Pros and Cons of Backup Power

Author: Halls Gap Resilience Group
secretary@resiliencegroup.org.au

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1 Introduction

1.1 Background

At the Resilience Group meeting on 23 August 2022, a number of items were agreed to be a priority for the subsequent three months. One of these items was: “The pros and cons of a backup generator should be explored so that a report can be provided to the next meeting.”

1.2 Purpose

This document is intended meet the above requirement.

1.3 Audience

The audience for this document is the members of the Halls Gap Resilience Group.

1.4 Scope

The pros and cons of a backup generator can only be fully considered in the context of alternative backup power systems, so the scope of this report also includes consideration of

- solar backup, and
- battery backup, with or without solar panels for battery charging.

1.5 Caveats

This is a preliminary document only.

- With the exception of the water treatment plant, power requirements, including for backup battery capacity, are based on the average daily power usage at each location.
  - For kVA estimates, the average daily kWh has been converted using a ten hour working day, a peak to average ratio of 2:1, and a power factor of 0.8.
  - For the required battery capacity, a battery duration of 2 hours has been assumed (to match a 2 hour outage – see section 2.1) and a depth of discharge of 70%.
  - For battery recharge, solar panels are assumed to recharge 70% discharged batteries in 4.1 peak sun hours (i.e. 1 day.)
- Costs do not include any allowance for shipping/ freight, or for any additional costs due to installation in a regional location. As a consequence, costs are estimates only, and may prove to be low if the project moves into implementation.

2 Backup Power Requirements

2.1 Power Outages in Halls Gap

Most power outages in Halls Gap last no longer than 1-2 hours.

If load shedding is ordered by the Australian Energy Market Operator (e.g. in a heatwave) rotational power outages also usually last 1-2 hours.

In 2021 Powercor had a target of no more than two outages longer than 3 minutes per year, with a total outage time of <4 hours (e.g. worst case of two 2-hour outages.)

2.2 Locations Which May Require Backup Power

Some important community locations already have backup power. They include

- the Budja Budja Medical Clinic, and
- the essential services precinct encompassing Victoria Police, the CFA, and Ambulance Victoria.

However there are several other community locations where backup power may be desirable:

- During the 2014 fires, residents (particularly in Pomonal) who stayed to defend their properties did not have access to water as there was no backup power for the water treatment plant, and the clear water tank couldn't be filled to maintain water pressure[1].
- If the Centenary Hall is to be used as a cooling space during periods of extreme heat, backup power may be required for air-conditioning in the event of a power failure.
- The Primary School does not close on days of extreme heat. Providing backup power for air-conditioning could be part of the community response to extreme heat.

2.3 Amount of Backup Power Required

The backup power required for each of the locations listed above is summarised in Table 1. For the locations other than the water treatment plant, the power is estimated based on the previous 12 months of power usage (see Section 1.5.) The highest power demand is for the water treatment plant.

Table 1: Backup Power Requirements

Location	Estimated Peak Power Requirement
Water Treatment Plant	150kVA[2]
Centenary Hall	30kVA
Primary School	18kVA

2.4 Options for Providing Backup Power

The options for providing backup power are

- to provide backup power at each location, or
- to provide portable backup power which can be moved to a location on demand.

[1] Schetzer A., and Dow A (2014) "Halls Gap residents begin evacuation as fire approaches" *The Age*, Jan 17, https://www.theage.com.au/national/victoria/halls-gap-residents-begin-evacuation-as-fire-approaches-20140117-30yso.html

[2] Advice from TRILITY, October 2022

Providing power at each location means there is only a requirement to provide the backup power needed for each site, whereas providing portable power requires the backup power to be sized to meet the needs of the site with the largest power usage.

Portable power means there is a need to prioritise its usage when there are multiple competing demands, or even a need to remove the backup power from one site in order to provide it to another higher priority site as new emergencies arise.

The primary alternatives for backup power are

- the use of batteries, with or without solar panels to keep them charged (not very portable when large backup capacity is required), or
- a backup power generator (which can be trailer mounted for portability.)

The highest capacity trailer mounted generator commercially available appears to be about 100kVA. Anything larger requires a custom build, which is likely to be expensive (see 4.1.1.)

A smaller portable power generator which would satisfy all requirements other than the water treatment plant would need to have a 30kVA capacity (see Table 1.)

2.5 Optional Enhancements

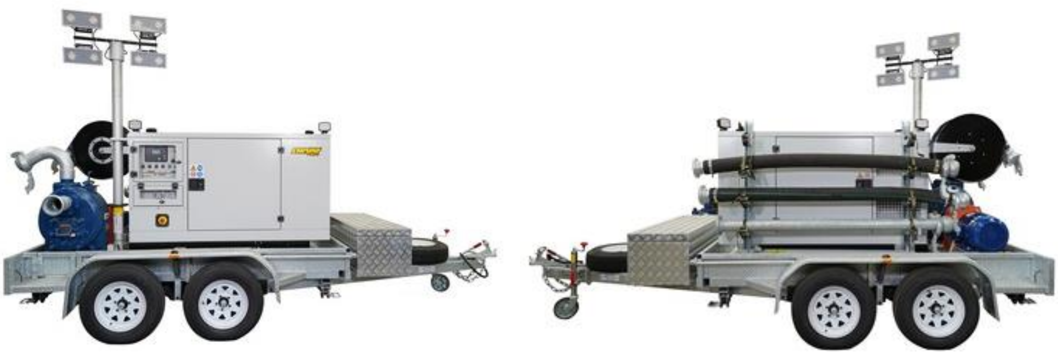
A trailer mounted generator can be enhanced to become a trailer mounted emergency response unit.

For example, Lampo Emergency units (Figure 1) come in a number of sizes (20kVA, 30kVA, 60kVA, 80kVa and 100kVA.) A 30kVA unit includes

- a 30kVA generator in a sound suppression canopy, to cope with power failures,
- a self-priming 85l/s electric pump to cope with the alleviation of burst mains, flooded roads and ditches, fast filling of fire tankers at water points, etc.,
- a 24l/8bar air compressor to power pneumatic emergency tools, inflate tires, etc.,
- an extendible 6m high 61,400 lumen LED light tower to illuminate accidents/ incidents or other emergency sites, and
- ancillary equipment e.g. discharge and suction tubes, discharge hose on hose reel, two drop-down legs to give trailer stability, and a large tool box for additional equipment.

However, the costs of these units is relatively high e.g. they start with a 20kVA unit at $79,040 and end with a 100kVA unit at $156,300[3].

Figure 1: Example Emergency Trailer



[3] Quote provided by Hydro Innovations, October 2022.

3 Comparison of Generators and Batteries

3.1 Overview

The main differences between fuel-powered generators and batteries charged by solar panels are summarised in Table 2.

3.2 Key Differences

Key differences affecting a decision for Halls Gap are:

- Trailer mounted batteries charged by solar panels are largely limited to 6-10kVA (see Figure 2) compared to trailer mounted generators which can be up to 150kVA if custom-built. Based on Table 1, a portable solar system is inadequate, so batteries charged by solar panels should be considered as a fixed option (i.e. each location would need its own solar array.)
- Generators can generally provide a longer duration of backup power (days) than batteries charged by solar panels (hours) because the high cost of long duration battery backup tends to limit their capacity, particularly when charged by solar panels. This is less of a factor for Halls Gap as the requirement is for an outage of only two hours.
- Generators are not dependent on the weather, whereas solar panels are largely dependent on the hours of sunlight. As a consequence, using solar panels as backup power for essential services, in the absence of batteries, is an inadequate solution.
- Conversely using batteries without solar panels (i.e. rechanging batteries using the grid) is a viable solution for backup power, provided the battery capacity is sufficient to cover the duration of the outage. Using solar panels to charge the batteries simply increases the up-front cost of the system, although it offers the benefit of long term power savings. Trailer mounted batteries without solar charging are far more costly than generators for comparable output.

Figure 2: Examples of Trailer Mounted Power Units

150kVA Generator

4.6kW Solar Array, 14kWh Battery Bank

75kWh battery bank under floor of trailer

Table 2: Comparison of Fuel-Based Generator and Batteries Charged by Solar Panels

Characteristic	Fuel-based Generator	Batteries Charged by Solar Panels
Duration of power provision	Generally has much longer duration (days) than batteries (hours.) Extended provision of power requires a large fuel tank, or storage of additional fuel for re-fuelling. Refuelling typically cannot be completed when the generator is running/hot. Not dependent on the weather.	Generally has shorter duration (hours) than a generator (days.) Panels requires sunlight for power generation. Without sunlight, duration dependent on the size of the batteries and the capacity of the panels which charge the batteries during sunlight. (Alternatively, batteries can be charged by the grid.)
Switch over	If connected to one of the locations listed in Table 1, it can be configured to start automatically when a power outage occurs	When connected to the grid, can be configured to automatically switch over to batteries when there is a power outage.
Maintenance	A generator is an active mechanical device which requires regular maintenance e.g. replacement of lubricants, replacement of parts affected by wear and tear etc.	Batteries and solar panels are passive, but still need maintenance e.g. cleaning panel surfaces, and replacing batteries, inverters, cables, etc., as each reaches end of life.
Environmental factors	A generator creates exhaust gases including carbon dioxide. The amount and mix of exhaust gases depends on the fuel used to power the generator (petrol, diesel, gas.) Most generator components can be recycled or refurbished.	Batteries and solar panels do not generate exhaust gases, but recycling of batteries/ panels when they reach end of life can be an issue. Lead-acid batteries are 98% recyclable, but recycling of lithium-ion batteries and solar panels is only just emerging.
Noise	Generators can be noisy, although they can have mufflers and sound-reduction canopies to minimise the sound.	Batteries and solar panels are very quiet, although not completely noiseless.
Up front cost	Generally much lower up-front cost than batteries, with or without solar panels, for a comparable power output.	Generally much higher up-front cost than a comparably sized generator, particularly if solar panels are included in the system.
Operating cost	Ongoing cost of fuel and maintenance	No cost of fuel, but still have cost of maintenance
ROI	Generators are a capital and operating expense. There is no ROI.	If used, solar panels can feed power to the grid, and energy rebates can offset the up-front cost i.e. there can be a ROI.
Operating life	Good-quality generators can run for 3,000 hours, as long as they're well maintained. If the generator is run for 6 days per year, then it should last about 20 years.	Over time batteries lose the ability to hold a charge e.g. a Tesla Powerwall retains only 70% capacity after 10 years. Quality panels last 25 years, with efficiency declining to ~80% over life.
Warranty	Depends on brand, but often 2-5 years or a number of operating hours (e.g. 1000 hours) whichever comes first.	Battery warranties are typically 10 years. Similarly, a solar panel defect warranty is 10-15 years. Solar panel performance warranty of at least 80% of nominal power is typically 25 years.
Portability (see Figure 2)	Even large capacity generators (e.g. up to 150kVA) can be trailer-mounted. This means that a suitably sized generator can power the water treatment plant, the community hall, or other emergency service, provided their electrical systems are modified to accept generator power.	In Australia, fully installed battery systems cost about $1,500 per kWh. Trailer mounted solar/battery systems in Australia can generate 4.6kW/14kWh (Figure 2) at a cost of $52,000+. To fully charge the batteries for one of the locations listed in Table 1, the solar array would have to be large/fixed.

4 Backup Power for Halls Gap

4.1 Analysis

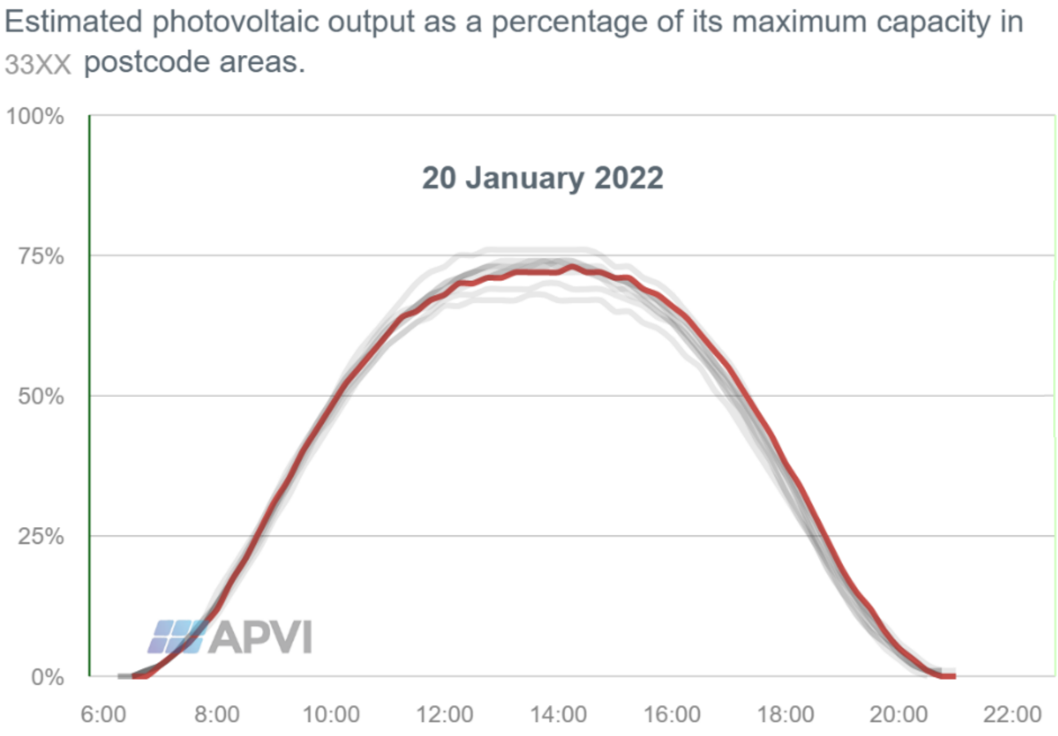
4.1.1 Water Treatment Plant (Heaviest Power Load)

If a generator is to be used, the water treatment plant would need a three phase 150KVA generator with 15 meters of power supply cables (3 phase, with crimp lug connections.)[2] A 'name brand' 150kVA backup generator (e.g. using a Perkins diesel engine) will cost about $40,000 including GST[4], and would weigh 2480kg. A 3-tonne trailer would cost about $8,000 including GST[5]. The cost to integrate the two (e.g. implement the bracing/ connections that ensure the generator cannot shift or break free under hard braking or sudden movements), and provide ancillary equipment (e.g. electrical cables, fire extinguisher, spare wheel/tire, etc.,) could add $15,000, so the total cost would be about $63,000, depending on the supplier and the trailer specification. In addition, the electrical connections of the water treatment plant would need to be modified to accept generator power as an alternative to grid power.

A solar array designed to deliver a peak of 120KW/150kVA would cost about $77,000 depending on the quality of components, excluding batteries. It would require 75+ solar panels (depending on brand and wattage) and require about 125m^2 of shade-free space, well beyond a portable solar option (see earlier.)

However, while nominally a 120kW system, it will not actually deliver the required power consistently, as it will vary by hour of the day (Figure 3) and by month of the year (Figure 4), will be weather dependent, and it will not deliver at all at night i.e. a sunlight-dependent system is not a realistic backup power solution without battery storage.

Figure 3: Example of Solar Power by Hour

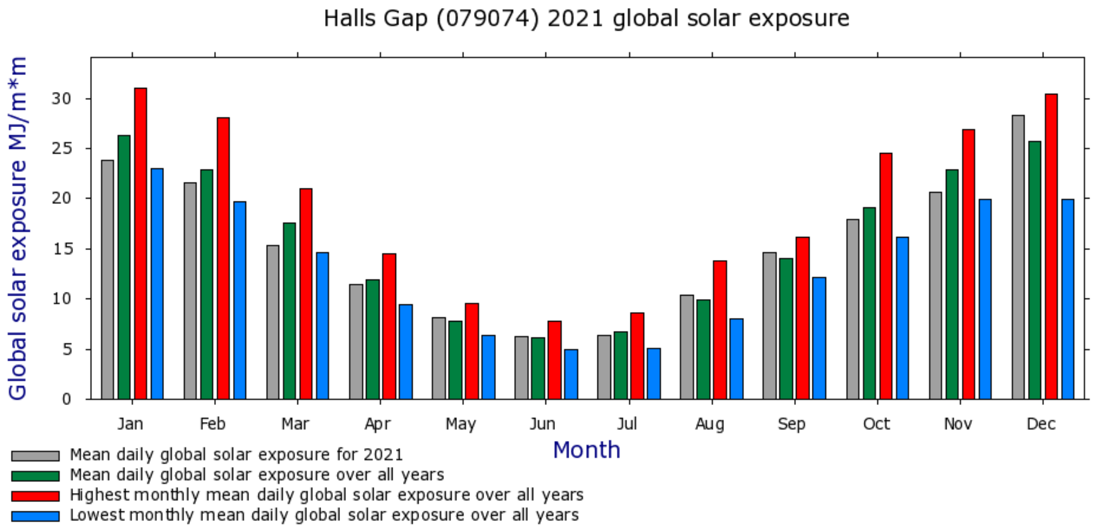


Australian PV Institute, https://pv-map.apvi.org.au/live#2022-01-20

[4] Blue Diamond Machinery (2022) https://www.bluedm.com.au/150kva-diesel-generator-perkins-engine-415v/

[5] Quote provided by Powerlite, September 2022

Figure 4: Examples of Solar Energy by Month



Bureau of meteorology, http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_display_type=dataSGraph&p_stn_num=079074&p_nccObsCode=193&p_month=13&p_startYear=2021

A full Clear Water Tank should act as a buffer for supply if the water treatment plant is not operating i.e. a short power outage will have little effect, as when the power is restored and the plant restarts operations, it would simply top up the tank again. TRILITY has advised that dependent on

- the time of year,
- how full the tank was when an outage occurred, and
- the size of the population resident in the town at the time,

in a worst case scenario the tank could last anywhere from half a day to a matter of hours.

In a prolonged outage, if batteries are required to deliver 120KW for two hours, with a 70% depth of discharge, the battery bank could cost about $380,000. The batteries could be charged by the grid, or by solar panels (at additional up-front cost.)

Overall,

- solar alone is not an option, and
- batteries are about six times the upfront cost of a generator without solar charging. and over seven times the cost with solar charging.

A generator is therefore the appropriate backup power source for the water treatment plant.

4.1.2 Other Power Loads

Confirmation of power requirements, and quotes from a professional would be required before a final decision is made, but estimated costs of a stand-alone generator, or batteries and solar panels for charging them, for each location, is summarised in Table 3.

Table 3: Approximate Cost of Alternatives

Location	Peak Power	Solar		Portable Generator
		Batteries	Panels/Charger	
Water Treatment Plant	150kVA	$380,000	$77,000	$63,000
Centenary Hall	30kVA	$73,000	$15,000	$25,000
Primary School	18kVA	$42,000	$9,000	$10,000

1. Battery cost includes inverter/charger and installation costs. Solar battery rebate of $2950 assumed.
2. Solar panels are assumed to recharge 70% discharged batteries in 4.1 peak sun hours (i.e. 1 day.)

If a trailer-mounted 150kVA generator is assumed as the only practical option for the water treatment plant, then it can be reused for all other locations as well (acknowledging the potential problem of competing demands.) No other investment is required.

If the Halls Gap community decides that the cost of a 150kVA backup generator is not justified by the consequences of a 2-hour power outage, then a smaller 30kVA trailer-mounted generator could meet the needs of all sites other than the water treatment plant.

Additional benefits could arise from extending this option to a 30kVA emergency response unit at a cost of $96,000, but this is almost four times the cost of a simple trailer mounted generator.

One approach for the Centenary Hall may be to install solar panels in order to capture the power savings which would result. This approach has already justified solar arrays on the Shire’s library, Town Hall and the McPherson nursing home. Installation of a generator or batteries for the Centenary Hall could then be considered at a later date if it is decided to use the Centenary Hall as a place of last resort in case of fire or a bad heat wave.

4.2 Using a Backup Generator in Halls Gap

Implementing a trailer-mounted backup generator in Halls Gap would require some planning:

4.2.1 Generator Positioning

The location and custodianship of the generator will need to be determined e.g. stored at the CFA fire station, with usage allocated by the CFA Duty Officer, or comparable arrangement.

4.2.2 Servicing and Testing

Backup generators need to be serviced and tested regularly. An appropriate agreement would need to be put in place with a generator servicing company, and with a diesel fuel supplier to keep the tank topped up. (This is similar to the management of fire trucks.)

4.2.3 Training and Education

Local emergency personnel will need to be trained in the operation of the generator, where the generator connection points at each location are, who the contact point is for approvals to connect at each location, etc.

If a portable generator is adopted, community awareness would need to be promoted:

- A *Backup Power Generator Factsheet* would need to be developed and distributed to Halls Gap residents and location managers.
- Local digital channels (*Fill the Gap*, HG Community web site, social media, etc.) would need to be used to educate the community on what the backup generator is, how it is used, and who is responsible for managing it.

4.3 The CFA’s Position on Generators

The current CFA messaging surrounding Catastrophic fire rating days encourages residents to evacuate the area i.e. to ‘Leave Early’.

As such, the CFA does not support the use of generators by community groups to maintain water pressure as it encourages people to remain in the fire danger area and attempt to defend their properties.

As a consequence, the CFA has explicitly stated that it will not house, maintain, deliver or operate any community backup power generator in Halls Gap.

There is no obvious community alternative to the CFA.

5 Recommendations

It is recommended that:

1. The Resilience Group should first decide whether the frequency and duration of outages, and the consequences of an outage, justifies backup power in Halls Gap at all.
2. If backup power is not justified, then the issue should be dropped from the Resilience Group's agenda.
3. Any decision on backup power for the water treatment plant needs to consider
   - the relatively high cost of a 150kVA trailer-mounted generator (about $63,000 funded by grants and donations),
   - the fact that the CFA will not house, maintain, deliver or operate the generator, and
   - that fact that there is no obvious alternative to the CFA for the management of the generator.
4. If backup power is not justified for the water treatment plant, but is justified for the Centenary Hall and Primary School, then any decision to acquire a 30kVA trailer-mounted generator needs to consider
   - the cost of about $25,000 (funded by grants and donations, and
   - whether any organisation is willing to house and manage the generator.
5. Consideration should be given for the installation of a solar array on the Centenary Hall roof in order to capture the related energy cost savings. If the Centenary Hall is subsequently nominated as a cooling space, the addition of a generator or backup batteries can be considered at that time.
6. If a decision is made to proceed in principle for any of these initiatives, then confirmation of power requirements, and quotes from a professional, should be obtained before the project proceeds.

6 Outcomes

The Resilience Group explored with TRILITY the option of a backup generator permanently located at the water treatment plant i.e. housed, maintained, and operated by TRILITY. TRILITY was prepared to fund the operating costs if the Resilience Group funded the capital cost.

At the February 2023 Resilience Group meeting the issue was discussed. Key points raised were:

- Where water was required to supply fire trucks, collar tanks can be used. (The ICC in Horsham has them and they can be put in place by helicopter.)
- Where water is required for residents defending their properties, the residents should examine how they can become self-sufficient e.g. by installing water tanks, pumps and hoses.

Given the cost of the generator, and the limited residual benefit if the above actions are taken, it was resolved that the issue of a backup generator for the Halls Gap water treatment plant be dropped from the Resilience Group's agenda.

A backup generator for other purposes was dropped due to the lack of an organisation to manage the generator.

NGSC has advised that it has no plans for solar panels for the Centenary Hall at this time, but this may change if the hall is designated as an emergency management venue.