WHITE PAPER

Nothing but the BESS: Why Integrating Temporary Small Batteries Optimizes Your Site

Executive Summary

This whitepaper outlines the numerous advantages of utilizing small mobile battery energy storage systems (BESS) in temporary power scenarios. It also provides guidance on identifying suitable applications for their deployment. The key components of a BESS are detailed, highlighting their design for mobility, rapid installation, and ease of configuration.

WHAT IS A BATTERY ENERGY STORAGE SYSTEM?

A Battery Energy Storage System (BESS) is a device that stores energy in batteries and releases it when electrical power is needed. Storage capacities range from a few kilowatt-hours (kWh) for residential systems to multiple megawatt-hours (MWh) for grid-scale applications. BESS can be either stationary for fixed installations or mobile with robust designs for repeated relocations and swift deployment. This whitepaper focuses on small mobile BESS with a capacity of 150 kWh or less.

WHAT IS INSIDE A SMALL MOBILE BESS

ENCLOSURE

A sturdy subframe, not typically present in stationary BESS, equips the mobile BESS with the durability needed for frequent transportation. The folded metal enclosure offers weather protection and restricts access to internal components. The battery mounting system is enhanced for greater strength and vibration isolation compared to stationary systems.

POWER CONNECTIONS

To minimize installation costs, speed and simplicity are crucial. Power connections are designed for easy access, enabling swift cable connections. Small mobile BESS typically feature separate input and output connections, unlike the bi-directional connection often found on larger BESS. This configuration places synchronization controls within the BESS itself, simplifying installation and allowing connection to a standard generator set with non-synchronizing controls. Additionally, the separation of input and output means that power from the supply passes through the BESS to the load. A small mobile BESS will have a pass-through current limit that is usually quoted on the BESS datasheet. This is an important parameter to consider, as it will determine the highest genset rating that is feasible to be used in combination with the BESS.

INVERTER-CHARGER

The inverters utilized inside a small mobile BESS are often the combined inverter-charger type. As with the BESS itself, the inverter-charger has separate input and output. Synchronization monitoring and controls, including synchronizing contactor and the neutral-earth relay are all contained within the inverter-charger, simplifying the internals of the BESS. Other designs that use inverters with a combined bi-directional input-output are more complex, as the monitoring, controls, and contactors needed for synchronizing are external to the inverter. Most inverter designs allow power from the supply, that is not used to charge the battery, to pass directly to load without any power conversions. However, there are some designs in the industry that involve multiple power conversions for power passing from the supply to the load. This has the disadvantage of introducing additional power conversion losses, that are not present in designs with a direct pass-through.

BATTERIES

Most manufacturers of small mobile BESS equipment install lithium-ion battery modules in their products, although some designs with lead-acid batteries are still available. While lead-acid batteries can be significantly cheaper, they come with several drawbacks. One noticeable difference is the size and weight: a lead-acid BESS can weigh more than double that of a lithium-ion BESS with the same nameplate kWh capacity and take up about 50% more volume.

However, what might be less apparent at first glance, is the relative difference in kWh capacity between the two types of battery chemistry. The useable kWh of the lead-acid BESS will be much lower than the lithium-ion BESS of the same nameplate kWh capacity. The usable kWh of a lithium-ion BESS is typically 80% of the nameplate kWh and can be extended to 90% by accepting a moderate reduction in battery life. In contrast, the usable kWh of a lead-acid BESS is only about 40%, which can be increased to 60% at a significant cost to battery life. Furthermore, the useable kWh of lead-acid BESS is greatly impacted by the rate of discharge and cold temperatures. Only a fraction of the 40% mentioned above, may be available if a lead-acid BESS is discharged faster than the 10-hour discharge rate or if the temperature is below 25C. Therefore, while the lead-acid BESS may seem cheaper than a lithium-ion battery, if the useable kWh is compared instead, the lead-acid looks less competitive.

A lithium-ion BESS will also accept a higher rate of charge than a lead-acid BESS. Charging a lead-acid BESS at its maximum rate further reduces the usable kWh, and the charge rate drops much earlier in the charge cycle compared to a lithium-ion battery. Therefore, to charge a lithium-ion BESS, a genset will run for a shorter time and maintain an optimum load for the duration of the charge cycle. This will achieve greater fuel savings and a larger reduction in genset servicing costs. This savings delta is further increased by the lower round-trip efficiency of lead-acid batteries. That is, for the same amount of energy you put in, you get less out from a lead-acid battery compared to a lithium-ion battery.

Another important factor is battery life. Lithium-ion BESS can handle far more charge-discharge cycles than lead-acid counterparts. This is compounded further in temperatures above 25C, due to the greater detriment high temperatures have on the life of lead acid batteries. When comparing the cost of a lithium-ion BESS to a lead-acid BESS, the longevity of the battery should be included in the calculation.

WHY USE A BESS

FUEL CONSUMPTION AND GREENHOUSE GAS EMISSIONS

The benefit of using a small mobile BESS that is most often promoted is reduced fuel consumption and associated greenhouse gas emissions. Gensets in temporary power applications often run at 30% load or less. For example, the size of the genset can be selected based on a peak load requirement but, for much of the time, the genset may only be required to supply a very low load. Additionally, load profiles can be asymmetric, with high loads during the day and low loads outside working hours. In other instances, the size of genset can be selected based on a distribution panel rating, yet only a small amount of load may be connected to the panel. The impact of prolonged genset operation at low load is bad for the engine and wastes fuel. However, when a BESS is used in conjunction with a genset, the combined site load and charging power increases the load on the engine to a more efficient operating point. Once charged, the genset will stop and the site load will seamlessly transfer to BESS power. This reduces genset runtime and ensures it operates more efficiently, lowering fuel consumption reducing greenhouse gas emissions.

ENGINE AFTERTREATMENT

Further complications occur when operating gensets with EPA Tier 4 Final or EU Stage 5 engines at low load. Problems occur when exhaust system cannot reach a temperature high enough to allow regeneration to take place, causing the diesel particulate filter to become clogged and the genset to shut down. A common solution for this is to add a load bank that will provide a sufficient load for regeneration to occur. However, by doing this, fuel consumption and greenhouse gas emissions increase substantially. Using a BESS in place of the load bank will dramatically reduce the amount of fuel burned and greenhouse gas emitted, and despite the low cost of a load bank compared to the cost of a BESS, the fuel savings will be greater than the higher rental rate of the BESS.

PEAK LOAD

Adding a BESS can shave peak loads by combining the peak output of both the genset and the BESS, therefore increasing the system's peak load capacity. This allows for the use of a smaller genset, leading to fuel savings.

SERVICE COST AND ASSET LIFE

Using a BESS reduces genset runtime, which in turn lowers service frequency and prolongs asset life. This results in savings from reduced service and maintenance costs and longer-term benefits from decreased wear and tear. In some applications, genset runtime can be reduced by 60 to 80%, potentially shifting from double or triple shifts to a single shift, eliminating shift multipliers and delivering additional savings to customers.

LABOR SAVINGS

Introducing a BESS can also reduce labor costs. Some sites require trained staff to be present when a genset is operating. By using a BESS, it might be possible to supply night and weekend loads from the BESS instead of the genset, removing the need for 24/7 staffing. Most BESS feature remote monitoring capabilities and can send alerts for parameters such as faults, high loads, or low battery state of charge. Potential issues can be dealt with remotely, as they arise, and settings can be changed, such as reprogramming the on/off schedule, eliminating the need for employee to travel to site. For sites located far from the depot, labor-hour savings can exceed fuel savings.

SECURITY OF SUPPLY

The addition of a BESS also provides an extra level of redundancy. During genset maintenance, the stored energy in the BESS can supply power to the load, to allow servicing to take place without interruption to the electricity supply. In the event of genset failure, the BESS can prevent power outages and buy critical time to address the fault. This can be a valuable benefit for some customers, where downtime costs a lot of money. For example, where equipment needs to be reset manually following an outage or a process gets interrupted resulting in product getting lost. Similarly, the extra redundancy a BESS provides can be a benefit at events, converts and TV/Radio broadcasts, where a power outage can cause significant negative impact.

NOISE POLLUTION

Many manufacturers promote their small mobile BESS products as being a silent power source. However, when the cooling fans are running, some noise will be present. Nevertheless, provided the fans are variable speed and set correctly, the BESS can provide significant noise reduction over a genset. Running a BESS instead of a genset can ensure a quieter and more pleasant environment for attendees at an event or at sites adjacent to residential areas. Locations with noise ordinances enforce, the addition of a BESS can keep the power on during the quiet hours when genset operation is prohibited.

SOLAR

Some BESS products come with inputs for connecting photovoltaic (PV) panels for capturing solar power and storing the energy in the BESS for later use. This makes integrating solar into a project much easier to implement. Adding PV panels can further reduce fuel consumption and, in some cases, eliminate the need for gensets altogether, achieving zero emissions and removing the need for site visits for refuelling and servicing.

BATTERY ELECTRIC MACHINE CHARGING

A BESS can assist in the transition from diesel-powered plant machinery to battery electric machines (BEM). In situations where a small BEM might not be considered practical, due to energy limitations to cover a full shift and no local access to a utility supply, a small BESS can make the project viable. For instance, using the BESS to top-up charge the BEM during lunch breaks can provide enough charge to allow the BEM to complete the shift. In cases where returning the BEM to a utility supply for recharging isn't feasible, a mobile BESS can transport the necessary energy to the BEM, much like a tanker refuels conventional machinery.

WHEN AND HOW TO USE A BESS

IDENTIFYING THE RIGHT JOBS

It is important to recognize that a small mobile BESS is not a genset and will not be the best fit for every job. If a genset is optimally sized with an average load above 50%, adding a BESS is unlikely to deliver fuel savings or reductions in greenhouse gas emissions. However, if the average load is low or if there is a large variation over the day or week, then the benefits of adding a BESS are worth investigating. If environmental concerns are important to the customer, quantifying the reduction in greenhouse gas emissions from using the BESS will demonstrate the value to the customer. If a load bank is being considered because the average load is too low for regeneration on an emission compliant genset, then a BESS should be investigated as an alternative to avoid the additional fuel costs and greenhouse gas emissions from using a load bank. When assessing if a job is suitable for a BESS, it is important to identify all the savings in addition to fuel savings and include them in the calculation of total cost. These include lower servicing costs, extending asset life, reduced labor costs, and removing shift multipliers.

Another factor to consider is projects where noise pollution is an issue, this includes any applications where noise from a genset is undesirable or prohibited. Also, sites where security of supply is a concern can provide BESS opportunities. If supplying the load is critical and there are costs or negative implications from an outage, then the extra redundancy of a BESS may provide the assurance required. If a customer is looking to install PV panels, either with or without a genset, a BESS can provide an easy way of integrating solar power to create a microgrid. Furthermore, for any site considering a small BEM, it is worth investigating if a small mobile BESS improves the viability of the project.

SIZING THE BESS AND GENSET

A BESS will have a power rating in kVA or kW and an energy storage capacity in kWh. The power rating is typically the rating of the inverter, but this can be limited by the maximum discharge rate of the batteries. Therefore, the full kVA may be available for a limited time to avoid a battery overload trip. The BESS will also start the genset if the load is high, so it may be necessary to keep the load below around 80% if you don't want the genset to start before the batteries have discharged. BESS models using lead acid batteries will be limited to a much lower average power to avoid a substantial reduction in their usable kWh capacity. As stated above, a small mobile BESS is not a genset, and comparing one to a genset with the same kVA rating can be misleading. For example, the optimum average load on a genset is typically 75%, whereas applications where a BESS is a good fit are typically much lower loads that are not the ideal load for a genset.

Most small mobile BESS have a pass-through current limit, which is the maximum current that can be passed directly from the input to the output of the BESS. It is better not to use a genset that has a capacity much greater than the pass-through limit because it will not be possible to efficiently load the genset. This determines the largest genset that can be feasibly used with the BESS. When the pass-through from the genset and the inverters are combined, a greater current than the pass-through limit is usually permitted, enhancing the combined peak load capability. This may allow for a smaller genset selection than would be required without the BESS.

Ideally, the genset should be adequately sized to provide enough power at around a 75% load factor to both charge the BESS and supply the load. A smaller genset can be used if the BESS can be adjusted to limit the current drawn from supply to avoid overloading the genset. However, smaller gensets will need to run for longer, due to the reduced power available to recharge the BESS batteries.

The duration a BESS can provide power before needing a recharge depends on the load and the BESS's kWh capacity. It's important to consider the usable kWh rather than the nameplate capacity. The usable kWh capacity of a BESS with lithium-ion batteries is typically 80 to 90% of the nameplate capacity. As previously mentioned, the usable kWh capacity of lead-acid BESS is lower and affected by temperature and discharge rate. The BESS discharge curve is a plot of average load against discharge time and is used to determine how long the BESS can provide power before needing recharged. The discharge curve is useful for determining if the BESS will have enough stored energy to provide quiet power for the duration of an event or to cover the nighttime hours before the shift starts the following day.

USING A BESS WITH PV PANELS

The onboard solar charger included on some BESS models is typically plug-and-play. However, there are important parameters to keep in mind when selecting and arranging the PV panels into strings. The input voltage to the solar charger must be high enough to charge the batteries—typically 5 to 10V higher than the DC bus voltage. Also, the solar charger input voltage must not exceed the maximum allowed by the charger. It is essential to calculate the worst-case scenario, which is the maximum open-circuit voltage from the PV panel at the coldest site temperature. This determines the number of PV panels that can be connected in series without exceeding the charger's maximum input voltage. It is also necessary to calculate the maximum short-circuit current from the PV panel at the highest site temperature. This will determine the maximum number of PV strings that can be connected in parallel without exceeding the short-circuit current limit of the connectors or solar charger. The kW rating of the solar charger must also be considered when calculating how many PV panels to connect.

If the site requires a greater number of PV panels, then it may be possible to connect solar inverters to the output of the BESS. This is more complex than connecting PV panels to the onboard charger but does allow more PV panels to be connected. If the addition of solar inverters is supported by the BESS, excess power from the solar inverters can be used to charge the BESS batteries. Conversely, when there is insufficient solar power to supply the load, the BESS will provide the extra power needed to fill the shortfall. BESS models that support the connection of solar inverters will use frequency shifting or SunSpec commands to curtail the PV to avoid overcharging the BESS batteries.

CONFIGURING A BESS

Configuration is usually accomplished through a control panel fitted to the BESS. These are often graphical, can have touch screen display, and are intuitive to navigate. Through various screens, it will be possible to adjust settings and setpoints to configure the BESS for the application. This includes setting the minimum battery state of charge for genset start-up and the maximum state of charge for genset shutdown. Most control panels also feature multiple timers for scheduling genset operation at various times of the day or week, and it may be possible to set timers for turning power to the load on and off. The maximum input current that can be drawn from the supply can be adjusted to avoid tripping the supply breaker or overloading a smaller genset. The load threshold above which the genset will start is usually adjustable as well. By modifying these simple set points, it is possible to optimize the BESS for most applications. However, for more complex jobs, it may be necessary to access a deeper level of adjustment reserved for advanced users.

Through the control panel, BESS models with remote monitoring capabilities can be configured to send email alerts to notify staff if a fault or an alarm is present. It may also be possible to remotely access the BESS to clear faults or adjust settings, avoiding the need to travel to the site. Remote monitoring can provide automatic reports showing information such as reduced genset running hours or solar generation metrics, adding value for customers.

CONCLUSIONS

It's crucial to recognize that a small mobile BESS is not a replacement for a genset. Instead, it's often better suited for applications where gensets are less ideal, such as noise-sensitive environments or sites with low average loads. Depending on the load profile of the installation, the addition of a BESS has the potential to deliver substantial fuel savings and reduction in greenhouse gas emissions. Additionally, a BESS offers further savings through lower service costs, extended asset life, reduced labor costs, and decreased genset rental rates. All these factors should be considered when calculating the total benefit of deploying a BESS.

The extra redundancy provided by a BESS is invaluable in scenarios where power outages could be costly or have undesirable consequences. For customers looking to harness solar energy through photovoltaic panels, a BESS simplifies solar integration, offering further fuel savings, lower greenhouse gas emissions, and, in some cases, a zero-emissions solution by eliminating the need for a genset altogether.

Using a BESS to transport energy for recharging battery electric machines can be the key factor in making a project viable for transitioning from diesel-powered machinery. This whitepaper does not cover every possible application but aims to highlight potential opportunities where a BESS can add significant value.

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