DELIVERING ENERGY STORAGE SYSTEMS: OBSERVATIONS FROM THE FRONT LINES

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Introduction

Reports, studies, and analysis demonstrating the huge growth projections for the U.S. Energy Storage Battery sector have become commonplace. Not long ago, The Wall Street Journal posted the main headline "Batteries Will Power the World" (Feb 5, 2021), a clear sign that Energy Storage has gone mainstream in the public view.

But along with these opportunities come some significant challenges for companies who are actively engaged or thinking about entering this rapidly growing market. This paper discusses the first-hand observations and lessons learned from one firm who moved beyond traditional DC Power systems solutions into larger scale Battery Energy Storage System (BESS) projects and attempts to identify and discuss core issues and risks to success and profitability in this sector.

Having a better understanding of these primary issues and factors that should be considered and addressed when delivering Energy Storage Battery Solutions will have a significant impact on the organizational decision to enter this market and mitigate many of the risks involved in making that decision.

Current Supply Chain Issues That Impact Our Ability to Effectively Deliver Energy Storage Solutions; Choosing Your Supply Chain Partners

The US Supply Chain for lithium batteries remains fragmented and volatile with many global forces contributing to the dynamic nature of this sector. Lithium battery OEMs from China and Asia dominate the global supply chain, with US lithium cell production accounting for only 7% of the global battery production capacity. In 2021, the DOE released its National Blueprint aimed at boosting US manufacturing capacity, with the goal of increasing US production to 18% of global capacity by 2027. Despite this effort, it is clear that the US market will remain highly dependent on China/Asia for years to come.

For a variety of reasons, it can be hard for small and even medium sized firms to get the attention of many OEMs for typical stationary BESS applications. One way to understand this is to compare the breakdown of annual revenue between the automotive/motive sector vs. the stationary sector for both the lead acid battery market and the lithium battery market. The 2021 BCI report breaks down US lead acid battery revenue as $1,083,000,000 for motive/automotive, and $902,000,000 for stationary, demonstrating rough parity between the two sectors.

The same comparison for the US lithium battery market paints quite a different picture, with stationary applications being dwarfed by the automotive/motive sectors. In 2021, BESS applications represented a mere 6% of the total US lithium battery volume. For many of the OEMs, the primary focus is volume production to support the automotive sector. The experience of developers in this space has demonstrated the difficulty in getting the attention of many of the OEMs to support our typical ESS projects in the 250 kWh to 3 MWh range.

Compounding this problem is the extremely dynamic nature of the US lithium market. A significant number of the prime players focused on Energy Storage in 2018 are no longer in the US market, with new entrants popping up every year, often with an uncertain future in the business. Furthermore, OEMs who had an initial motivation and intent to support smaller ESS applications often find their priorities shifting to larger applications as they enjoy success in the market, dampening their enthusiasm to support smaller BESS projects.

One approach has been to identify relatively young and promising suppliers, many of whom have a similar business model. They import lithium cells from China or Asia through a Joint Venture or long-term supply agreement with Chinese manufacturers, assemble and package the imported cells into modules, then assemble and package the modules into battery stacks. Most develop their own Battery Management Systems (BMS) tailored for US customers, and partner with US OEMs to offer Master Site Controller solutions for both battery dispatch and integration and signaling to other balance of plant systems and Distributed Energy Resources (DER) management.

It is important to understand the level of resources provided by these newer OEMs to provide engineering services, technical support and applications engineering, integration capabilities, customer service, and distribution/ logistics support. Understanding their capitalization and financial resource base was always a key part of our selection process, to best determine their ability to sustain their presence in the business. Lastly, experience in this market demonstrates the importance of validating that the potential supplier understands the market focus, reviews ‘typical’ stationary battery system configurations for Energy Storage applications, in order to help validate their sincere, long-term interest in supporting these types of projects.

The Importance of Opportunity Qualification & The Growing Need for Good Technical and Economic Analytics to Cost Justify BESS Projects

One of the most interesting aspects of offering Energy Storage Battery Systems is how it has changed the typical customer attitudes regarding battery systems. Our traditional lead-acid battery solutions are often perceived as a necessary evil; customers understand the need for critical back-up but also see lead acid battery systems as a significant capital expense with ongoing operational costs for maintenance and testing.

But when you contact a customer to talk about Energy Storage batteries, it is usually a very different response! Almost every larger end-user is interested in and thinking about how to develop a viable Energy Storage plan. Company Boards are putting pressure on corporate senior managers to develop strategies aimed at promoting ESG policies aimed at cutting carbon footprint, utilizing more renewable energy sources, and scaling back on traditional fossil fuel-based infrastructure. Branding organizations as Green, environmentally responsible social citizens has become a powerful driver in corporate America.

Adding to this pressure are a number of Federal and State initiatives promoting ‘clean’ Energy Storage battery systems to reduce fossil fuel energy sources, which are backed up by strong financial incentives in the form of grant subsidies, tax incentives, and higher utility and demand surcharge rates. States like California, New York, and Massachusetts have used the power of legislative and executive action to encourage greener power and punish fossil fuel energy users.

Further customer interest centers on how we talk about Energy Storage battery systems. Unlike most traditional lead-acid power systems, we don’t talk so much about ‘applications’ and ‘use cases.’ We instead identify ‘revenue streams’ to be captured by the ESS to maximize the Net Present Value and the Internal Rate of Return (IRR) and Return On Investment (ROI) for their battery system investment.

The typical revenue streams (e.g., use cases) we work to identify, and address include:

- Peak Shaving (Demand Surcharge Management)
- Energy Arbitrage
- ISO Demand Response
- Frequency/Voltage Stabilization of the Grid
- Capital Deferral: e.g., Transmission & Distribution (T&D), Commercial & Industrial (C&I)
- Electric Vehicle Charging
- Overall Revenue Stream Stacking

The 'Holy Grail' of Energy Storage systems is to stack as many revenue streams as possible to maximize and optimize the best use of the battery system throughout the 24-hour cycle. We work to answer the following questions: What should we do? Where should we do it? How much are we going to save? At the most fundamental level, we are looking to achieve the best possible return on BESS investment while addressing core power issues.

No wonder customers are now eager to meet with the battery guys!

And while that is all good, therein lies a potential trap for those of us in the business. The reality is that most end users have only a vague understanding of BESS technology, functions, battery chemistry, and the complexity of the systems integration requirements for the range of the system components. Additionally, they aren't clear on the various revenue streams that might be possible with a properly designed and configured battery, as well as how the utility tariffs and demand surcharge rates would impact their investment. In most cases, they don't even know what size battery they should be considering or at best have a very imprecise estimate.

The result is that there are many potential clients and projects who will occupy a lot of time and effort to help them to develop a viable strategy, only to conclude that a system at this time just doesn't 'pencil out.' This underscores the need for better Opportunity Qualification processes, to help quickly determine the potential viability of a BESS project before too much time and effort are invested on projects with a low probability of a good Cost Justification to launch the project.

So how does one accomplish this important qualification task? A 2017 Battcon paper titled "Optimizing Battery & Dispatching to Maximize Economic Return" (Travis Simpkins & Carey O'Donnell) proposed the use of powerful mathematical algorithms to create an optimized modeling and analytics tool for determining the best sizing and configuration of a BESS system, as well as to create the ideal dispatch strategy for the BESS across a range of multiple stacked revenue streams. This platform would create both a technical system analysis and recommendation as well as an investment grade financial analysis showing the IRR/ROI of the BESS investment to maximize Net Present Value. The paper called this technical and financial analysis 'Techno-Economic Analytics'. This energy optimization platform now exists; one provider calls it Redcloud Planning (muGrid Analytics).

It should be noted that this process is quite different than traditional algorithmic approaches, which typically involve pre-programmed algorithmic dispatch routines. The power and flexibility of a mathematical optimization tool allows for constant and rapid changes in the battery dispatch strategy throughout the day, quickly solving for hundreds of thousands of decision variables to optimize battery performance throughout the day.

This process utilizes a LOT of data that is then run through a powerful series of algorithms to spit out the technical and financial analytics. There are a number of categories for the types of data used in this process. As always, the more accurate the data, the better the quality and accuracy of the final analytics package. The types of data needed include:

- **Distributed Energy Resources**: What forms of energy resources are available for the proposed site/facility? This includes renewables (PV, wind), conventional technologies (diesel, natural gas, CHP), and Energy Storage (batteries, hydrogen, water, thermal). This category should also identify all dispatchable loads, including HVAC, EV Charging, water purification, etc.
- **Utility Costs**: TOU rates, Demand Surcharge rates, Marginal prices, and any Ancillary services.
- **Load Profile**: Facility load data is usually provided by the utility as an interval data report (preferably in 15-minute increments); 2 years of data is best, with the minimum being one year of data.
- **Financial Incentives**: Tax benefits, legislative incentives, and 3rd party ownership/equity.
- **Customer Goals**: Resiliency, carbon footprint, and cost-savings.

The result is an accurate and precise analysis that customers can bank on, with a clear cost justification for the proposed BESS system. It eliminates 'anecdotal decision making' as a part of the process, providing instead fact-based decision metrics.

For those of us proposing BESS hardware and system integration solutions to users, this capability can quickly separate the 'wheat from the chaff' in terms of identifying good, viable project opportunities. Qualifying opportunities is the foundation for maximizing our time and efficiency in closing and implementing projects.

Technology Choices and Challenges: Battery Choices, Emerging and Evolving Regulations, Balance of Plant Capabilities, Grid-Edge Applications

Lithium-Ion chemistries and specifically Lithium Iron Phosphate (LFP), Lithium Manganese Oxide (LMO), Nickel Cobalt Aluminum (NCA), and Nickel Manganese Cobalt (NMC) battery cells for large scale energy storage have won and will dominate the BESS sector over the next 10 years. Some argue that cobalt chemistries will start the wane in popularity for stationary storage applications given the issues of these 'conflict metals' and their association with child labor mining practices. There are newer chemistries on the horizon (e.g., LFMP), and there is always lithium titanate (LTO) as a possibility (if they can lower their cell prices!) for this very solid chemistry.

The recently passed "Inflation Reduction Act" and its codification of Federal Tax Credits (FTC) for Battery Storage has pumped oxides into the hot thermals of the Battery Storage market…it's going to explode (Mega Pun intended). The IRA further incents domestic content to create space for US based manufacturing of systems, packs and eventually cells at scale and cost effectively. Last time we checked high demand and restricted supply just might lead to higher prices. Within that supply chain, stationary storage competes with motive EV, with the same cells, same materials supply chain. This is important to understand, and securing supply of batteries from a responsible, reliable, sustainable, price competitive source is the first challenge in building an integrated battery system.

Applications:

Bulk Storage, Grid Asset: This involves “siting reserve power” to instantly supplement increased power demand and can also support other market participation applications such as frequency response and VAR support. These tend to be larger system configurations (e.g., 20 MWh and larger systems). The flexibility and responsiveness of battery systems make them ideal replacements for many peaking plants managed by the ISOs. Large scale storage on the Grid today, including projects such as the Vistra Energy’s Moss Landing 1600 MWh BESS, supplement bulk power requirements for demand response, peak shifting, and resiliency. These projects are primarily owned and operated by Independent Power Producers who have long-term service agreements with Transmission and Distribution (T&D) electric utilities. Independent Power Producers (IPP) use utility construction firms as well as battery OEMs to Engineer, Procure and Construct (EPC) these “grid scale” battery plants at the lowest cost per kWh to maximize the ROI for the developers. Development costs are offset by federal and state tax credits, incentives, grants, and offsets.

Traditional battery service companies can have a role to play by providing 3rd party maintenance and repair services to include decommissioning and recycling services as the battery modules need replacement and possibly supplementation.

Lastly, these large-scale projects are expensive sources of energy but do provide cleaner energy when charged by carbon free sources such as wind and solar.

Grid Edge: These are typically storage assets that enable renewable penetration, enhance Power Quality characteristics, and improve demand response and resiliency.

Grid Edge projects are excellent examples of the flexible power and energy offered by Lithium-Ion battery systems. Grid Edge applications for Lithium BESS systems include:

- Distributed peak shaving close to the loads or behind the meter at Commercial & Industrial (C&I) users.
- Non-Wire-Solutions – Grid Distribution or substation-based power to supplement infrequently overloaded circuits and equipment.
- Power Quality applications to supplement overloaded circuits, increase power quality through frequency regulation, voltage support, VAR support, and resiliency.
- Community based micro-grids to increase resiliency and energy security.
- Enabling Fast EV charging support for passenger vehicles, fleet vehicles and material handling equipment.

Grid Edge projects are frequently developed and owned by utilities, municipalities and Commercial & Industrial customers for the various use cases that increase the efficiency of the electric grid, reduce the cost of peak power demand, and enable additional DER resources.

Grid Edge applications rely on capable battery engineering and service companies to deliver and maintain these complex systems. Systems improperly designed or constructed can lead to catastrophic failure. These small (<5 MW) systems require the same level of complexity to engineer, develop, install and maintain as their larger cousins, starting with interconnection studies, engineering design for civil, mechanical and electrical engineering, integration of all major equipment in conformance with customer standards and local authorities (e.g., applicable electrical and fire codes). Lastly, there is the care and handling of the battery modules from manufacture, test, transport, installation/commissioning, and maintenance through end of life.

It should be noted that the Life cycle of Lithium-Ion will be no different than our current model for lead-acid cells. While the battery chemistry significantly increases the feasible use cases for stationary cells, lithium battery packs won't sell, install, or remove themselves. Caveat Emptor.

Typical System and Site Integration Requirements; Required Skill Sets and Capabilities

Ohms law made the operation of traditional DC battery systems simple: connect a couple of sources to the load with a common piece of copper and physics takes over. If large scale storage with Lithium Cells were only that easy! The use cases for Battery Energy Storage Systems using Electrochemical batteries drives the need for complex balance of plant equipment to maximize the benefit of these systems while keeping them operationally safe for humans and for the grid or facility to which they are connected.

There is a vast array of balance of plant electrical and mechanical equipment required to convert the DC power stored in Battery Packs. We can illustrate this by following "Charlie the Coulomb", our favorite overexcited electron, as it navigates the BESS. Large scale Energy Storage Systems (BESS) need a large-scale source for charge and discharge power, which is typically sourced from the grid or facility or other DER. While Charlie is anticipating a typical ride through some critical load, he is suddenly sucked backwards by a giant Power Conversion System (PCS)…fancy words for a 'bi-directional inverter.' Bouncing through an isolating power transformer, shooting past a scary disconnect switch, Charlie joins his extended family at a 'DC Combiner'…or what battery professionals call a DC buss or Main Panel. Charlie Coulomb ends up in a crowded warm luxury "cell" where he will wait for the next dispatch mission.

In a typical BESS, thousands of 3-4 VDC nominal cells are connected in series and parallel to create a hierarchy of cells, packs, modules, and battery strings (which we now call "stacks"), in order to store large quantities of energy in high voltage configurations (typically 1000 to 1500 VDC). The stacks and subordinate elements are controlled by the Battery Management System (BMS); all lithium battery systems require a BMS, which controls the battery operation at the cell, pack and string levels including all aspects of charging and discharging of the cells, and monitoring and reporting of cell and system status. The complete BMS system should come from a single OEM who has designed and properly balanced the performance metrics of the stack along with the safety and thermal management of the system.

With traditional lead and nickel based electrochemical battery storage, the supply chain from raw materials to manufacturer to user has been well known and predictable for decades. A handful of recognizable manufacturers have been well known to the industry for many decades and manufacture battery cells using a century old manufacturing process. For Lithium-ion based electrochemical batteries the path from materials processing to the end-user is not nearly as transparent and predictable. We are constantly asking the following questions: "Who exactly is the manufacturer or OEM of the actual lithium cells? Who is the pack or module assembler? Who designed and built the BMS? Is it the North American based entity who puts a label on it, or is it sourced entirely from Asia?"

Our own position is that the designer/builder and IP owner of the BMS is ultimately the entity that owns the safe operation of the cell/pack/string and is therefore the most important and closest responsible entity to the BESS integrator and owner/user. This BMS provider/integrator also owns the responsibility for proper cell selection and manufacturing quality of the sub-components and systems.

A typical BESS has two types of control systems: 1.) The BESS controller which will be a single point of control, providing management and alarms through which BESS sub-systems are integrated. The BMS oversees the PCS/Inverter, mechanical controls, safety equipment and any other subsystems reporting to the BESS. 2.) The second type of controlling function is for the actual dispatch of energy from the BESS. As noted previously, the charge and discharge of large-scale Lithium based battery systems is strictly controlled by the system BMS and driven by the PCS/Inverter. In short, the BESS needs to be told at every minute of the day what do to and when to do it. Dispatching of BESS energy can be configured for time-based charging and discharging or condition-based charging/discharging, but there must be a controller to issue these charge and discharge commands.

A DC Combiner is the BESS industry terminology for the common physical point at which the battery stacks are connected in parallel. The high voltage and power of these BESS systems require a brute force panel to land and consolidate DC power on its way to the PCS/Inverters. Some PCS systems provide for landing of multiple battery strings on a common DC Bus within the PCS. However, the high voltage and power present make the DC combiner an important design consideration. These systems are commonly used in Solar/PV systems to combine PV strings. Care should be taken to ensure that ratings, terminations, and switches are designed for permanent connections of the battery cables.

Power Conversion Systems (PCS), or bi-directional inverters, provide clean AC power to the Grid or facility power source behind the meter. These sophisticated systems can provide both grid following and grid forming service to the facility or grid connection. It is important to ensure that these systems are integrated with the Battery Management System or BESS controller such that they can operate and respond symbiotically with the batteries, other DER, and the loads. Most systems require a grounding transformer to isolate electrical noise and harmonics from affecting the load. It should be noted that site standards are continually evolving.

From simple disconnects for a single unit BESS to large scale BESS combining with other distributed energy resources (DER), safety switching equipment is essential for the segmentation, integration and the overall safety of the system when connected to both behind-the-meter and in-front-of the meter applications. Switchgear, relaying, and SCADA controls can be a significant part of the project cost and engineering effort and will typically require separate enclosures and infrastructure on the project site.

Many distributed energy resources (DER) require separate grounding transformers. DER presents risk for temporary overvoltage conditions beyond the limits of IEEE 1547.1-2020; typically, this can occur when DER's are interconnected to an electric power system between the time the Area power source is lost, and the DER disconnects from the Area EPS due to a loss of ground reference. Ground reference transformers prevent this from occurring, as well as providing additional benefits such as possible ferro resonance dampening. Therefore, many regulators are requiring grounding transformers for DER sites to meet IEEE 1547 standards. DER causing fluctuating and elevated voltages on the Area EPS beyond acceptable levels must be mitigated and the use of grounding transformers at the DER site is a good way to mitigate the risk.

Virtually all BESS require either an isolation transformer that interfaces between the PCS/Inverter and the customer equipment, as well as a power transformer for grid connection at medium voltage. The PCS/Inverter output typically requires an ungrounded Delta connection, and therefore the typical isolation transformer for this application is a Delta/WYE isolation transformer which can also double as the voltage converting step-up power transformer. Typically, smaller auxiliary transformers for single phase loads supporting the BESS equipment are part of the package.

Regulations and standards have generally lagged BESS technology development, apart from the early (and prescient!) FDNY requirements for the safe implementation of large-scale Energy Storage Systems, with particular emphasis on lithium chemistries in proximity to personnel. The National Electric Code, Fire Code and International Building and Fire Codes have all been recently updated to include extensive guidance for installation of various capacities of Energy Storage systems in different physical environments. The creation of UL Standard 'UL 9540 the Standard for Energy Storage Systems and Equipment' and NFPA 855 'Standard for the Installation of Stationary Energy Storage Systems' have provided excellent direction for the safe design and installation of these high-power, high-energy content systems. While these standards have increased the installed costs for BESS systems, the increased safety factors are well worth the added investment.

The emergent codes for construction of BESS systems have reshaped the philosophy and design of structures to house BESS equipment. Modified, walk-in ISO containers have been replaced with steel or CMU structures with external access to all equipment to minimize hazards to personnel. Battery manufacturer supplied UL9540A test results inform enclosure designers and fabricators on the application of environmental controls, fire and thermal detection and fire and heat suppression systems, to include methods to comply with NFPA68/69 requirements for deflagration mitigation. There are also some recent trends to return to small energy segmentations of <600 kWh silos, and to implement water spray or deluge systems as matter of last resort. Today UL9540 compliant structures are the industry standard. These emerging codes are informing safe design and implementation. Overall, we believe our industry is far better off in terms of safety and reliability because of these standards.

The Need for Long-Term Preventative Maintenance and System Technical Support for the Rapidly Expanding BESS Infrastructure in the U.S.

There is a growing focus on how the industry is going to be able to support the long-term maintenance and site field support for the exploding U.S. Energy Storage infrastructure. For many of us in the battery industry, the initial idea of pursuing maintenance contracts for Energy Storage Battery Systems can be an intimidating prospect, given the perceived and real complexities of a typical BESS system.

But on the other hand, who would be better than 'the battery guys' to help customers maintain and repair their lithium battery stacks and associated systems? In our experience, the parameters for the maintenance contracts we have for our BESS installations largely follows many of the same metrics for the maintenance contracts we hold for traditional battery installations in utility, telecom, and industrial sites. Certainly, the use of BMS and ESS controllers adds additional layers of complexity to these battery systems, but most of the PM work with these systems involves software upgrades and patches, which is a significant part of our maintenance routine. There is not that much difference from typical network maintenance procedures.

Many people assume that the BMS system will perform most or all of the system monitoring and provide alerts and alarms for any system problems. BMS systems offer critical safety functions and controls that is all software driven with algorithms, sensors, and system parameters built into the controller. This highlights the importance of periodic software updates and patches to ensure the optimal performance of the BMS. Any failure of the BMS system presents real risks of BESS system failure and fire if not operating properly.

There are a growing number of associations and groups that are working to standardize the overall maintenance requirements for BES systems. One example would be the California Energy Storage Alliance, who in May of 2020 recommended a process of semi-annual and annual maintenance checks for BESS installations. The semi-annual checks involved typical physical inspections of the system, including the HVAC, fire suppression, black start UPS, and inverter systems. The BMS and ESS systems would involve ensuring that the software controllers are operating normally, and that all communications interfaces are working properly. In summary, the semi-annual checks are to verify optimal battery system performance, including identifying battery degradation levels, performing software upgrades, and inspecting the power conversion, HVAC, and fire suppression systems. IEEE P2962 for Li-ion installation, operation, and maintenance is getting close to its first published edition, and it will likely recommend annual checks/analysis of the BMS data, as well as discharge tests every 3-4 years for systems whose BMS don't track their capacity very well due to less frequent deep discharges. The discharge tests also provide a method for tracking intermodule connection integrity via use of a thermal camera.

This maintenance Scope of Work is very manageable for many of the service companies in attendance at Battcon this year. The annuity revenue opportunities for BESS maintenance and emergency dispatch are large and will continue to grow rapidly. The battery industry should move decisively to position ourselves as the front line for the long-term management of the BESS infrastructure in the US.

This brings up the next challenge, given the global labor shortage that we have all experienced firsthand with our supply chain and our own internal field technician hiring requirements. Good help is hard to find these days! Our industry needs to accelerate our efforts to hire and train the field technicians and site engineers that are going to be needed to support this infrastructure. Training will be required to develop people with the skill sets to manage BESS systems, and will need to combine battery, mechanical, and IT experience and skills to ensure proper BESS reliability.

Lastly, we are seeing an interesting trend regarding customers looking for service providers to operate their battery systems for them. Shortly after we delivered and commissioned our first BESS project for a utility, we were contacted by them with a request for a quote to operate their battery for them. The annual contract was significant. The same thing happened after we delivered our second BESS project for a large C&I customer; at that point we knew we had stepped into a new business opportunity and model. We have seen a number of battery integrators developing their own 'NOC' capabilities, where they can actively monitor the system BMS and ESS controllers and ensure that the battery is being dispatched per the system design parameters established with the customer. In many cases, the hardware and software requirements to perform these functions are relatively simple and straight forward, involving a few large flat screens, a dedicated server, a good firewall and tight security procedures and the use of encrypted software. It is a very reasonable investment with the potential for excellent return in the form of annual operation and maintenance contracts.

Summary

For companies looking to enter the BESS market, understanding the current dynamics of the lithium battery supply chain is critical to their success. Stationary lithium battery systems represent a small percentage of the global and US demand, with automotive consuming the large percentage of the current global cell production. Picking the right suppliers who are motivated and focused on stationary projects 3 MWh and smaller will be critical to our success.

There is a growing need for better technical and economic analytics tools to help qualify BESS opportunities, optimize system size and configuration, and to create investor grade Cost Justification analytics to accurately determine system ROI/ROE for informed decision making. This type of tool can help us optimize the technical configuration of the proposed BESS, while maximizing the economic return on the BESS investment. These techno-economic analytic platforms now exist and are a powerful tool to drive BESS projects forward.

Lithium-ion based BESS are not simple DC batteries connected to loads, but a far more complex system that requires detailed engineering, construction, commissioning, and maintenance in order to delivery energy to Front & Behind the Meter applications safely, efficiently, and reliably over the system's design life. Our review of the technology, applications engineering and service requirements emphasize the need to stay abreast of the continuing evolution of industry standards and practices in this still emerging use case for electrochemical energy storage.

Developers must be careful to stay disciplined in this period of significant supply chain constraints and cost increases to deliver these systems safely and reliably.

Owners and standards engineers need to be acutely aware of existing and proposed engineering and safety standards to enforce discipline during BESS project development and installation.

And finally, like any other electrochemical battery, the BESS must be operated and maintained within the specifications and requirements of the battery manufacturer and/or OEM. This is complicated by the supply chain haze of various cell, pack, module, string of lithium-ion manufacturers and assemblers. Contrast the lithium-ion supply chain with that of our traditional lead and nicad battery manufacturers, who are easily identifiable and accountable from factory to the user-owner with fewer agencies in between. The contrast is significant.

Lithium-ion BESS will continue to dominate the BESS industry over the next 10 years.

Finally, in 2016 Dan Borneo, Sandia National Lab, Mass Energy Storage Project Lead, on May 11th, 2016 (International Battery Conference 'Battcon2016') stated that **"It is the Battery Industry Experts here that will help bring the Mass Energy Storage Industry to maturity."** This statement is even truer today than in 2016, and Mr. Borneo's vision will continue to resonate as we, the battery experts and industry standard bearers, continue to enable wide scale adoption of this fascinating technology and associated revenue streams.

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