WHITE PAPER

Going Vertical with Building-Based Solutions for Battery Energy Storage Systems

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The U.S. Energy Information Administration (EIA) estimates that the nation's battery storage will reach 30 GW of capacity by the end of 2025, a stark increase from the 7.8 GW operating in 2022. The surge in battery energy storage systems (BESS) correlates with the need to stabilize the variability of solar and wind on the grid and provide for the retirement of baseload fossil generation as the renewables revolution continues.

Things Are Looking Up

From the onset of the battery energy storage boom, BESS projects have been located in areas where land was readily available, market conditions were favorable, and building out and not up was the way. The result is that California and Texas currently make up more than 75% of today's battery storage capacity nationwide. For these states, the abundance of land made BESS installations an attractive approach to harness the existing renewables developed to see that power was available when needed.

While the demand for energy storage continues to increase, the spatial availability for new projects is finite. On the U.S. East Coast, states such as New York, Massachusetts, and Virginia have established energy storage targets that require storage solutions. These mandates will require battery energy storage systems to be installed in urban areas where many of the installation requirements are different from those BESS facilities that have been located in open areas. Additionally, there is a growing movement to place battery storage projects near urban load centers where BESS installations can be used to address power quality and reliability at the local level. As a result, many project stakeholders are considering how to handle BESS installations in densely populated areas.

Unlike BESS projects in wide-open spaces developed horizontally, BESS projects located in urban areas must consider a new approach. Most urban areas do not have the luxury of space and high property costs. To meet urban utility energy demands, utilities and developers will need to look to vertically orientated BESS to address the challenges and demands of the growing energy storage market.

Vertical Bess Project Planning

Whether installing BESS in an open area or a multi-story building, the components are similar but the challenges of executing the installation are very different. Unlike a vacant plot of land for conventional installations, BESS projects in urban areas must deal with space constraints, additional regulations, and a closer relationship to the public.

All projects benefit from early, and upfront analysis and clear decision making and a building-based BESS project is no different. However, as developers explore urban BESS project development, there are several unique challenges that a building-based vertical BESS project presents, which should be carefully considered.

Constructability

Finding viable properties, buildings or land for BESS projects in urban areas near an interconnection point is an essential but challenging first step in the development process. Potential properties should be located nearby or have relative access to an interconnecting point to the area grid, have favorable zoning requirements, and sufficient space for construction of a BESS facility. Use of existing structures may be limited due to requirements for BESS facilities such fire protection, thermal management, and structural capacities. Many times, existing structures may need to have significant retrofits completed or need to be demolished and new purpose-built BESS facilities built in their place, adding to the construction complexities and costs of development.

When considering multi-story BESS installations, materials of construction must be considered, along with potential logistics related to how the construction will be completed. These include use of steel vs. concrete structures for fire protection, available crane space for building construction, timing of construction deliveries, and impacts of local zoning requirements on building size and heights. Future operation and maintenance considerations such as access ways and crane/lift access for augmentation and replacement of BESS components must be considered. Additionally, selection of the BESS product and the specific requirements for installation as well as operation and maintenance space need to be considered in the layout of the building and the supporting ancillary systems – including the routing and location of thermal management systems, electrical collection systems, and ventilation.
Considerations such as maximum allowable quantities (MAQs) and maximum probable loss must be considered when considering building layouts to facilitate the advancement of the project through the development and permitting stages.

Safety Considerations

BESS projects should focus on safe operation and management of the facility, including comprehensive safety systems developed in coordination with the applicable authorities having jurisdiction (AHJs) to allow for a safe response to an emergency. Whether looking to adapt an existing facility or new construction for a challenging site, technical challenges are present to provide these comprehensive safety systems. The complexity of segregating kilowatt groupings into MAQ zones, understanding structural fire ratings, designing for confined spaces, limited egress and securing fire marshal approval are increased. Consideration must also be given to the operations and maintenance impact on smoke and gas detectors, fire panels, fire suppression systems, ventilation systems, and testing and inspection schedules. Having defined and sufficient egress paths within and around the BESS facilities are also key to providing for safe operation.

The nature of battery energy storage presents unique risks compounded in a size-restricted space. Preparing project risk analysis and assessments such as hazard mitigation analysis (HMA) and failure mode and effects analysis (FMEA), should drive site design and enhance project safety systems. Collaboration and coordination of all the project stakeholders will be key to a successful and safe application.

While designing a BESS for fire protection is a key design priority, consideration must also be given to the insurability of the site. Design aspects such as spacing of adjacent BESS racks/enclosures and segregation of areas for limitations on maximum probable loss impact the overall site layout and resulting installed energy site capacity. Careful consideration should also be given to the selection and design of an appropriate building-based suppression system.

Thermal Management

The safe operation of any BESS asset requires efficient management of the surrounding ambient environment as operating of battery modules outside of prescribed temperature ranges and air flows can be detrimental to the BESS, resulting in an increased possibility for a thermal runaway event. An effective thermal management program, including mechanical cooling, heating, and ventilation, aids in maintaining operating stability while maximizing safe battery performance.

Building-based and vertical solutions pose significant challenges to mainlining sufficient ventilation and cooling due to proximity of adjacent units and the aggregation of the exhausted heat. Air flow modeling, including computation fluid dynamics (CFD) studies, should be completed to confirm sufficient air flow and temperatures are provided. Additionally, the compact BESS solution of a building or vertical application open the door for centralized solutions for battery cooling such as DX air-handing units or central utility plants. The use of direct expansion (DX) air handling units that use refrigerant liquid for cooling battery cooling represent a less expensive initial installation but can become increasingly inefficient over time. Central utility plants (CUPs) use large centrifugal chillers that distribute cooled water across multiple locations and buildings. A proven technology, CUPs offer the potential for added redundancy and greater operational flexibility and efficiency.

BESS thermal management design options also include rack placement, equipment located in different heat zones, hot/cool aisles for air distribution and more. A thermal management approach must be determined early to safely maximize space and efficiency for building-based solutions.

Operations and Maintenance

With every design decision for a vertical, building-based BESS comes the evaluation of operations and maintenance impacts. The analysis may be at the module level or focused more holistically across the site. Consideration should include the broader operation and maintenance of replacing modules, transformers, and inverter components within the confined area of a building where the utilization of large, heavy equipment may not be practical. Providing sufficient maintenance areas around the BESS equipment and a "path to ground" are key considerations.

As battery performance degrades over time, BESS augmentation, where additional battery capacity is added as the overall system ages, requires additional review during the early planning process for building-based BESS installations. How the BESS augmentation will be completed over the life of the system, including provisions for how augmentation units will be located and connected to the initial BESS ancillary systems, should be studied to confirm a constructable augmentation exists.

All BESS projects must evaluate the operating conditions for each site. Storms, flood risks, and humid, salty coastal air can affect how the equipment will operate and can tolerate before maintenance is required. To maximize effort, the development of an operations and maintenance program should be evaluated in tandem with design, safety and equipment decisions.

Permitting and Public Support

Developers of building-based vertical BESS projects must plan on the engagement of local authorities, planners, fire departments and the local community from the early outset of the project.

Urban centers revolve around zoning restrictions that can cause unexpected project constraints. Zoning review boards can surface challenges that might have otherwise been avoided with early engagement and planning. Local press reporting development inaccuracies can derail progress. Project planning that includes, engages and communicates with the project's wide range of stakeholders stands a better chance of success. Similarly, paying attention to project aesthetics, such as screening, architectural features and landscaping, before being asked may make a difference to the surrounding community.

Bess Enclosure Options

A range of battery storage enclosure options and design styles are available for BESS projects. However, going vertically heightens the challenges of airflow, thermal management and maintenance. The key is identifying the option that maximizes the investment but contains the risk.

An approach may exist to compress a BESS site to accommodate equipment while enclosing the facility in a structure. This approach builds in safety but allows for operability. An open-air design, similar to a mezzanine, can create an accessible internal layout with systems on different levels. Conventional enclosed solutions that use a modular approach but require space can be evaluated.

Many innovative approaches exist beyond rack storage or purpose-built solutions. But any design approach must address — and achieve — all project challenges and goals.

Conclusion

Going vertical with BESS projects may be the future for energy storage. While there are benefits in dealing with a smaller footprint, there are more challenges with this type of project. Because of the inherent constraints they are facing, developers can gain an advantage by partnering with an organization experienced in the planning, design and execution of BESS services. Burns & McDonnell has been involved in the construction of two building-based BESS projects and have been involved in the review and planning of several others, including single-story and multi-story applications.

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