WHITE PAPER

Providing Resiliency Through Battery Storage Technologies

ABSTRACT

As data center facilities continue to focus on innovation, resiliency, and sustainability, incorporating distributed generation technologies and sources of renewable energy into the traditional data center design model provides an innovative way to provide resiliency to data center facilities. Integrating distributed generation technologies, such as battery energy storage systems (BESS), can provide an interactive and resilient power distribution design to the data center's critical equipment. Additionally, a sample University Data Center project utilizing a battery energy storage system for backup power is demonstrated.

BESS DESIGN OVERVIEW

This design application connects a BESS to the building's power distribution system and utilizes the island mode (off-grid) capabilities to supply conditioned backup power to the critical loads. Refer to Figure 1 below for a typical distributed generation topology design. An on-grid, Alternating Current-coupled device, the BESS consists of a bi-directional power converter and rechargeable lithium-ion batteries designed for outdoor installation. As a microgrid application device, the BESS can also operate in an island mode configuration, independently supplying conditioned backup power to the building's loads upon loss of the utility grid power. The BESS is provided in conjunction with a fast-acting static switch, which will supply the building with uninterruptible power during power outages and other incoming utility power quality events. During utility outages, the lithium-ion batteries will provide backup power to the load for the rated KWH time frame. When the utility has been determined to be within an acceptable quality range, the static switch will close, supplying

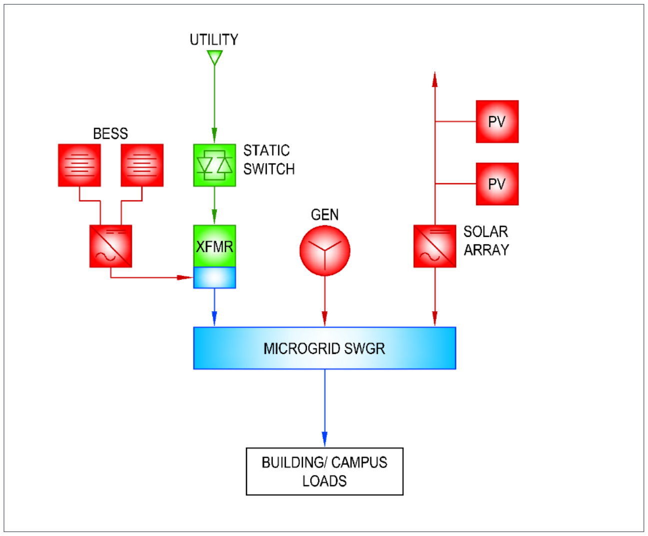

Figure 1: Typical Distributed Generation Topology

the load directly from utility again. The batteries will then charge as needed to maintain the appropriate energy storage capacity.

Lithium-ion batteries are becoming more popular for many power applications due to their higher power and energy density properties. Due to these properties, lithium-ion batteries have the capability to supply more power for a longer duration than other types of battery chemistries, such as lead acid or nickel cadmium. Additionally, lithium-ion batteries have a high cycle lifetime and efficiency, meaning they can be charged and discharged many times without derogation and excessive power losses, and often are provided with 10-15 year warranties.

Traditionally, BESSs are utilized in utility microgrid applications; storing energy when renewable energy production exceeds demand, and exporting power back to the grid when demand exceeds production. For non-utility, building applications, a BESS can synchronize and interact with the incoming utility to discharge the lithium-ion batteries and reduce energy consumption at peak demand times. Other forms of renewable energies can also be integrated into the power distribution and utilized during loss of utility power with the BESS. For example, if the BESS is coupled with a solar array and a natural gas generator, these power systems can independently operate and supply conditioned power to the facility with or without a utility grid available. Being able to independently operate without a utility grid for extended periods of time increases the building's uptime availability, providing further resiliency to the power distribution system.

BESS Design Summary:

- Uninterruptible conditioned backup power upon loss of the utility grid power.
- High cycle lifetime and efficient lithium-ion batteries.
- Reduce energy consumption at peak demand times.
- Couple with other sources of renewable energy to independently operate without a utility grid for extended periods of time.
- Increase power distribution system's resiliency.

APPLICATIONS AND BENEFITS OF BESS DESIGN

The benefits of a fast-acting BESS can also be supplemented with engine generators and/ or other UPS technologies to increase the resiliency and redundancy of the data center. Since the BESS can provide conditioned backup power, it can reduce the quantity of redundant engine generators and UPS systems, which are traditionally provided in power distribution designs for critical operating facilities, required for the design. Refer to Figure 2 for a sample design solution for a redundant distribution system where the redundant standby generator and UPS system is substituted by the fast-acting BESS design.

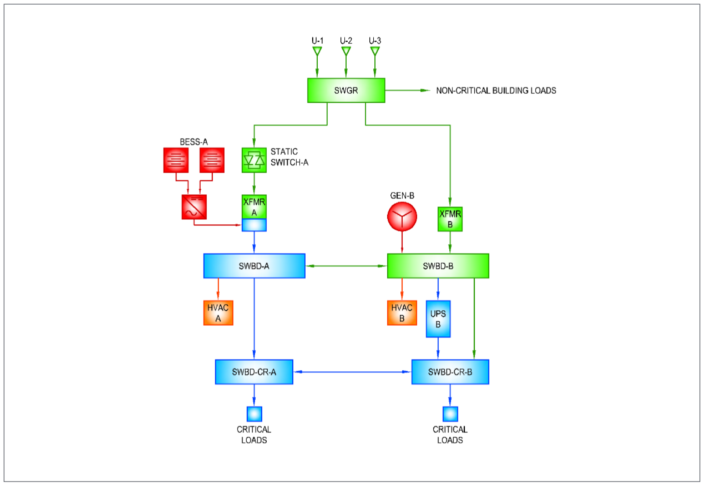

Figure 2: Sample BESS Design

Substituting on-site generators and UPS systems with BESSs can also alleviate operational risks typically encountered by these systems, such as battery starter failures and fuel filter clogs for generators, or battery end of life failures for UPS systems. Since the BESS will provide uninterrupted power to the connected load, this design solution can also simplify the controls and sequence of operation between the electrical and mechanical systems - no downtime and restart cycle of the mechanical systems is required.

The BESS design also provides the opportunity to simplify the process of a typical mission-critical construction timeline is as follows:

- Simplify site selection process by minimizing on-site emissions and fuel storage permit requirements.
- Simplify construction phase with standardized off the shelf "plug-and-play" equipment.
- Simplify commissioning phase by minimizing the amount of on-site adjustments that need to be made with the "plug-and-play" equipment.
- Potential capital and operational cost savings of up to 10% for the electrical system when compared to an electrical system for a traditionally designed data center facility of equal resiliency and redundancy.

UNIVERSITY DATA CENTER PROJECT

The following description illustrates the first design of its kind, in which a University Data Center project utilizes a BESS for backup power to the facility's HVAC and IT loads. Refer to Figure 3 for the facility's power distribution design.

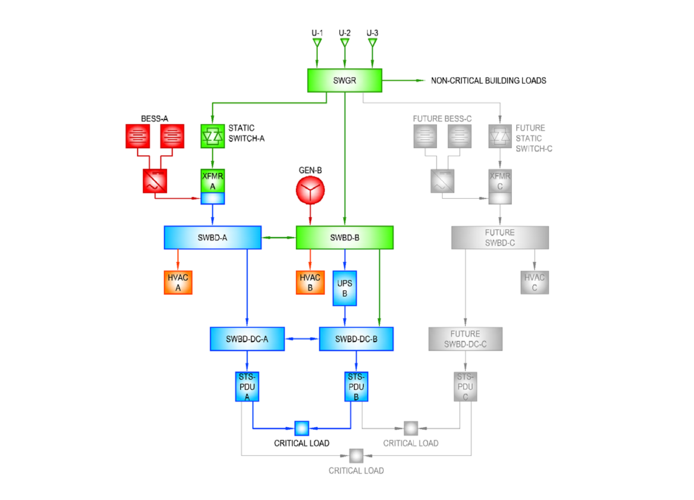

Figure 3: University Data Center Project Single Line

> **The ability to handle critical load growth and fluctuations within a live data center is the core feature of the University Data Center Project's electrical system configuration.**

The design intent of electrical system configuration was to provide a stand-alone data center that maximizes system efficiency and economy. The ultimate design of the data center will be a block redundant topology to provide system flexibility, expandability, and cost efficiency corresponding with the University's anticipated IT growth profile. The ability to handle critical load growth and fluctuations within a live data center is the core feature of the electrical system configuration.

An initial "Day One" power distribution configuration was designed to match the University's anticipated 5-year growth profile with redundant A- and B-side distribution pathways. The B-side critical distribution path is set up with a traditional UPS and generator configuration, where the UPS will provide power conditioning and uninterruptible power to the critical IT equipment until the generator starts up and assumes both the IT and HVAC loads. The A-side critical distribution path is set up with a BESS (installed outdoors) for both power conditioning and uninterruptible island mode operation to the connected load. During utility outages, the lithium-ion batteries will provide backup power to the load for the rated KWH time frame. When the utility has been determined to be within an acceptable range, the static switch will close, supplying the load directly from Utility again. The batteries will then charge as needed to maintain appropriate energy storage capacity. Once the University has reached their IT growth limit, the C-side distribution path can be installed, increasing the data center's MEP infrastructure capacity.

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The power distribution design features three levels of transfer schemes to ensure either backup or conditioned power is supplied to the critical IT and HVAC equipment. The three levels of transfer schemes are as follows:

1. STSs supplied from A- and B- side sources to minimize the stress on the IT servers internal power supplies upon loss of either A- or B- side power supply.

2. A- and B-side main switchboards configured in a Main-Tie-Tie-Main-Generator configuration, such that failure or depletion of either backup source will initiate an automatic transfer sequence to ensure utility, generator, or BESS power is available to each switchboard's distribution pathway.

3. DC-A- and DC-B-side downstream switchboards configured in an automatic transfer Main-Tie-Tie-Main configuration, to provide an additional level of assurance that the critical IT load can be supplied with either BESS or UPS power during maintenance or emergency scenarios.

Since the A-side BESS actively interacts with the connected utility, providing power conditioning in conjunction with uninterruptible supply to the load, it alleviated the need for A-side UPS and generator systems; the building footprint that would have been used for the UPS system in a traditional design was now able to be exchanged into usable space by the University. The BESS was also designed with scalability and modularity in mind, allowing the University to scale the capacity of the BESS by installing additional lithium-ion battery pack modules alongside the growth of the IT equipment, minimizing initial capital costs. Using the BESS as the A-side source of backup power in lieu of a generator minimized the building's environmental impact to the campus by reducing the associated emissions, pollutants, and on-site fuel storage required.

With flexibility, innovation, and cost efficiency being prime areas of focus in the data center's design, the BESS was a key design component in achieving these goals. As future data center facilities continue to redefine what resiliency means to them, incorporating distributed generation technologies, such as a BESS, can provide an innovative way to meet these definitions of resiliency as well as provide additional resiliency to the site and flexibility to integrate future emerging technologies which may arise.

MANUFACTURE SAMPLE PRODUCTS

Tesla's Powerpack BESS features a scalable and modular design allowing the system's power and energy to be scaled up in proportion to the growth of the IT loads. Tesla's Powerpack is rated for exterior applications, provided with an internal thermal cooling and heating system.

System Specifications

- Voltage: 380 – 480 V, 3-phase
- Power: 70 – 700 kVA, per inverter block
- Energy: 210 – 4200 kWh, per inverter block

Picture 1: Telsa Powerpack Assembly

Picture 2: Tesla Powerpack Battery Pod

MANUFACTURE SAMPLE PRODUCTS CONT.

Cat BESS module consist of a pre-engineered container that can be rapidly deployed and installed on site. Container is installed outdoors and houses all required inverters, batteries, thermal conditioning, and auxiliary systems.

System Specifications

- Voltage: 380 – 600 V, 3-phase
- Power: 250 – 1000 kVA, per container system (typ)
- Energy: 287 – 1148 kWh, per container system (typ)

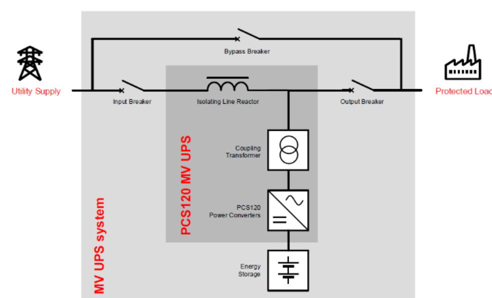
Alternatively, ABB is in development of a medium voltage UPS product which will be able to provide full power conditioning and emergency power to the connected load on the Megawatt capacity scale.

System Specifications

- Voltage: 12 – 15 kV, 3-phase
- Power: 2.25 MVA, per unit
- Energy: Dependent upon desired application and coupled energy storage system

Picture 3: Cat Battery Energy Storage System Module

Picture 4: ABB PCS120 MV UPS Assembly



Picture 4: ABB PCS120 MV UPS Assembly

ABOUT THE AUTHORS

Rajan Battish PE, NCEES, LEED AP has more than 25 years of experience in innovative design and project management on data centers and mission critical projects. With a specialization in power infrastructure, Rajan pioneered the Tesla Battery Storage Systems for data centers and has published numerous papers on energy efficiency and data center reliability.

Chad Jones PE, LEED Green Assoc., is an electrical engineer with expertise in power distribution systems for mission critical facilities. Chad gets is especially adept at new technology research and typically remains involved throughout a project's design and construction phases to ensure the proper implementation of complex power distribution systems.