# APPLICATION NOTE

## UNDERSTANDING BATTERY BACKUP & SIZING

Application Note
Empower Energy Pty Ltd
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# Contents

# 1. INTRODUCTION

Many customers assume that a home battery system will provide backup power to their entire premises in the event of a grid outage. While many battery system vendors market their ability to provide backup power, it can come with quite a few caveats that are hard for the average customer to understand clearly. This Application Note will discuss the capabilities and limitations of battery backup and the inherent trade-offs that result. Understanding the contents of this Application Note is vital to ensuring a battery system performs to expectation during a grid backup event.

# 2. WHOLE HOME OR ESSENTIAL BACKUP?

The natural impulse when considering battery backup is to backup an entire home. Unfortunately, sizing a solar-battery system for the normal power demands of an entire home necessitates a much larger battery and creates additional peak power requirements on the inverter. While the objective of this application note is not to deter anyone from choosing whole home backup, it is important to point out that "true" whole home backup will be very costly and the customer will need to manage loads within the limitations of the battery system, which can be a complex task and runs the risk of a poor customer experience, if not carefully administered.

## OFF-GRID SIZING

An off-grid home needs to be able to provide power, rain or shine, multiple days in a row. It is common to size a battery system to around 5 times average daily load of the home, as one has to be prepared for multiple successive days of poor or inadequate charging from solar. Furthermore, a diesel generator is often included in the system to provide reliable power during the rainy season and as a redundant backup should the solar battery system fail.

Designing an off-grid system is complex, and this App Note will not help. A credentialed off-grid battery system designer and installer should be consulted.

## GRID-CONNECT SIZING

When a home is grid-connected, a modern solar battery system can most often handle the majority of the homeowner's daily power and energy needs, and the grid can supplement any shortage (import) or absorb any excess (export). It's not critical to oversize the system for poor weather or peak load, because the grid is available as an instantaneous source and sink. Therefore, rather than attempt to achieve 100% independence from the grid 365 days of the year, a common objective is to efficiently size the solar and battery system to maximise return on investment (ROI) for the homeowner. This means choosing a battery system that meets the majority of the home's needs, the majority of the time.

### Peak Power vs Energy

Power is measured in kW and energy is measured in kWh. Power is the rate of energy consumption. For example, a kettle will have a high peak power of ~2kW, but it only heats for a few minutes, so is not a large consumer of energy. However, if the kettle was set to run continuously, then it would consume a significant amount of energy.

### Peak power Output

To avoid overloading the battery system, the total power of all the simultaneous loads must be less than the **peak power rating (kW)** of the battery system. Typically, appliances are turned on and off in a home in a staggered fashion, so one would rarely actually generate the potential peak power of the home. However, the chance is there, and if a homeowner is not careful, they could overload the battery system, causing it to shut-off to avoid being damaged. The peak power rating of a battery system typically has a short-term rating, meaning it can only run at this peak power for a limited period.

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*Inductive loads (motors), like air-conditioning, power tools, refrigerators, pool pumps, washing machines, can draw high current for short periods thereby overloading the battery system. So, their startup currents must be taken into account when calculating the peak power of all the loads in a home.*

## Continuous Power Rating

If the intent is to run loads continuously (e.g. refrigeration, lighting, tv), then those simultaneous loads must be less than the **continuous power rating (kW)** of the battery system. Both the continuous power rating and peak power rating are determined by the manufacturer after careful consideration (and testing) of the various components, such as the circuit breakers, batteries, and internal power electronics. The ratings and constraints of the ElektroBank 14 are discussed in a later section: ***Peak and Continuous Power of ElektroBank 14***.

$$kW\ Continuous\ Power_{Inverter} > kW\ Total\ Power\ of\ all\ continuous\ loads_{Home}$$

## Energy Capacity

The inverter does not store energy; therefore all the energy is sourced from the batteries. To determine how long a battery system can sustain all the loads, the calculation is to divide the **energy capacity (kWh)** of the battery by the total energy consumption of the loads (kWh).

$$Hours\ of\ Operation = \frac{kWh\ Total\ Energy_{Battery}}{kWh\ Total\ Energy_{Loads}}$$

Figure 1 shows the kWh energy consumption of the loads in a typical home. A hashed yellow line is drawn around loads that are generally considered essential, or in other words, most important when facing an 8–12-hour grid outage. These selected loads are only recommendations and Empower does not intend to prescribe to customers which loads are and aren't essential, as this should be carried out uniquely for each home with the support of their installer. Other electric essentials like hot water, cooking and air-conditioning can drain a battery very quickly (if not monitored closely) so must be carefully considered as to whether they should be included for backup.

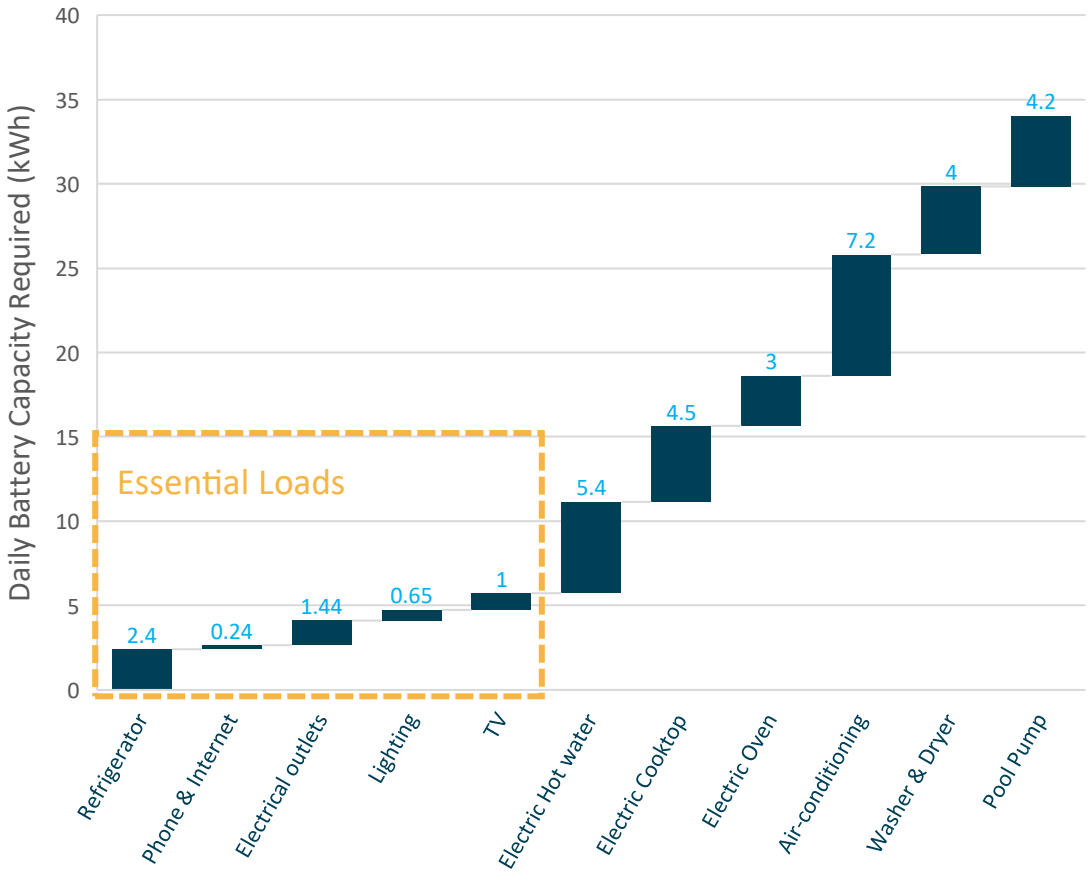


*Figure 1: Incremental battery capacity required to fulfill household loads*

In summary, short term power spikes in the home should remain below the peak power rating. The total power of loads that run continuously for long periods (e.g. refrigerator, lighting, TV, etc.) should remain below the continuous power rating of the inverter. And the continuous runtime of the loads that a battery system can support (without solar or grid) is dependent on the **energy capacity** of the batteries.

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*The highest cost component of a solar battery system is the batteries. In addition to the considerations discussed above for home backup, the battery size may also be dictated by other customer interests such as establishing self-sufficiency, reduction of their carbon footprint, electricity bill savings, and long-term financial investment, among others. Where ROI is a main driver, the battery should be sized just right so the full capacity is completely utilised each day (e.g. charged to 100% and discharged to 0%). If not, the unused extra storage is a latent expense which does not provide incremental savings to a home's electricity bill. This does change for 'wholesale tariffs where you can sell you excess energy and for 'future proofing' your investment.*

## Critical Takeaway

An accredited solar-battery installer should be able to help a customer determine the appropriate size of the battery depending on their battery backup objectives and the type of electricity tariff (single rate or time-of-use tariff structure, for example).

Whole home backup requires a full audit of the home's loads and large load appliances like electric heaters, stoves, washer & dryers, ovens, and pool pumps can increase the battery costs unnecessarily.

The peak power and continuous power ratings of the battery system will typically cover essential loads such as refrigeration, laptops, lighting, internet modem/router and a few extras such as a TV. If additional loads like an oven, heat pump or EV charger are desired, they must be carefully managed so as to not overload the battery system (by turning on simultaneously) or drain the battery making the battery system unavailable for the essential loads.

# 3. INTERNAL VS EXTERNAL AUTOMATIC TRANSFER SWITCH

Many battery inverters in the market provide a dedicated backup port. Unlike dedicated PV inverters that require an existing electrical grid to sync to, battery inverters can form their own grid through this backup port. When the battery inverter forms its own grid, it is paramount that it is disconnected from the main grid.

Battery inverters typically use an automatic transfer switch (or sometimes simply referred to as a contactor) to electrically isolate from the grid. When the grid voltage or frequency is out of tolerance, the contactor is triggered, the main grid is disconnected, and the battery inverter will begin generating its own islanded-grid—restricted to the home. The contactor can be located within the battery inverter itself or installed externally in the homeowner's switchboard.

With an internal contactor, the battery inverter is in series between the electrical grid and the house loads. The main disadvantage to this approach is if the inverter faults or is off, there will be no electricity flow to the loads connected to the backup port. The other disadvantage of an internal contactor is the built-in circuit breakers become a bottleneck for how much power can flow onto the house loads. For example, if the internal circuit breaker for the grid is sized at 40A (equivalent to ~9.6 kW), and the batteries are charging at their maximum rate of 5 kW, that only leaves 4.6 kW to onflow to the house loads. For heavy users with air-conditioners, and electric cooktops and ovens, this could overload the internal circuit breaker, even while the battery inverter is happily connected to the grid.

When an external contactor is used the home circuits can broken out into essential and non-essential loads. The essential loads can be sized above the 20A limit (4.6 kW) of the backup port, however there are three important considerations.

1. The incoming circuit breaker that feeds the contactor must be rated less than the contactor (e.g. less than 63A).
2. While grid connected the essential loads must remain under this incoming circuit breaker rating (typically sized for 32A), otherwise even with the grid available, it will overload the circuit breaker.
3. During a backup event, the incoming circuit breaker limit (per item 2 above) no longer applies, as the contactor has switched the supply from the grid to the backup port of the battery system. During backup the homeowner must be careful not to overload the 20A circuit breaker and therefore should be very careful to only turn on loads that remain below this 20A limit (e.g. don't turn on all home loads on this essential circuit at once).

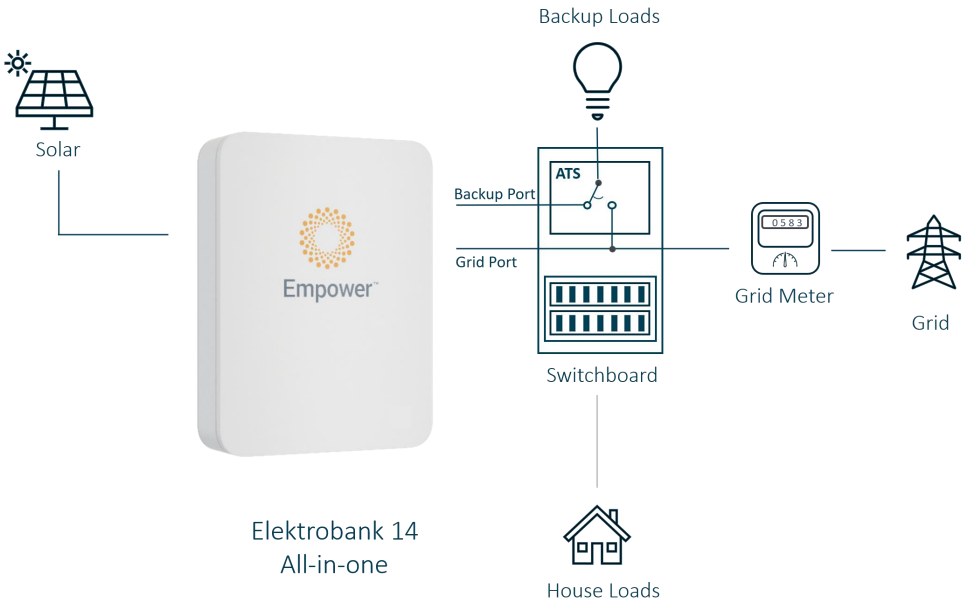


*Figure 2: Single Line Diagram of the external contactor approach showing the automatic transfer switch (ATS) in the switchboard*

## Critical Takeaway

The advantage of an external contactor is that it operates independently of the inverter, with the sole purpose of detecting availability of the grid and then disconnecting the house loads from the grid when the grid is out of tolerance (such as during an outage). Thus, any issues or faults in the battery inverter will not interrupt the homeowners access to the electrical grid.

# 4. EMPOWER'S RECOMMENDATION

## ONLY BACKUP ESSENTIAL LOADS

While the initial instinct when purchasing a battery system is to wire in a whole home backup, it is can become very expensive and if not done correctly, create a scenario where the battery system is overloaded, making it unable to fulfill its backup duties during a grid outage. Empower encourages its customers to be sensible about their priorities during a grid outage and focus on determining their essential loads. It is vital that prior to the installer completing the installation and leaving site, they provide guidance and training to the customer on how to avoid overloading the battery system during a grid outage.

- ☐ Refrigerator
- ☐ Communication (landline phone, modem/router)
- ☐ Electrical outlets for laptop, tablet, or mobile phone charging
- ☐ Lighting
- ☐ Powered pumps for drinking water or toilets
- ☐ OPTIONAL - TV

## USE AN EXTERNAL CONTACTOR FOR ISOLATING THE BACKUP PORT

Although the ElektroBank 14 was designed with an internal contactor to perform the electrical isolation duties, limitations on the maximum current of the internal grid circuit breaker and occasional

possibility for unexpected inverter faults has led Empower to no longer recommend this approach nor support it in the field. Empower only supports installations where a quality external contactor is used.

Empower Insight

Empower has encountered field issues with low quality contactors and thus we emphasise the importance of sourcing well known components from trusted suppliers. The only contactor we currently recommend is the **ABB: ESB63-22N-06**. Please confirm with Empower for advice before selecting a non-recommended contactor. The contactor must have 2NO+2NC at 63A to provide the required functionality. “

## PEAK AND CONTINUOUS POWER OF ELEKTROBANK 14

The ElektroBank Technical Data Sheet specifies that the backup port is limited to 3.5 kW continuous power. This limit only applies if the internal contactor is being used. Empower no longer supports installations utilising the internal contactor, as the external contactor provides a more robust and reliable approach.

Empower has proven field experience with the ABB ESB63-22N-06. If this external contactor is used, the following ratings apply:

- **Peak Power**: 5kW with solar and battery
- **Continuous Power**: 4.6kW continuous power

## BLACK START CAPABILITY

Black start is a term that describes the battery system’s ability to power on without the grid (e.g. from external power sources such as solar) in scenarios where the battery system has been powered off due to a deep discharge of the battery.

The ElektroBank 14 was designed to never turn off, as even in a backup event there is solar power coming in (even on cloudy days!). If the grid is disconnected, then the ElektroBank 14 will enter backup and will stop discharging the batteries, keeping 10% SoC to power only internals, with no 230V being generated.

If solar is present at any point, then it will start to charge the batteries. Once the SOC goes above a certain threshold it will re-start backup mode and generate 230V output to support the loads again.

If there is no solar or grid for an extended period, we would expect the internal systems to remain powered for at least a week. If the batteries fall to 0% (lower voltage limit of the battery), then the unit will power down, the LED will turn off and communications would be lost to the ElektroBank 14. When grid returns, the unit would power back on, but depending on how long the unit has been powered down for the batteries may have depleted too far, in which case a site visit by a technician would be required to manually re-charge them.

To avoid a site visit, please contact Empower if your SoC falls below 10% and you want to turn your system off for more than a week, for example if you are having renovations done.

# 5. APPENDIX

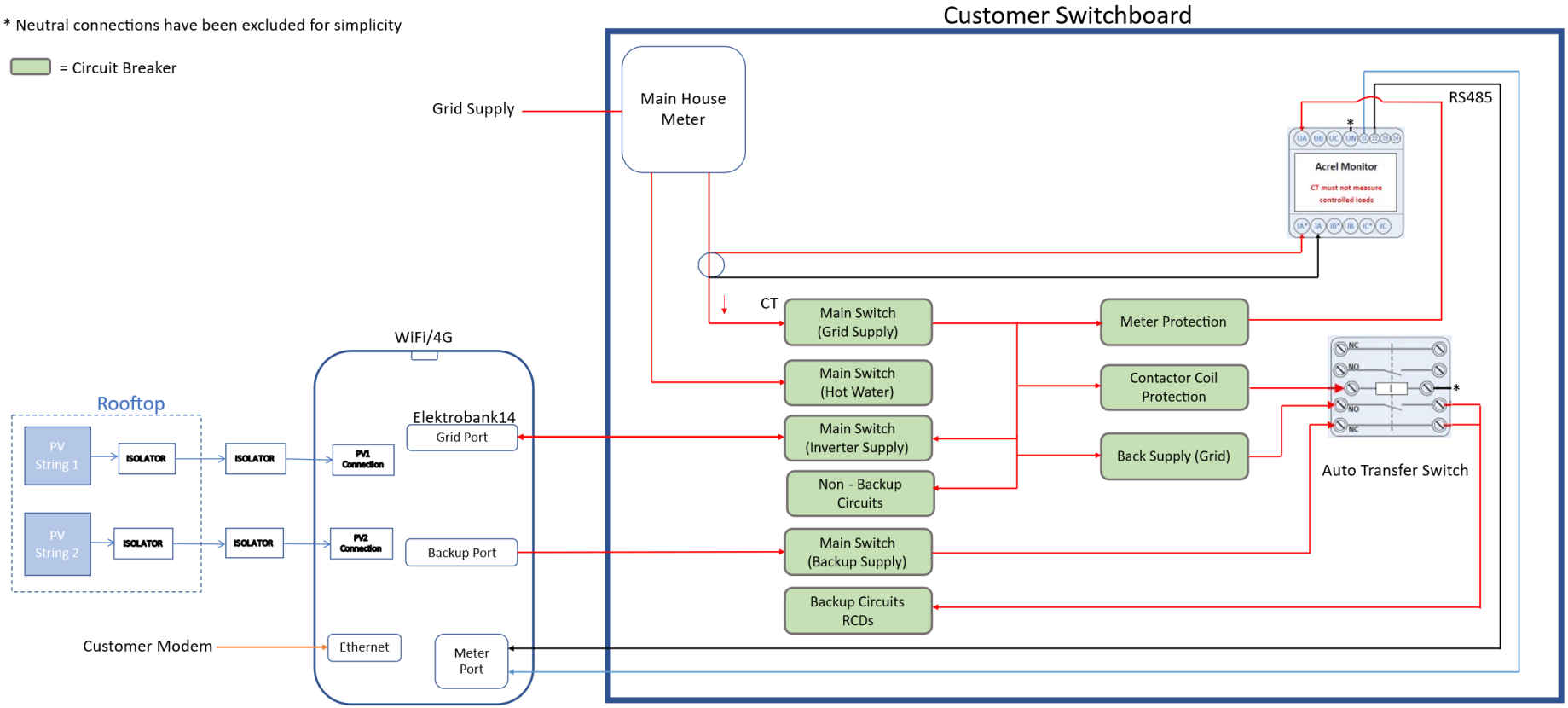


*Figure 3: Detailed wiring diagram for External Contactor*