, increase in petrol/diesel costs, and government incentives, the case for EVs is set to improve.

Aside from fleet cars, there is perhaps a more compelling case to look at electrification of heavy vehicles. The City of Casey in Victoria has commenced garbage collection services with an all-electric truck and many factories already use electric forklifts. Again, the case for these will be made more compelling in years to come if Council has the ability to set its own pricing for the electric 'fuel'.

The most obvious conflict with solar energy and electric powered vehicles is in the time of use – that being the overlap of solar generation and daylight working hours. This can really only be managed through the use of batteries and/or by analysing which vehicles/plant can be charged during the day. There are fleet monitoring companies/devices that can be deployed to monitor vehicle movement and behaviour and this data can then be used to accurately build the case for transition to EVs.

An additional issue with EVs arises in relation to charging capacity; not just where to place them but the engineering behind delivering large amounts of energy quickly. So-called 'superchargers' require large amperage, not always available through the existing grid, and therefore can incur significant costs to establish. This leads to longer charge times and the necessity of charging overnight.

A final impact of EVs, though not for a few years, is the capacity for bi-directional charging. This is where vehicles become mobile batteries, capable of powering buildings to avoid peak consumption for example. In time, council may need to develop a policy for staff who charge their vehicle at work and power their house with it overnight!

Recommendation: That ARC participate in the NSW EV Strategy and invest in a small number of electric vehicles to test how they can be best integrated into operational activities. ARC would also benefit from improved tracking of vehicle usage.

4.7.2 Hydrogen powered drive trains

It is important to understand the 4 distinct elements involved in production and utilisation of hydrogen as a fuel.

1. Energy Source. This needs to provide regulated, good quality electricity and be matched to full chain production capacity.
2. Hydrogen Production. Classified as 'green' = produced with renewable energy or 'blue' = produced with fossil fuels. Basically, using energy to either split water or hydrocarbons.
3. Gas storage. From short term (buffering in production) to long term and both stationary (as energy storage) or transportable (like LPG).
4. Energy Conversion. Oxidation of the hydrogen to release water and energy in the form of electricity and heat. Most commonly in fuel cells or turbines.

Based on CE research it is possible to purchase existing small-scale electrolysers and produce hydrogen at around $5 - $6 per kg. This could be done at the site of a solar array to produce a transportable form of renewable energy.

The following table indicates the relative value of the hydrogen fuel in application.

Table 13. vehicle and pump performance and cost comparison

Toyota Mirai		
5.6	kg tank capacity	
0.76	kg per 100km	
737	km per tank	
$5	per kg x 5.6kg	$ 28.00
3.8c	per km	
7	L/100km	petrol car
$1.80	per L	
12.6c	per km.	
Truck FB	Scania/Volvo EV	
200	km range	
80	kWh battery	
2.5	km per kWh	
412.5	Km for 5kg	$25.00
6.1c	per km	
50	L/100.km	diesel truck
90c	per km	
Water pump		
100	kW capacity	
3.03	kg H per hr	$ 15.15
25	L diesel per hr	$ 35.00

It is important to remember that hydrogen vehicles are actually electric vehicles with a hydrogen fuel cell replacing chemical batteries. The advantage of this approach is in energy density and recharge times. A hydrogen powered vehicle can be recharged in a few minutes, just like a standard gas vehicle, and as can be seen in the table above, just 1 kg can move a vehicle >100km.

There is much conjecture about whether EVs or HVs will win the Australian market for renewably powered vehicles however it is the view of CE that each system has strengths and weaknesses. The range and speed of refuelling through existing infrastructure point to an advantage for HVs in regional and remote Australia. Certainly, one Australian company is banking on a solid market - H2X currently plans to produce 20,000 HVs each year by 2025 out of the Illawarra region in NSW.

ARC own and operate a range of plant and equipment for which there are currently no battery-electric or hydrogen-electric powered models available. Caterpillar, Hitachi, New Holland and many more start-up firms are researching and developing renewable powered alternatives to the full range of heavy plant and equipment. Mining companies at the forefront in much of this development.

The Australian Government is invested in the CSIRO National Hydrogen Roadmap released in 2019 and has leveraged $ billions in private investment to stimulate a hydrogen economy for both internal and export markets. The stated aim in much of this investment is to lower production costs to meet a $2 per kg threshold. Some commentators expect the price to fall from the current $5-6 and reach $3 by 2025.

Recommendation: That ARC position itself as a centre for R&D in the emerging hydrogen economy as part of the REZ. That Council conduct feasibility into a pilot plant and vehicle(s).

4.7.3 Electric devices

Cordless power tools and light plant such as lawnmowers are also the focus of many manufacturers. For example, Makita have ceased all R&D into petrol powered tools and plan to move completely away from internal combustion engines. While these tools and plant use a small amount of energy in comparison to cars for example, there are operational advantages in not having to deal with mixing fuel and small engine maintenance.

Commercial grade brush-cutters and chainsaws are quieter, simpler and deliver instant power with back-pack battery systems that can deliver several hours of continuous operation. They are more expensive to purchase however these prices are falling with increased market share. In time we can expect to see a greater range of electric small plant and equipment as the energy density and affordability of batteries improve.

If ARC seeks to electrify small plant and equipment, we suggest that a decision is made to, as much as possible, stick with one ‘family’ so that battery packs and chargers can be shared. Thought must also be given into the creation of battery e-waste and the non-sense in discarding perfectly functional equipment which may only have occasional use, simply to remove a small amount of hydrocarbon fuel consumption.

Recommendation: That ARC adjust procurement policy to preference electric plant and equipment for replacement and new purchases.

5.0 Other Renewable Energy Options

5.1 Pumped Hydro

The Armidale Regional Council region contains hills, gorges and disused mining facilities that may be appropriate for pumped hydro schemes as evidenced by the 600MW Oven Mountain proposed project.

Pumped Hydro is emerging as a preferred dispatchable energy source, particularly over longer timeframes (8+ hours), due to its flexibility and low carbon emissions. Using combined pump/turbine plants, water is pumped from lower reservoirs to higher ones at times of plentiful or cheap energy and then released at times of peak demand when the price for electricity is high. Medium scale Pumped Hydro is likely to become an important 'product' in future markets as a buffer or insurance against high power prices and to time-shift large solar production from the middle of the day until night-time.

If Armidale Regional Council elects to proceed with a mid-scale array, then an equivalent scale pumped hydro scheme could be investigated in comparison to other forms of storage. For example, are there opportunities to construct a 'turkeys' nest' dam near Malpas Dam? Regardless of progressing Armidale Regional Council's own solar, it may be that a council-owned pumped hydro facility would be economic on the basis of services to other renewable energy projects in the area.

In the medium term dispatchable energy is becoming increasingly valuable to the National Energy Market, often attracting pricing around twice the value of daytime generation. On a micro scale, with water pumping being a major cost centre for ARC, any new Council upgrades or water security initiatives should also consider energy production as part of their remit, particularly if there are pressure reduction valves in the water distribution network.

Recommendation: Limited action in relation to pumped hydro at this point in time. It may be something to have 'on the radar' in discussion with TransGrid and other organisations looking to develop energy projects in the REZ.

5.2 Wind

Armidale Regional Council is in a valley however the surrounding ranges have a fantastic wind energy resource which was part of the rationale behind selecting the region for a Renewable Energy Zone. Technologies that harness wind energy may present a significant opportunity for ARC to reduce operational costs and meet carbon emissions reduction ambitions, not least of which because they are capable of generating at any hour of the day.

Cases for wind energy include powering:

- Lighting for footpaths and roadways.
- Public amenities - roadside rest areas, toilet blocks, barbeques and shelters.
- Pumping stations.
- Telecommunications towers.
- Telemetry systems such as for water monitoring devices and security systems.

From the energy consumption data, street lighting produces around 17% of Council's emissions which, if wind powered, would meet a significant proportion of Council's emissions reduction goals. Given that around 2/3 of Council total energy use occurs outside daylight hours, wind requires further investigation. The question is, at what scale and how might a Council utilise wind energy?

5.2.1 Small Wind Turbines

Small wind turbines are emerging as a cost-effective renewable energy technology. These systems can be beneficial where there is a desire to provide amenities to the public in locations where grid-connections are cost prohibitive. In many cases, the cost to buy and install these amenities can be significantly less than the grid-connection, with the additional benefits that the operational cost to power the sites is effectively zero, using zero emission technology.

Smaller turbines are common in Europe on public buildings and some councils in Australia have engaged with small-scale turbines as part of hybrid solar-wind-battery remote energy systems. There are several Australian owned companies providing barbecues, shelters and other public amenities furniture with integrated solar, small wind and battery systems.

One Australian start-up Diffuse Energy (https://www.diffuse-energy.com/) has designed and commercialised small wind turbines. Their Hyland 920 turbine has been designed to work side by side with solar and batteries to reliably power telecommunications infrastructure at remote locations. The operating costs for this technology are extremely low, compared to diesel power generation.

To demonstrate how this technology may be applied for ARC, we have produced a conceptual model of a new off-grid public amenity (based on a typical amenity block).

Table 14. Armidale Regional Council Off grid public amenity concept

New amenity	Load	kWh/yr*	kWh/d*
1	New amenity	4168	11.4
	Annual cost	$1,436.00	
	Cost per day	$3.93	
Grid connection			
1	Grid installation CapEx	$30,000.00	
	reduced to daily rate at	10	year Payback
	=	$8.47	per day to finance
	Total cost	**$12.40**	per day
*Usage figures modelled off Mckie Parkway Recreation Area			
smallWind	System size	220	W
1	Daily output	2.1	kWh
	Annual output	766.5	kWh /yr
	Annual cost	$2,433.33	
	Cost per unit per day (installed)	$6.67	
Solar	System size	3	kW
	Daily output	12.8	kWh
	Annual ouput	4,674	kWh / yr
1	Per W installed	$1.35	
	CapEx	$6,000.00	
	=	$1.69	per day (10 years)
Battery	System size	13.5	5kW/13.5kWh
1	Installation cost	$11,700	
	reduced to daily rate at	10	year Payback
	=	$3.21	per day to finance
	Total cost	**$11.57**	per day
	Carbon Offset	3.37608	tonnes p.a.
*Emission factor 2021 (NSW)			

As can be seen from the above figures, if a new grid connection was to cost $30,000 (e.g., connection fees + new pole + undergrounding + consultants) then this can be reduced to a daily cost over a lifetime or depreciation period of $12.40. Applying the same logic to the capex for an off-grid hybrid energy solution leads to a daily cost of $11.57. Of course, the absence of daily supply and consumption charges improves the case for an off-grid solution in this instance too.

5.2.2 Large Wind

There is also the potential for Council to use larger wind energy installations to offset significant amounts of energy usage. Larger installations necessitate more planning requirements with longer implementation timeframes but can provide significant benefits due to long project life and low operating costs. Large turbines typically range from 2MW to 5MW and even at the smaller scale, a single turbine would be readily capable of providing all of the energy consumed by ARC.

Although 'mid-scale' turbines are available from 100kW to 1,000kW, the economics of wind energy and challenge gaining approvals tend to leave out the middle ground, leading to the massive turbines and multiple tower wind farms we see developing. That said, Armidale is somewhat unique in having REZ and there may be opportunities to leverage the work of wind energy developers to the benefit of council. It may also be worth testing the market for a mid-scale turbine in the vicinity of a possible solar farm on high ground, in proximity to usable network infrastructure, and away from residences.

An ARC backed community project, in a form similar to the Hepburn community wind energy project (https://www.hepburnwind.com.au/) may be achievable. That project delivers around 10 GWh per year - more than double ARC's energy consumption. An innovative business model, where ARC has a power purchase agreement (PPA) and/or part ownership with the community project could provide the necessary incentives to get the project running and attract external investment, while also allowing ARC to meet its goals of becoming net carbon neutral. However, the approvals process for large scale wind turbines can be slow and may not be realistic until at least 2025.

Recommendation: Small-scale wind generators should be considered for any new or existing remote infrastructure. Mid-scale wind generators could be considered as part of a hybrid mid-scale project (which we have not modelled). Local wind farms could be approached to provide renewable energy to Council to fill the shortfall if Council elects to proceed with solar only as the offset strategy.

5.3 Virtual Power Plants

This model has been identified in principle in Section 4.3.2 above. In essence it says that, rather than seek renewable energy from a retailer or large corporate owned generator, seek the equivalent amount through aggregating surplus from a group of smaller installations.

The distributed community model is viable and there are precedents in Australia however this model can become complex and should be thought through carefully. It would be advisable to plan this with the engagement of service/community groups and business groups. It may be that there is significant community interest and that Council's role is welcomed under the following model.

- Council leverages relationships and procurement expertise to identify a trustworthy, reliable solar solution and provider(s)
- Council guarantees to purchase the export from non-council participants
- Council subsidises the 'up-sizing' of arrays to increase export available to purchase
- Council coordinates retailers and provides confidence in a 'good deal'.

In the current environment where large retailers are generally disliked and there is resentment at the looming removal of residential feed in tariffs (in fact the possibility of being charged to export), Council offering to purchase the export may be welcomed.

As can be imagined, this approach would require Council to recruit and facilitate a group of 'partners' with the capacity to install solar that, after whatever self-consumption occurs, resulted in the equivalent of about 2.5 MW capacity. Subtracting the 1.35 MW identified in section 4.3.2 above, this equates to a further 1.15MW. This could potentially be met through oversized systems on about 200 - 300 premises.

CE have previously modelled this for another council and found the $ per kW installation cost significantly more expensive than the mid-scale array option however this could be re-tested. Install cost could be mitigated if an attractive deal can be constructed for participants to part fund the installation themselves. This approach clearly places Council in the realm of community solar projects and as such, council need to be sure they have the appetite internally and confidence in the community to become engaged in such an approach. The approach would require detailed modelling, careful structuring and a recruitment campaign.

Recommendation: ARC decide on the degree to which their 100% renewable target should be pursued with discrete projects they can readily control, versus a community engaged approach with incentives and a VPP structure for Council to claim the entire generation pool.

5.4 Bioenergy

Bioenergy requires organic feedstocks which are digested or gasified in vessels, resulting in a range of simple hydrocarbon gasses (e.g., methane) or liquids (e.g., ethanol). While bioenergy can be applied as a dispatchable energy source, it can also potentially become a renewable fuel source to replace gas and diesel, rather than electrifying diesel plant and equipment.

There are broadly three approaches to converting biomass into energy: direct combustion, gasifying and digestion. Different feedstocks lend themselves to each approach but in all cases, it is important to secure a consistent and reliable supply.

Given the fertile nature of the Armidale region there are potential feedstocks of organic materials or wastes, such as feedlots. Residential and commercial waste transported to the waste treatment centre may provide enough feedstock to match council demand, but this has not been quantified for this report. For example, in simple terms, would there be around 30,000 L per year of waste cooking oil to be converted into biodiesel for running Councils heavy plant and equipment? (Not-withstanding production quality and warranty issues). Could the landfill site generate enough methane which, when scrubbed, would be meet the demand for LPG to provide heat energy?

There are also systems that utilise the high calorific value in human waste. CE has experience in researching a US firm that operates sewerage treatment plants at around the 8ML per day capacity. These 'Nepsus' systems use a digestion process that results in clean water, low volumes of powdered solids, and which runs itself on gas-fired generators. The systems are also smaller than trickle or aerator plants and have reduced Capex and Opex. If and when the Armidale STP is due for upgrade or replacement, CE strongly suggests that ARC investigate 'waste to energy' treatment options.

The Australian Energy Market Operator has identified bioenergy as part of the 'future mix' of energy for Regional Australia and Armidale Regional Council presents as an excellent candidate for the integration of this technology in a diversified and distributed low-carbon energy future. A specific high-level audit of organic waste streams would be the starting point for investigating bioenergy. Refer to Latrobe City Council for business case for installing a bio energy unit at their landfill site.

Recommendation: ARC make a strategic decision on how to approach renewable energy for building HVAC gas and diesel plant/vehicles. ARC may seek interest or funding with stakeholders in the REZ to further investigate the potential of bioenergy.

5.5 Microgrids and embedded networks

The term microgrid traditionally applies to a discrete network of interconnected loads and one or more generators independent of a larger network. More recently it applies to sub-sections of the grid with a single point of connection, multiple loads and embedded generation and with the capacity to run independently. These are also called embedded networks and examples are shopping centres and some industrial or housing subdivisions.

Microgrids are going to play a large role in future new greenfield developments in regional Australia. The costs of installing and firming renewables are now competitive and, in some circumstances, much cheaper than installing and maintaining the poles and wires to new remote locations. There are also examples where a number of meters can be consolidated into a single market facing meter and with basic wiring and administrative changes, result in reduced billing due to standing charges.

Interestingly, in the evolution of providing energy as a service to communities, local governments were the original providers to households and businesses through what we would now call Microgrids. Councils operated the generators (usually coal, gas or diesel) and looked after billing. When state governments offered a centralised alternative, it was attractive because it saved hassle for councils. With new enabling technology, good business cases and an agenda to decarbonise energy sources, council owned and operated microgrids may be viable again.

In our view, the most obvious potential is with Industrial microgrids where council can be part of underwriting the development of estates where energy supply is both renewable and affordable. This could be attractive for Commercial and Industrial enterprises seeking to establish in the regions.

Recommendation: For Armidale Regional Council, microgrids should be considered for any development likely to have a few or more meters connected to the network. If Council is the enabler, then it is likely to result in reduced operating costs for sub-metered customers and an on-going revenue stream to Council.

Constructive Energy has the role of Technical Director in a federal government funded study into the application of microgrids in agriculture with Queensland Farmers Federation and others.

5.6 Off-grid facilities and critical infrastructure

Many remote communities and mining operations are currently installing independent generation facilities. A good example of this has occurred in remote farming communities around Esperance WA. In 2015 a large bushfire caused loss of life and property, including large swathes of the local electricity distribution infrastructure. In agreement with the local community the electricity provider (Horizon Energy) has installed a virtual microgrid with each customer having their own solar production and firming capacity (battery). Locals have confirmed that the outcome for them has been stable and reliable power at equivalent cost (source: ABC news Oct 2019)

We recommend that serious consideration is given to installation of solar, battery and backup generation capacity for any new developments planned by Armidale Regional Council where access to the network may be problematic or expensive. Further, this approach can provide energy security for critical infrastructure in the event of natural disasters or other supply interruptions. The emerging hydrogen economy can also offer solutions in this context.

Recommendation: That Armidale Regional Council consider the relative importance of energy security at key sites and factor this into considerations for BtM installations as this may be the factor that weights the business case towards proceeding.

5.7 Ground Source Heating and Cooling

Where major retrofits are being undertaken or new buildings constructed, the possibility of using ground source air conditioning should be considered. Opportunities such as open trenches for other plumbing work could be used to improve the cost-effectiveness of installing buried pipe loops as part of a ground source heat pump solution.

There are examples globally of roads being underpinned with a network of pipes to capture solar-thermal energy which then dramatically reduces heating costs for nearby buildings in winter.

While seemingly left-of-field, using the temperature of the earth to heat and cool can be low-cost, low maintenance renewable energy source, particularly in a setting like Armidale which receives high variance between daytime and night-time temperatures.

Recommendation: Include ground source as a technical solution to investigate in specifying upgrades to building Heating Ventilation Air Conditioning systems.

5.8 Demand Side Participation (DSP)

Demand Side Participation has been referenced elsewhere in the Plan however it does stand on its own as an opportunity for Council to participate and financially benefit from the scheme. The Australian Energy

Market Operator (AEMO) has forecast elevated risk to electricity supply over the next 10 years, and in particular, interruptions to electricity supply during peak summer periods.

A contractual arrangement can be entered into by Council (the participant) with AEMO, in which they agree to the curtailment of non-scheduled energy consumption or provision of non-scheduled generation in response to the demand of electricity.

Examples include industrial facilities that are exposed to the wholesale price and elect to reduce electric load at times of high prices, consumers that agree to let their battery be controlled by a third party or are incentivised to switch off air-conditioners, and small non-scheduled generators that have the ability to produce electricity at these times, offsetting local consumption (source: March 2020 - Demand side participation forecast and methodology).

DSP will become an increasingly prevalent component of energy retailing and network operation and should be included in the consideration of retail contracts.

Recommendation: Council explore opportunities to have control over solar and battery production and key discretionary loads to be enabled during peak periods for financial reward.

6.0 CAPEX Funding and Ownership Models

The strong economic return in renewable energy infrastructure is resulting in a range of potential investment options and there is currently significant investor interest which can be leveraged. The following enabling mechanisms all have relevance and precedent within the local government sphere.

Armidale Regional Council owned and operated on ARC facilities

Delivers ARC the shortest pay-back and maximum return (cash flow) but ARC carries all the risk (after warranty). ARC may choose to invest existing reserves (including grant funding) or take advantage of low borrowing rates to structure projects as cash-positive from day 1. TCorp are highly supportive of local government renewable energy projects and currently offering interest rates around 3%.

Corporate owned

Corporate owned on Armidale Regional Council facilities**:** It is common practice for solar companies to offer installation at no cost and to enter into a Power Purchase Agreement (or equivalent lease-type arrangement) that will slightly reduce and lock in a cost for energy over typically a 7 - 10-year timeframe. In this instance the provider carries the risk and maintenance burden but is able to generate a cash flow and profit after the pay-back period. The asset is often gifted to the host at contractual exit e.g., after a 12-year period.

Community Owned on Armidale Regional Council facilities

There is a strong movement for community ownership of commercial and larger scale solar plants and many models and organisations exist to facilitate this. The arrangements are similar to corporate investment however the financial returns are distributed to community investors, typically at around 6 – 10%. Community owned solar is seen as a way to engage community and to share economic benefits locally and in many parts of the world a set percentage of community ownership is stipulated as a condition of consent – particularly in wind projects.

Armidale Regional Council as provider on/to third parties

Subject to the right agreements and on the strength of business modelling, Armidale Regional Council may choose to invest in solar panels on or near industrial sites in ARC and to benefit from a Power Purchase Agreement while supporting local business through reduced operating costs and energy certainty.

Hybrid funding

For certain larger installations it is possible that a range of funders invest in the project. For example, the host/energy user, the community, Council and a third-party commercial operator may all invest in a set percentage share of a project.

7.0 ARC Renewable Energy Roadmap

7.1 Principles based approach

Recalling the Decision-Making Framework described at the front of this report, the following list may be helpful in prioritising the recommendation made throughout.

- Carbon reduction – does the project contribute to Project Zero30
- Benefit/Cost – does the project have positive financial impact?
- Community benefit – how does the wider community benefit from this project?
- Logic – is the project practical, defensible, sound, ethical, enduring?
- Leadership – will the project stimulate positive change in others?

Specifically related to point 4 'Logic', the following factors are worthy of including in a matrix to determine hierarchy.

- Speed – can this be designed, approved and operational in time?
- Complexity – in terms of both technicality and stakeholders
- Control – is ARC in the driving seat?
- Potential for funding support – grants, REZ proponents, etc.
- ROI – is it financially acceptable or compelling?

As ARC moves towards the energy self-sufficiency, price control and cost savings potential of renewable energy, it is important gain clarity on the relative priority of various project drivers. These will need to be continually reviewed in the context of each project as development brings new insight.

While CE have sought to identify a framework to support decision making it is the process of deciding what is important and how to decide that is most critical. For example, the solution for the same specific opportunity will change depending on the relative importance of, say,

- Local skills and employment
- Carbon reduction
- Project lifetime
- Financial dependencies

CE Strongly recommends embedding the practice of identifying and ranking the drivers associated with any of the projects that arise out of this Plan which will no doubt include drivers specific to the operation of the equipment itself.

7.2 Recommendations

Recommendations made throughout the report were tabled alongside actions required to meet the recommendation. This Recommendations Ranking Table (see Appendices) was used in a meeting with the key ARC staff and Councillors where each line initiative was discussed in the context of the decision-making framework introduced in Section 1.4 above.

As a result of the discussion, the following Summary Table was developed with the intention of clearly listing the ideal outcomes and next steps or activities associated with implementing the recommendations. While a timeframe has been indicated, the 'Responsible' column has been left blank pending internal dialogue at the time of writing.

A table specifically related to Energy Efficiency is also included.

Renewable Energy Action Plan – Summary Table

	Recommendation	Ideal Outcome	Activities	Timeframe	Responsible
1.	Increase energy awareness Improve energy transparency and control at all sites, including generation, storage and key loads.	ARC understands and controls energy usage to optimise productivity	Establish a Council-wide policy to implement smart meter and dynamic load control devices and platforms. Include site energy usage in PDs for relevant asset managers and operational staff. Ensure smart meters are installed in association with any other electrical installation or upgrade works. The meter should have capacity for sub-circuit and device load control.	2022 - Ongoing	
2.	Move towards energy autonomy Create sufficient council-controlled renewable energy generation to supply all of ARCs energy and/or offset emissions.	ARC supplies renewable energy to itself at a known and affordable price	Shortlist sites with sufficient space and potential planning consent, complete necessary network connection enquiries and develop high-level business case(s). Include energy storage in project/business modelling. Make a strategic decision about the application of on-site distributed renewable energy and its capacity to reduce energy consumed by Council. Consider Zero30, carbon and retailer strategies	2022 - 2024	
3.	Engage carefully with Retailers	ARC is serviced by flexible, fair retail arrangements.	Establish what it is that Council would ideally like from a retailer. Identify and develop relationships with innovative retailers.	Contract renewal and powerplant development	

	Recommendation	Ideal Outcome	Activities	Timeframe	Responsible
4.	Electrify vehicles, plant, and equipment	ARC fleet, plant and equipment is low-emission, affordable and effective.	Adapt procurement policies to preference electric plant and equipment for replacement and new purchases. Ask staff to research electric alternatives. Replace as current plant retires. Consider engaging a fleet tracking and optimisation service to identify and prioritise EV opportunities. Work with NSW Government to support charger roll-out and fleet changeover.	2022 - Ongoing	
5.	Lead energy innovation	ARC becomes known as an attractive place for R&D, trials and implementation of new technology	Define the 'things' that ARC can offer to 'players' in the energy sector, specifically around hydrogen, pumped/ hydro energy, alternative fuels and bioenergy. Develop communication materials specifically to position ARC as a centre for innovation in the emerging energy sector, especially as part of the REZ. Monitor industry developments with Hydrogen, liquid fuels and bioenergy.	Ongoing	
6.	Have a stake in energy asset ownership	ARC receives additional revenue streams through the provision of utility services	Consider microgrids when reviewing Planning Policies and/or proposed projects. Microgrids, embedded networks, certain Medium Voltage infrastructure, storage and generation assets should be considered for developments likely to have a few or more meters connected to a network or remote developments.	Ongoing	

	Recommendation	Ideal Outcome	Activities	Timeframe	Responsible
7.	Plan for energy security and climate resilience	ARC assets and communities are robust and resilient to the impact of climate change and other shocks	Investigate drivers of, and funding for, resilience initiatives. Consider the relative importance of energy security at key sites and factor this into considerations for BtM installations.	2022 - 2023	

Renewable Energy Action Plan – recommendations evaluation and ranking

Energy efficiency is presented as a specific subset of the recommendations on the basis that it is important regardless of the REAP and avoiding waste is often the most cost-effective way to improve energy productivity. However, in the context of this REAP, minimising consumption also minimises the extent of renewable generation required which in turn reduces the environmental impacts associates with the creation, use and eventual disposal of generation equipment.

	Recommendation	Action		Lead
1.	**Monitor consumption:** Engineering and/or Finance are responsible for reviewing energy usage at all sites and of key equipment/assets.	Energy consumption incorporated into all relevant Position Descriptions		
2.	**Reporting and performance:** Energy use for sites/assets is reported in regular section meetings and efficiency forms a component of staff position Descriptions and Performance Reviews.	Energy consumption incorporated into meeting/periodic reporting templates		
3.	**Procurement policy:** Energy consumption rates are considered in the procurement of any new equipment or servicing and maintenance of existing items. This includes new buildings and vehicles.	Energy efficiency standards integrated into procurement guidelines		
4.	**Retrofit strategy:** Building modifications will be carried out at least in part for the purpose of reducing energy consumption.	Building modification to trigger audit and/or NatHERS/NABERS rating.		
5.	**Education:** Armidale Regional Council makes it easy for staff and constituents to reduce energy consumption through promotion of strategies and materials that facilitate energy efficiency.	In corporate key message of energy efficiency into communications strategy.		
6.	**Planning**: Armidale Regional Council promotes energy efficiency in design through the planning phase where applicants are encouraged to adopt Guidelines for factors including – insulation, glazing, orientation, primary equipment, water use, etc.	Set minimum NatHERS/NABERS or GBCA star rating standard		
7.	**Product broker**: Armidale Regional Council applies knowledge and purchasing power to support residents and businesses with products that reduce their energy consumption.	Establish community working group		
8.	**Street lighting**: Armidale Regional Council continues to work with other councils/programs to replace existing lights with efficient alternatives.	Optimise uptake and control of efficient and smart lighting		

- NatHERS = National Home Energy Rating Scheme
- NABERS = National Australian Built Environment Rating Scheme
- GBCA = Green Building Council of Australia

7.3 Midscale solar powerplant

During CE's engagement with Council on the REAP, Council has articulated the appetite to pursue further renewable energy generation asset(s) across Council portfolio including a midscale solar powerplant.

The Mayor Cr Copeland and the Energy committee has expressed the desire of Council to have its own Renewable Energy assets that can: -

1. Generate revenue.
2. Reduce operational expenditure across Council facilities.
3. Reduce Council's carbon emissions.

CE recommends that the easiest methodology to achieve these objectives is via, a dispatchable midscale solar power plant (1-5MWp solar and BESS system).

There are three basic tenants required to develop a midscale RE powerplant:

1. Secure a long-term offtake agreement to underwrite the financial viability of the project.
    - Council immediately meets this prerequisite via its own annual energy consumption (3.8GWh p.a.). This volume of energy is enough to justify the business case for a RE powerplant of >2MWp. You are your own best customer.
2. Secure the land tenure via lease or purchase.
    - Council owns multiple sites that are likely suitable for a midscale solar powerplant. The STP seems the most obvious location. A powerplant could be located on the otherwise sterile land provided it is located close to the required electrical infrastructure needed to connect to the Essential Energy network.
3. Secure the necessary approvals (DA and network connection)
    - CE has guided several other organisations (government and private) through these applications. CE recommends staging the project and taking an iterative approach. This requires Council to commit initial finances to proceed the project. However, if Council decides to discontinue the project, during stages 1,2 or 3, some of the initial costs can be recovered via the sale of the project to another project proponent.

A midscale solar powerplant provides intergenerational benefits for ratepayers. Councils are in an ideal position to take a "long view" required for this type of project.

If Council are to embark on a midscale solar, we make several key recommendations and the following expectations need to be set.

- Leverage the ARC location in the New England REZ. Both the state government and leading private developers are likely to lend assistance to Council in development of your own asset. This may come in multiple forms e.g., procurement of solar modules or construction expertise.
- Don't be afraid to oversize the plant. The fixed CapEx on the HV connection is unavoidable and the economics are often more favourable if the LV component of the RE powerplant is scaled.
- Include storage and develop a dispatchable powerplant. Dispatchability provides price certainty for Council and ensures that ARC can provide energy at any time of the day. One thing is for certain, no one can predict future energy market conditions! A battery and\or storage solution is an insurance policy.
- Expect that this project will take 2 years to deliver. Network connection approvals take minimum 1 year to apply, complete studies and to seek approval.

- Don’t expect to have the same IRR of rooftop solar. These RE powerplants use different equipment, are very robust and have rated lifetimes of 25-years and beyond. Expect the payback to be between 8-12 years.
- The critical investment for Council is to secure the network connection. As RE technology continues to evolve and develop, the network connection will remain the key component enabling Council to share energy and benefits to the ARC community.

Outlined below in Diagram 1 is the proposed methodology and indicative pricing (inclusive of 3rd party fees) to get a midscale RE power plant project to ‘shovel ready’.

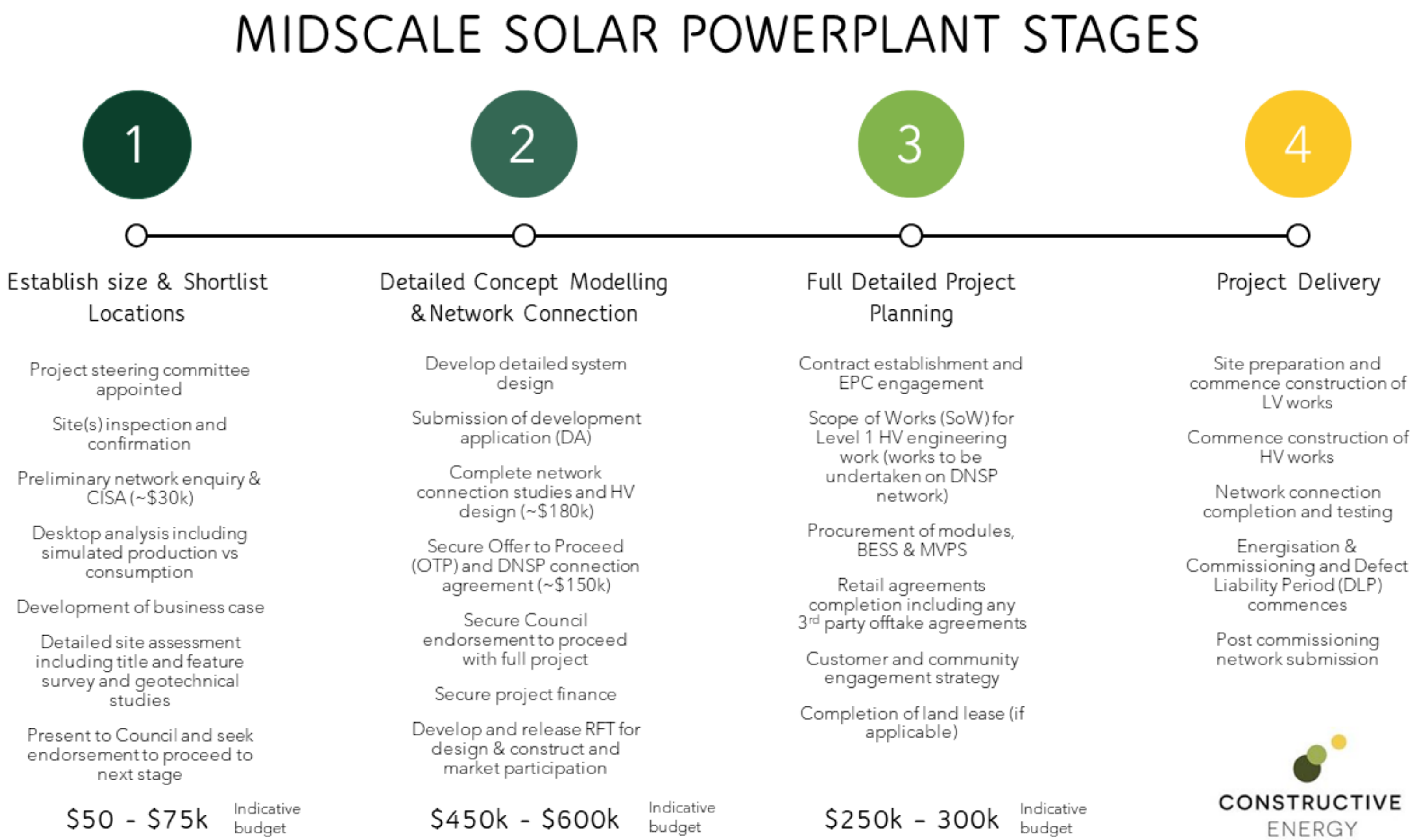


Diagram 1. Midscale solar powerplant roadmap

Appendix

Specific contract site analysis

This section of the report explores a series of charts related to each of the large market facilities managed by Council. Understanding when energy is consumed across time creates an 'energy profile' for each site which becomes important in making decisions about the business case for renewable power, load shifting, energy storage and efficiency.

Administration Centre

Site details

Street Address	135 Rusden St, Armidale NSW 2350
NMI	**NFFFNRKC04**
Roof space	Very limited
Map URL	Administration centre
Description	The administration centre is centrally located in the regional city of Armidale.

Assessment

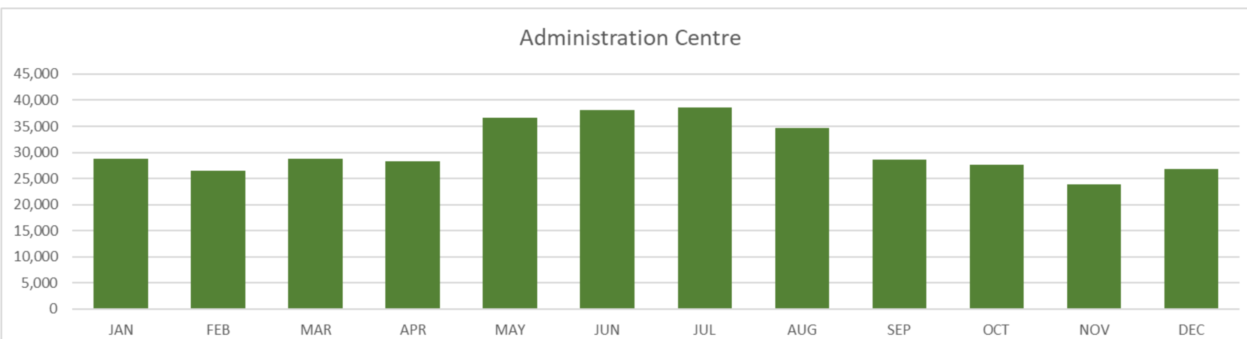
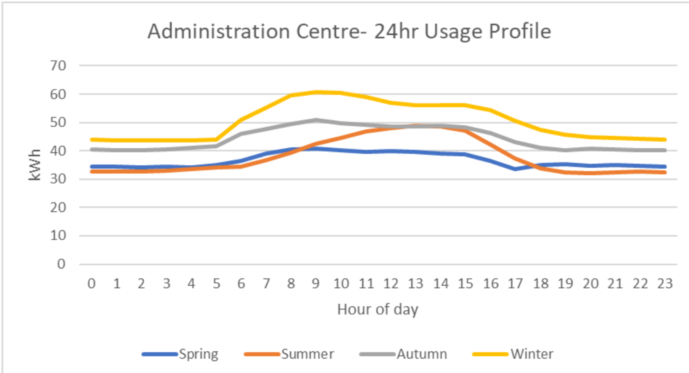


Chart 12. Administration Centre annual usage profile

As anticipated the Administration centre has a consistent 12-month energy profile. The energy consumption peaks during the winter months.

We commend the operations team for adopting significant energy efficiency measures at the administration centre. These including upgrades to the HVAC systems and halogen lighting replacement for the more energy efficient LED lighting.



The intraday energy profile is consistent with a typical office building profile. The energy consumption follows an energy curve, peaking in the middle of the day followed by a consistent overnight load (7pm-6am) ranging between 30-40kWh resting load.

This administration centre energy intraday profile matches well with a daily solar generation profile; however, the winter peak doesn't align with a reduced solar production over winter months.

Chart 13. Administration Centre 24-hour usage profile

Council has investigated a BtM solar installation for the administration centre, however the roof is unsuitable nor has adequate available space to install any meaningful solar system at this site. We would recommend offsetting the Administration centre's electricity load with a midscale solar and battery renewable energy plant. There are retail mechanisms available for Council to generate excess energy at other suitable RE locations and share the energy with the administration centre. This is covered in detail in section 4.3.1.

Our recommendation for the administration centre is to continue with any additional energy efficiency measures. The ARC facilities manager indicated that the main HVAC system was approaching end-of-life. We recommend that the replacement system be made with energy efficient system and that Council look to any other measures to reduce heat loss from the building.

If Council opt to pursue a midscale renewable energy power plant, a proportion of the annual spend for the administration centre can be used to service the loan repayments and energy can be shared amongst this site and other Council facilities.

We also recommend that Council refrain from locking into any long-term and inflexible retail arrangements for the Administration centre. These contracts will prove a roadblock for Council to pursue a midscale solar opportunity. CE are aware of electricity retailers that will offer c\kWh discounts that appear attractive on face value, however many of these arrangements lock the energy user into minimum monthly volumes for the term of the contract. These contracts also likely penalise the Council for an early contract exit.

Sewerage Treatment Plant

Site details

Street Address	Cafferies Road, Armidale NSW, 2350
NMI	NFFFNRKC02
Roof space	N\A
Map URL	ARC Sewerage Treatment Plant
Description	Located 5km from the centre of town on the Waterfall way.

Assessment

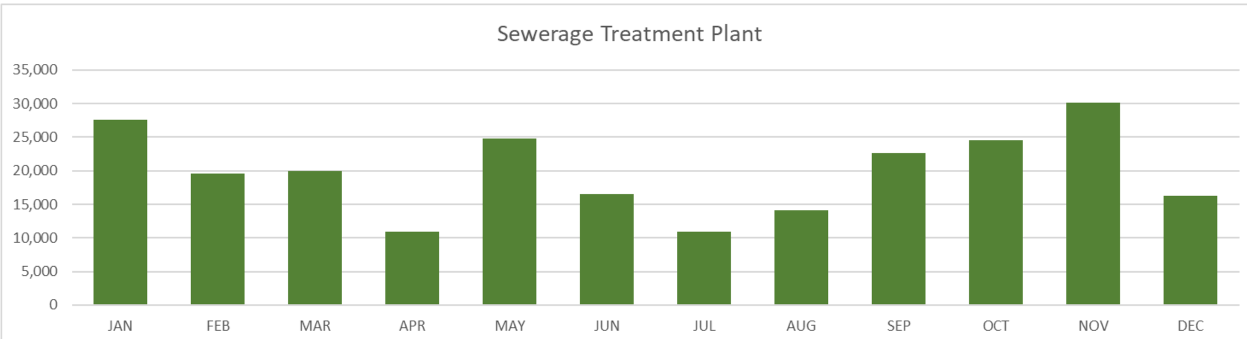


Chart 14. Sewerage Treatment Plant annual usage profile

The STP has a variable annual consumption profile. This likely fluctuates with weather conditions. The STP's 24-hr profile has a huge drop in load in the middle, likely caused by the existing BtM solar installation at the STP. This is likely accentuated with the operational schedule being set to take advantage of off-peak consumption charges.

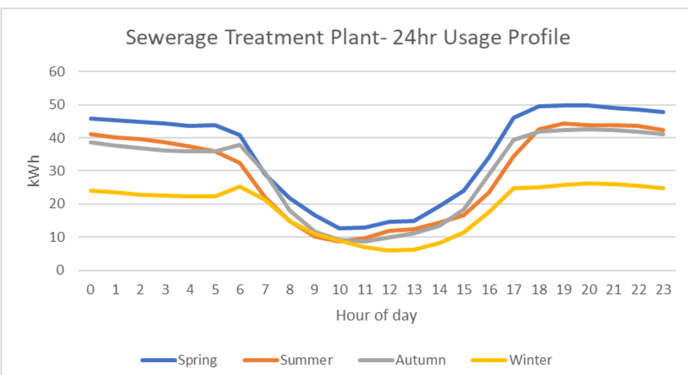


Chart 15. Sewerage Treatment Plant 24-hour usage profile

This site has been identified as an ideal location for midscale solar and storage. It is located <2km as the crow flies from multiple zone substations (Transgrid & Essential Energy).

There is available Council owned land at this site and being a STP, the land is 'sterile' and unsuitable for many other land uses.

We recommend that Council commence a preliminary network enquiry and undertake a detailed feasibility study into midscale solar and storage at this site.

Our desktop analysis and site inspection identified available land suitable with a north-westerly aspect suitable to install <5MWp. A plant of this size would enable Council to offset 100% of Council's annual grid energy consumption and allow Council to realise its ambition of 100% renewable energy.

Ozonation and Water Treatment Plant

Site details

Street Address	2 Edgar Street. Off Arundel Drive, Armidale NSW 2350
NMI	4001209713 & NFFFNRKC03
Roof space	Not available.
Map URL	Ozonation and water treatment plant
Description	Located on Edgar Street (off Arundel Drive), and approximately 4km from the centre of Armidale.

Assessment

The ozonation and water treatment plant has available land to the North of existing infrastructure. This site may be suitable to install some renewable energy assets. However, this space may be reserved by Council operations for future expansion of the plant.

The area is approximately 6200 m2, which would allow for ~3MW of ground mount solar to be installed. The site does have some established vegetation and is close proximity to residences, which may prove problematic for an installation.

Map 3. ARC Ozonation and water treatment plant (source: Six Maps May2022)

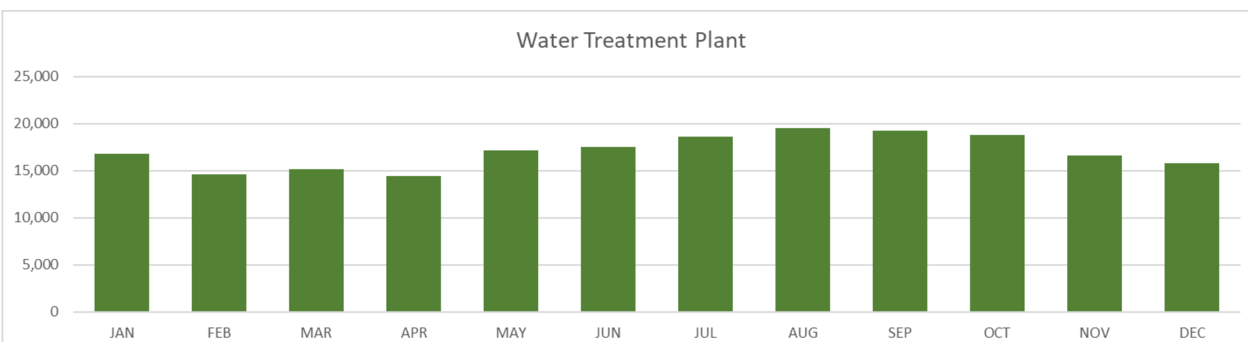


Chart 16. Water Treatment Plant annual usage profile

The usage profile for the water treatment equipment is very consistent across a 12-month period. The ozonation plant has more variance, and as expected uses more during autumn winter (May-September).

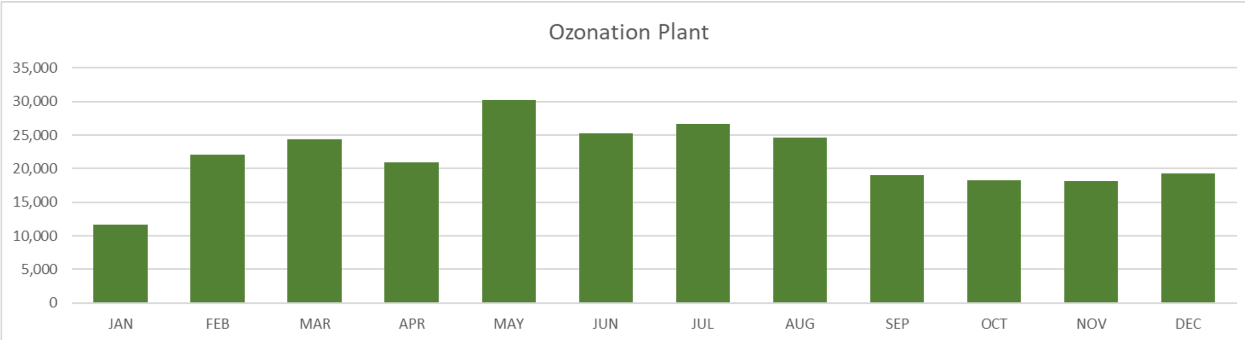


Chart 17. Ozonation Plant annual usage profile

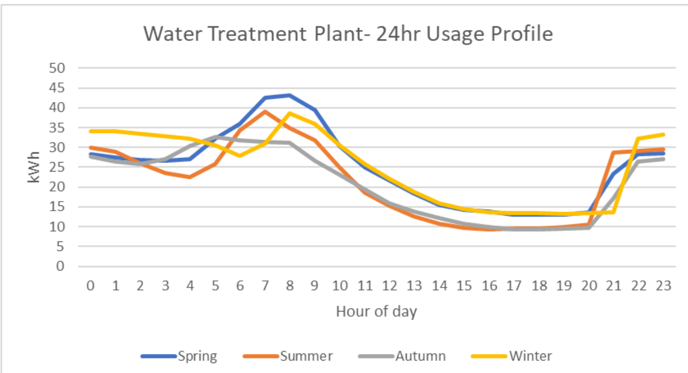


Chart 18. Water Treatment Plant 24-hour usage profile

The plant consumes most energy overnight and during off-peak times. It is consistent load overnight from 9pm through to 5am. The load then peaks between 6am and 9am, likely corresponding with town water peak usage.

Similar to the Garibaldi Street pumps. The operations of this plant may not be able to be altered as it provides an essential service.

However, BtM solar and storage would likely be able to time-shift renewable energy to the times of the day when the plant requires it.

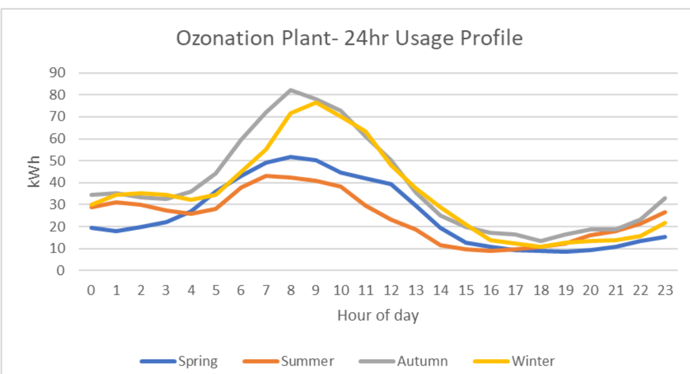


Chart 19. Ozonation Plant 24-hour usage profile

Similarly, the ozonation plant, has a similar usage profile. The plant does use more energy during the day and peaks between 9am-10am.

The profile does match closely to a solar production profile during winter and autumn. However, over spring and summer, it flattens and has a less pronounced daytime curve.

This makes it very difficult to size a solar only system across all 4 seasons.

If a solar system was sized to offset 100% of winter usage, it would result in large amounts of excess energy during spring and summer, when the plant is below its peak consumption. This may not give the best financial performance for the RE installation. Conversely, if an undersized plant were to be installed it may provide better financial performance, however, would not meet the winter peaks and energy would still be required from the electricity grid.

Our recommendation is to do a preliminary investigation for midscale solar and storage installation. We believe this site should be investigated as a potential location along with the Sewerage treatment works.

Airport

Site details

Street Address	9 Peter Monley Drive, Armidale NSW 2350
NMI	NFFFNRK081
Roof space	Yes
Map URL	Airport
Description	Located on the New England Highway. The Council has invested heavily in this location and surrounds to make it into a vibrant commercial hub.

Assessment

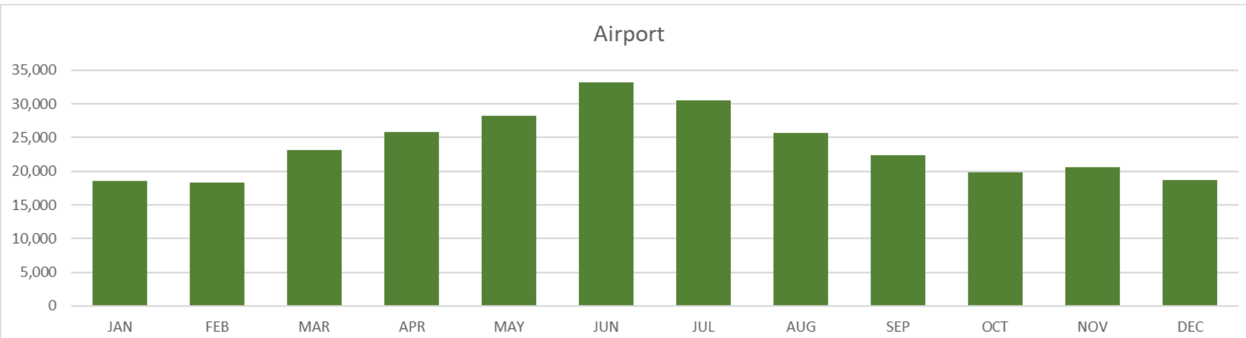


Chart 20. Airport 24-hour usage profile

The ARC has installed a 100kWp BtM solar system at the airport. There's still more available roof space to increase the size of the system, although all the small-scale certificates (rebate) will not be available for any additional solar.

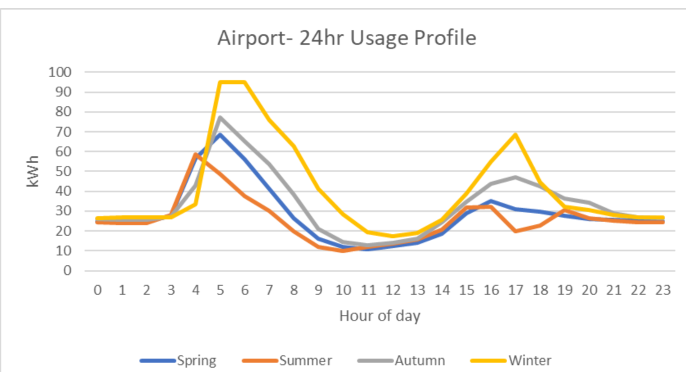


Chart 21. Airport annual usage profile

Both the annual and 24hr energy consumption profiles demonstrate the impact of the BtM solar installation. There is evidence of the 'duck curve' where in the middle of the day when the solar system is performing at its peak and the grid consumption falls to its lowest.

The energy profile at this site proves the case for oversizing the BtM solar system and introducing energy storage. However, increasing solar and introducing storage will not achieve Councils ambitions to be 100% RE across all facilities.

Capping the system at 100kWp has provided a solid IRR. However, it has not been able to provide energy to the site when it needs it the most during the peak periods of 5am-9am and 3pm-7pm. The 100kWp solar system will also use "string inverters" which are more complex and expensive to integrate with storage.

Our recommendation is to perform feasibility on an increasing the BtM solar and introducing storage in parallel with a midscale solar business and feasibility case. Note, that additional solar at this site will 'cannibalise' the financial case for midscale solar and storage at another location.

We also recommend performing the pre-feasibility for EV charging at this location due to its proximity to the New England Highway and the growing commercial precinct.

Guyra Water Treatment Works

Site details

Street Address	7776 Guyra Rd, Guyra NSW 2365
NMI	4407269563
Roof space	N\A
Map URL	Guyra Water Treatment Works
Description	Located off Guyra Road. Approximately 2.6km from the centre of Guyra township.

Assessment

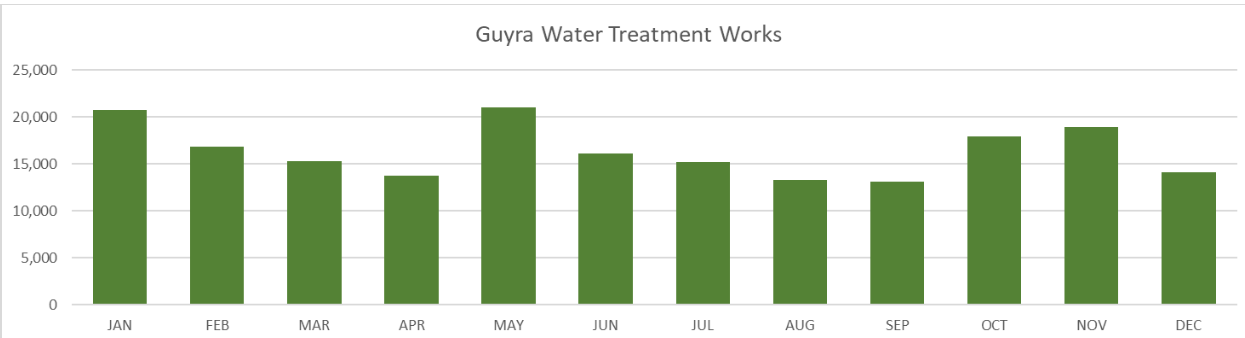


Chart 22. Guyra Water Treatment Works annual usage profile

The Guyra WTW has a consistent annual energy consumption profile, ranging from 15-20 MWh per month. The 24-hr profile aligns well, with a solar production curve, showing usage peaking at 60kwh between 9am-11am across all four seasons.

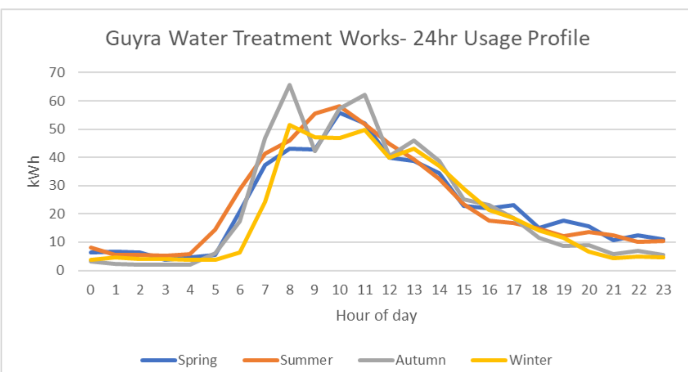


Chart 23. Guyra Water Treatment Works 24-hour usage profile

The annual consumption at this site is substantial and comes in at ~200MWh per annum.

Council has installed up to 40kWp of solar at this site, which should have had a noticeable impact on reducing the daytime grid consumption.

We recommend that Council also investigate the replacement of end-of-life or inefficient equipment. Often replacement with soft-start motors can generate very short IRR and paybacks and in some cases <3 years.

We also recommend review of the operation strategy at this site to see if any gains can be made to maximise the use of onsite solar and reduce any excess solar feed-in.

We would also recommend an investigation in an increase in the BtM solar at this site paired with storage. Although there is a maximum export limit of 30kW at this site, an increase in the solar would still qualify for STCs and help the business case for BtM storage.

Additional solar and storage would likely result in usage below 160MWh p.a. which would allow this site to reduce demand tariffs and charges applied by Essential Energy.

Garibaldi Street Pumps

Site details

Street Address	Garibaldi Street
NMI	NFFFNRKC01
Roof space	N\A
Map URL	Garibaldi Street Pumps
Description	The Garibaldi Street pumps are located ~2km from the centre of Armidale. Their pumps are used to fill town water storage tanks located on site.

Assessment

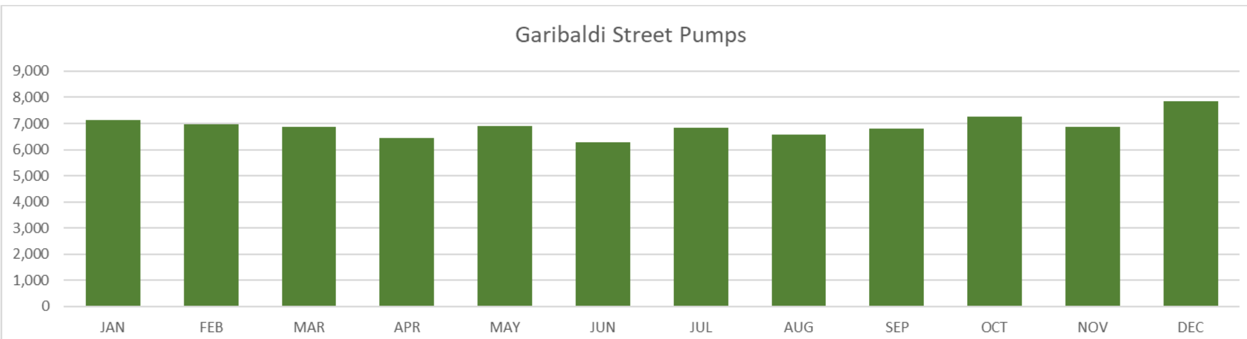
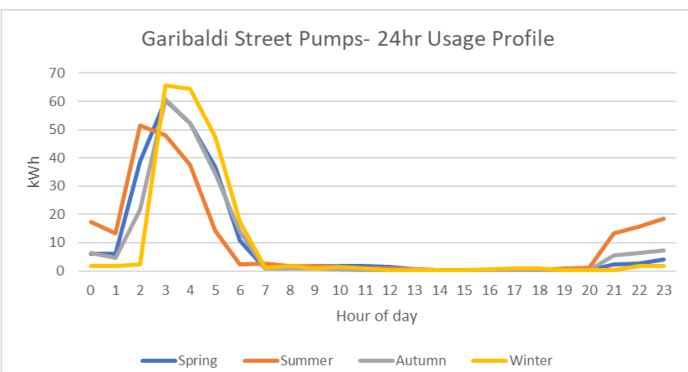


Chart 24. Garibaldi Street Pumps annual usage profile

The Garibaldi Street pumps have an extremely consistent annual profile. They consume ~100 MWh per annum. The site appears to not have sufficient space to install ground mount solar, nor any available roof space.



The 24hr consumption profile shows that the pumps have been programmed to commence at ~2am. The storage tanks likely fill to capacity (or minimum fill requirement) after 2-3 hours of pumping, where they idle back and remain largely dormant until after peak times in the evening from 8pm onwards.

As these provide an essential service to the town it is unlikely that the schedules can be shifted to daytime hours.

Chart 25. Garibaldi Street Pumps 24-hour usage profile

We recommend further investigation with operations staff to determine whether pumping schedules can be moved to the middle of the day or during daytime hours? If so, the energy profile could be matched to the solar profile of some of Council's rooftop solar or potential midscale solar asset. A participating retailer could then share energy with this site, when required. We recommend storage, be included as this would alleviate the times when pumping is required outside scheduled times e.g., during times of drought and\or low water supply.

Aquatic Centre

Site details

Street Address	152 Dumaresq St, Armidale NSW 2350
NMI	NFFFNRKW21
Roof space	Potential for installing a covered carpark and installing rooftop solar.
Map URL	ARC Aquatic centre
Description	The ARC Aquatic centre is located on the corner of Dumaresq Streets and Markham streets.

Assessment

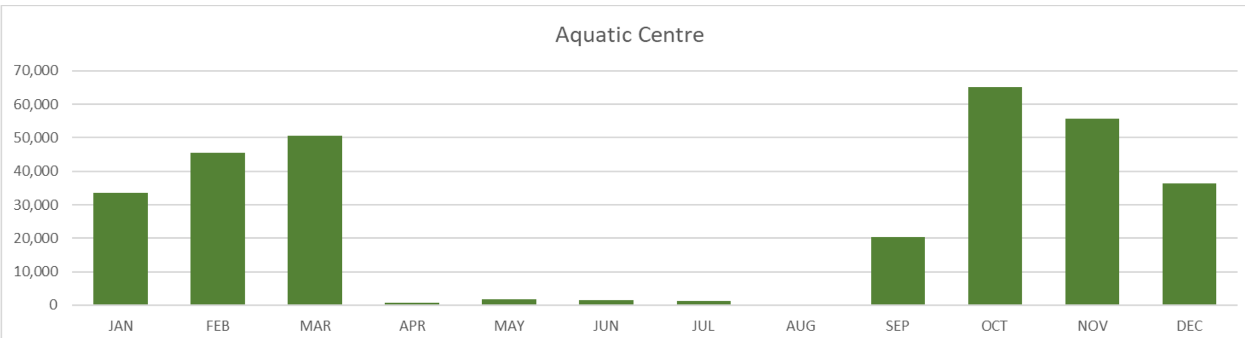
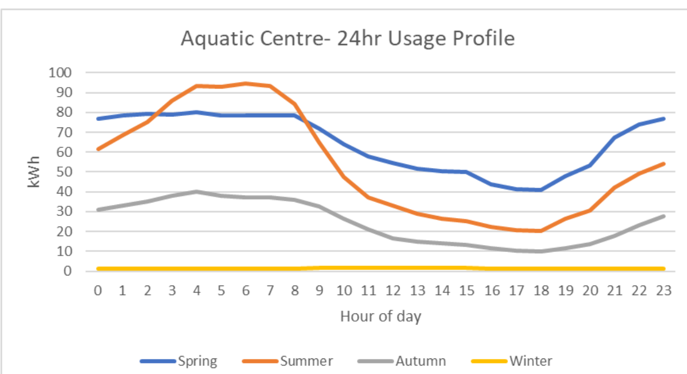


Chart 26. Aquatic Centre annual usage profile

The Aquatic Centre and facilities are open from October through to April. During the offseason there is little activity apart from September when maintenance works commence in preparation for the pool opening in October.



The intraday usage demonstrates that a large overnight and morning usage, likely when pool filtration occurs.

The site inspection revealed that the large carpark could be a suitable location for a solar covered carpark. Essential Energy has pad mount substation located on the corner and infrastructure close to the Aquatic centre.

We recommend that Council perform a preliminary enquiry and feasibility install rooftop solar above the carpark.

Chart 27. Aquatic Centre 24-hour usage profile

The carpark is approximately 2.5ha in area which would allow for minimum of 1MWp of rooftop solar to be installed at this location. Excess daytime solar could be shared via a "Virtual Net Metering" mechanism, with other large consumption sites particularly during winter months when the Aquatic Centre is closed.

We would also recommend that Council investigate carpark solar in parallel with other plans for upgrades for the Aquatic Centre, e.g., Combine Building Better Regional fundings grant application with a solar application at this site.

We also recommend electrification of all equipment on site. For instance, we have seen other regional Councils experience price shock due to sudden rise in East Coast gas prices and the unavoidable consumption by their gas boilers used by their community aquatic centres.

Malpas Dam

Site details

Street Address	Malpas dam road, Black Mountain
NMI	NFFFNRKW20
Roof space	N\A
Map URL	Malpas dam destratification unit
Description	Located approximately halfway between Armidale and Guyra. The dam was constructed in 1968 and is the major water supply for Armidale city and surrounds.

Assessment

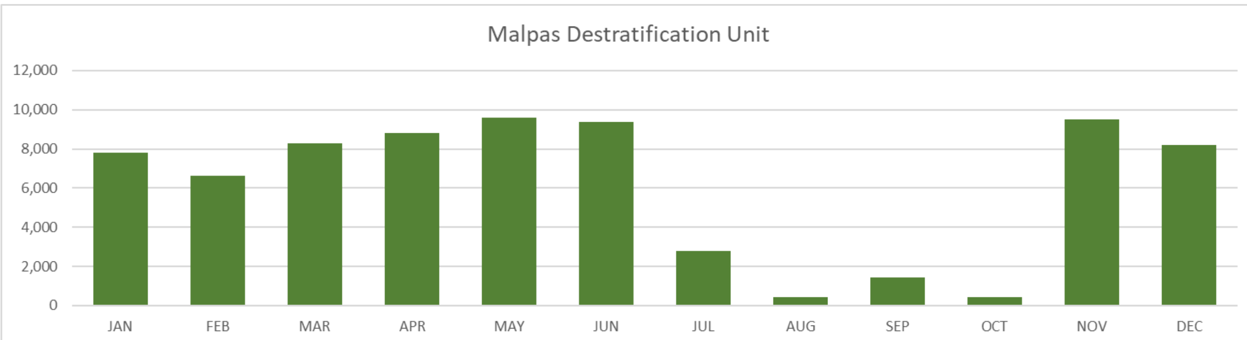


Chart 28. Malpas Destratification Unit annual usage profile

The Malpas destratification unit used the least amount of energy across a 12-month period at 73MWh of all the contract sites. For the 12-month window we assessed, we can see there were four months of little or no activity, which we assume was due to low water demand during July to October period and when equipment is taken offline for maintenance.

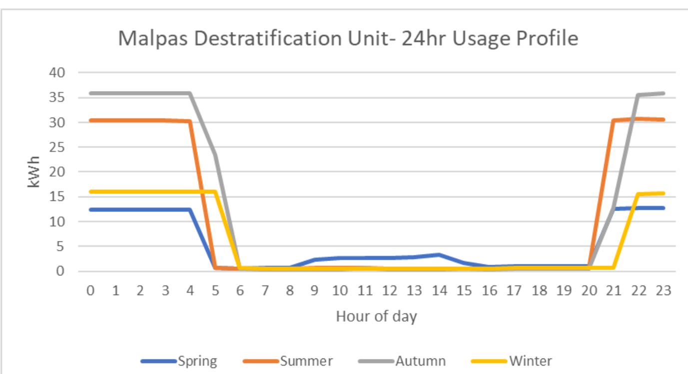


Chart 29. Malpas Destratification Unit 24-hour usage profile

The good news for Council is that the 24hr usage profile demonstrates that the plant and equipment have been optimised to take advantage of "off-peak" energy tariffs.

We assessed Malpas Dam as a potential location for an ARC midscale RE plant. Unfortunately, the distance to the nearest zone substation is some kilometres. The electrical infrastructure leading to the dam, appeared unsuitable and would likely require significant investment and upgrades.

If ARC wish to pursue your own midscale solar and battery opportunity (at a more suitable site), we recommend that the schedule for the Malpas plant and equipment, be reprogrammed to operate during daytime when there is an abundance and excess of solar energy. This is also advantageous for Council operations, as it means that the pumping etc, will be operating during daytime hours when operations staff are more available.

New Library

Site details

Street Address	2/182 Rusden St, Armidale NSW 2350
NMI	4001190746
Roof space	Limited
Map URL	Armidale Regional Council library
Description	Located centrally in town. Co-located to other local businesses.

Assessment

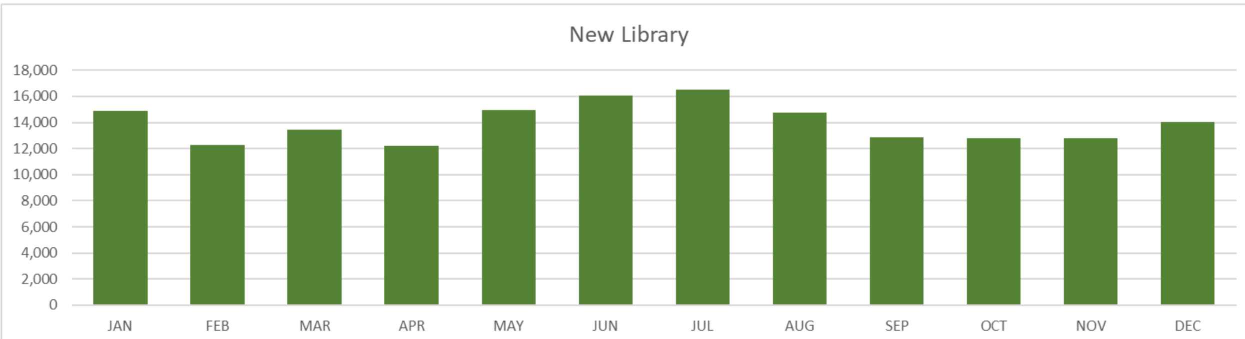


Chart 30. New Library annual usage profile

The New library has a consistent energy profile across a 12-month period. As we would anticipate during winter and summer months there are slight increases in usage likely due to additional load on the HVAC system.

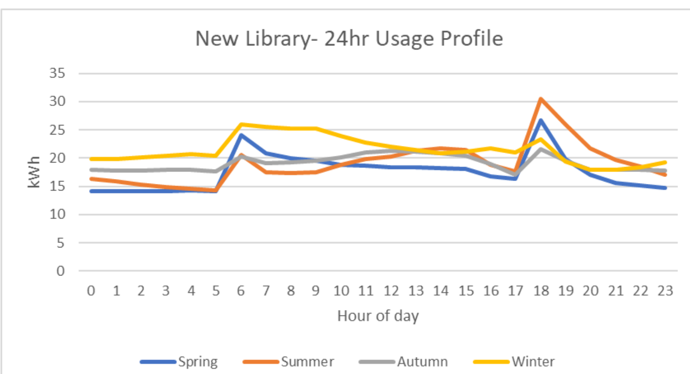


Chart 31 illustrates the average intra-day usage at the ARC library. This is relatively consistent across a 24-hr period, with morning and evening peaks. It also remains very consistent across seasons.

The new library has available roof space for some BtM solar, which could assist with reducing daytime grid consumption. We praise ARC operations for adopting Energy efficiency measures this site, including halogen lighting replacement.

Chart 31. ARC Library 24-hour usage profile

Armidale and Guyra Street Lights

Site details

Street Address	N\A
NMI	44073601885 & 44072694888
Map URL	Armidale streetlights
Description	Armidale Streetlighting

Assessment

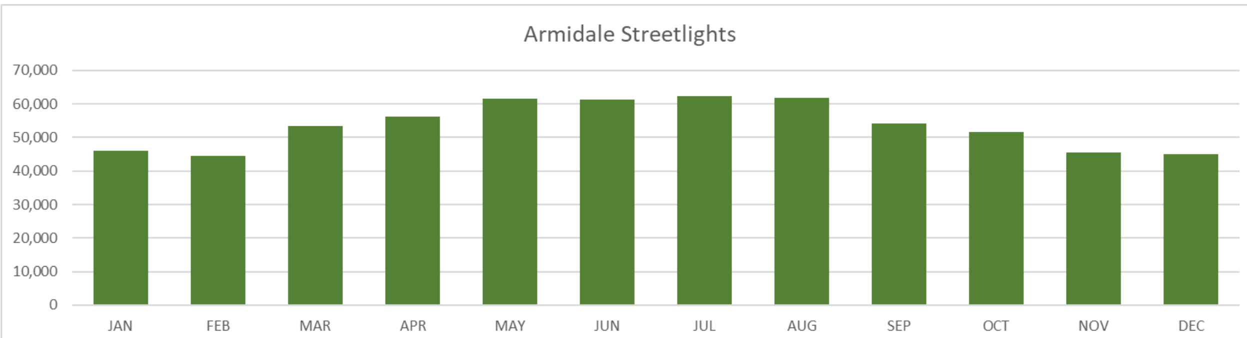
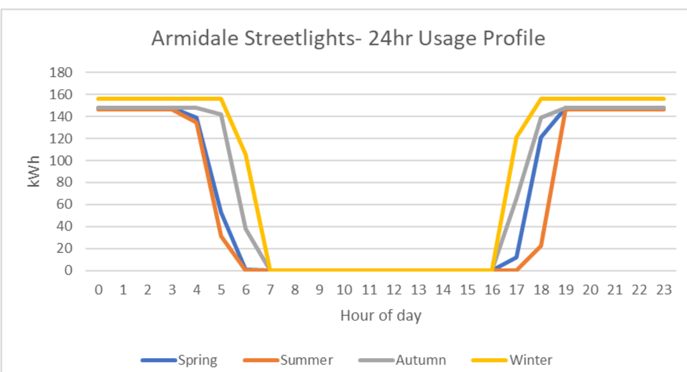


Chart 32. Armidale Streetlights annual usage profile

The ARC Armidale and Guyra streetlighting is as we would expect. A consistent overnight usage, with a slight increase over the winter months when days are shorter. The combined total for both Armidale and Guyra streetlights 725 MWh per annum. The Armidale streetlighting is a factor x10 more than Guyra reflecting the different in population sizes of the city and town.



We commend ARC for being proactive with adopting energy efficiency measures for your streetlighting.

These achievements have included installing solar lighting ~50x new lights on Armidale Cycleway (funded via the Safer Communities Fund).

The ARC has also replaced the inefficient halogen streetlighting with energy efficient LEDs. These solutions are up to 85% more efficient than Halogen lighting.

Chart 33. Armidale Streetlights 24-hour usage profile

Our recommendation for streetlighting, is to pursue 100% LED swap across the entire Guyra and Armidale towns.

To achieve 100% renewable energy for streetlighting we recommend that midscale solar with storage be used to shift daytime usage to night-time use.

For instance, a solar farm has enough excess energy during peak production hours of the day (2-4hrs around midday), to fill a DC connect Life battery solution. The DC connect batteries time-shift that energy and trickle feed it back into the grid during the 10-hrs that streetlights are operational. CE is adopting this approach with several other Regional Councils across the state.

Recommendations Ranking Table

Renewable Energy Action Plan – recommendations evaluation and ranking

	Recommendation	Action	Carbon	$BCA	Comm	Logic	Lead	Rank	Champion	Time
1.	Improve energy transparency and control at all sites, including generation, storage and key loads.	Establish and implement a smart meter and dynamic load control strategy and device roll-out								
2.	Investigate the potential for a council owned, mid-scale renewable energy generator that can supply all of ARCs energy and/or offset all necessary emissions.	Shortlist sites, complete a Preliminary Network Enquiry + high-level business case								
3.	Going forward, ensure smart meters are installed in association with any other electrical installation or upgrade works. The meter should have capacity for sub-circuit and device load control.	Upskill in metering and control options								
4.	Make a strategic decision about the application of on-site distributed renewable energy in the context of a mid-scale opportunity.	Consider Zero30, carbon and retailer strategy								
5.	Consider the case for energy storage in association with any BtM solar installation and especially for sites with energy quality or security requirements. Retailer provided batteries and community battery schemes should also be explored.	Include in scope and budget allocation for any renewable powerplant project								

	Recommendation	Action	Carbon	$BCA	Comm	Logic	Lead	Rank	Champion	
6.	If ARC decide to progress the mid-scale 100% offset option, this should be done in concert with identifying and negotiating with a retail partner. ARC will need to come to a position on how to value the export ranging from simple PPAs to sharing with local customers. E.g., Main street shops to assist in providing affordable, local energy.	Decide on an approach to valuing excess energy from ARC projects								
7.	ARC should model energy storage as part of the business plan for medium scale solar project options. This modelling should compare a single, mid-scale, grid connected storage device (ideally with the solar array) and multiple distributed devices.	Include in scope and budget allocation for any renewable powerplant project								
8.	That ARC does not commit to any long-term retail contracts until Council's own renewable generation strategy is clear. Council should gain understanding of the selling/retailing strategy of the emerging generators in the REZ and be mindful that retailing energy to Council and/or local customers can be facilitated and negotiated via a participating retailer.	Establish what it is that Council would ideally like from a retailer								
9.	That ARC participate in the NSW EV Strategy and invest in a small number of electric vehicles to test how they can be best integrated into operational activities. ARC would also benefit from improved tracking of vehicle usage.	Consider engaging a fleet tracking and optimisation service. Support charger roll-out								

	Recommendation	Action	Carbon	$BCA	Comm	Logic	Lead	Rank	Champion	
10.	That ARC position itself as a centre for R&D in the emerging hydrogen economy as part of the REZ. That Council conduct feasibility into a pilot plant and vehicle(s).	Promote ARC to emerging providers in the H space								
11.	That ARC adapts procurement policy to preference electric plant and equipment for replacement and new purchases.	Ask staff to research electric alternatives. Replace as current plant retires								
12.	Limited action in relation to pumped hydro at this point in time. It may be something to have 'on the radar' in discussion with TransGrid and other organisations looking to develop energy projects in the REZ.	Establish relationships with providers that could link to ARC project(s)								
13.	Small-scale wind generators should be considered for any new or existing remote infrastructure. Mid-scale wind generators could be considered as part of a hybrid mid-scale project (which we have not modelled). Local wind farms could be approached to provide renewable energy to Council to fill the shortfall if Council elects to proceed with solar only as the offset strategy.	Include wind energy as possibility in new projects								
14.	ARC decide on the degree to which their 100% renewable target should be pursued with discrete projects they can readily control, versus a community engaged approach with incentives and a VPP structure for Council to claim the entire generation pool.	Continue community engagement through Project Zero30								

	Recommendation	Action	Carbon	$BCA	Comm	Logic	Lead	Rank	Champion	
15.	ARC make a strategic decision on how to approach renewable energy for building HVAC gas and diesel plant/vehicles. ARC may seek interest or funding with stakeholders in the REZ to further investigate the potential of bioenergy.	Monitor progress with Hydrogen, liquid fuels and biogas.								
16.	For Armidale Regional Council, microgrids should be considered for any development likely to have a few or more meters connected to the network. If Council is the enabler, then it is likely to result in reduced operating costs for sub-metered customers and an on-going revenue stream to Council.	Consider microgrids for incorporation into review of Planning Policies								
17.	That Armidale Regional Council consider the relative importance of energy security at key sites and factor this into considerations for BtM installations as this may be the factor that weights the business case towards proceeding.	Investigate drivers of and funding for resilience initiatives								
18.	Include ground source as a technical solution to investigate in specifying upgrades to building Heating Ventilation Air Conditioning systems.	Add scope to feasibility studies								
19.	Other									

Key: Green represents good alignment with the decision-making factor. Orange indicates a less compelling case.