ENERGY STORAGE BEST PRACTICE GUIDE

Guidance for Project Developers, Investors, Energy Companies and Financial and Legal Professionals

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ENERGY STORAGE BEST PRACTICE GUIDE

An ACES Working Group Initiative

The Advancing Contracting in Energy Storage (ACES) Working Group is an independent industry led and funded effort founded to develop a best practice guide for the energy storage industry. This initiative was organized as a project of New Energy Nexus (formerly the California Clean Energy Fund Innovations (CalCEF)), with sponsorship contributions made through New Energy Nexus.

To help make this Energy Storage Best Practice Guide *edition possible, over 70 different companies and organizations contributed generously in the form of content, counsel, and expertise. (See following pages for Sponsors, Legal Counsel, Advisory Board, Investor Review Board, and Participating Firms.)*

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A group of experienced industry leaders provided leadership and program guidance to the ACES Working Group and spearheaded further outreach to the wider energy storage industry.

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- Richard Baxter: Mustang Prairie Energy
- Jeff Bishop: Key Capture Energy
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Important Note:

When citing this report, please reference as: Energy Storage Best Practice Guide, developed by the Advancing Contracting in Energy Storage (ACES) Working Group, Richard Baxter, Executive Director, ACES Working Group, December 2019.

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The content contained in the BPGs is current as of July, 2019.

In the BPGs, we have attempted to be neutral with respect to energy storage technologies. There are, of course, inherent differences between the different families of energy storage technologies in both design and operation. However, the process for energy storage project development follows a similar path, based on any typical power project. Where appropriate in the various chapters, the authors have highlighted issues with how individual energy storage technologies impact the project development in specific ways, but the emphasis of the BPGs remains a focus on the standardized project development process that any energy storage project must take into account and follow.

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ACKNOWLEDGEMENTS

Many individuals, private sector firms, governmental groups, and industry organizations came together to make the *Energy Storage Best Practice Guide* not only a reality, but an industry first: a comprehensive set of best practice guides for project developers, investors, energy companies, financial and legal professionals, and other parties seeking detailed and informed energy storage project development and financing guidance.

I wish to first thank our *Energy Storage Best Practice Guide* sponsors for the financial support that enabled us to fund this project. My gratitude also goes out to our Legal Counsel, Advisory Board, Investor Review Board, and other Participating Firms for their invaluable contributions of expertise, guidance and tireless work. And last but not least, I salute the extraordinary efforts of the *Energy Storage Best Practice Guide* Committee Coordinators and Chapter Leads—consummate professionals who researched, wrote, and guided this work's content.

This work represents another step by the energy storage industry to develop a more efficient power grid by enhancing reliability and resiliency, lowering costs for utility customers, supporting non-wires solutions, improving renewable energy opportunities, and reducing carbon emissions. It is my belief that, as energy storage projects continue to grow in number and scale, this comprehensive document will serve as a qualitative guide for energy storage developers and financiers alike and a basis for further effort in support of the industry.

Richard Baxter
Executive Director
ACES Working Group

President
Mustang Prairie Energy

Contents

Contents (Cont.)

Nomenclature

ACC	Arizona Corporate Commission
ACSM	American Congress of Surveying and Mapping
AF	Availability Factor
AHJ	Authority Having Jurisdiction
ALTA	American Land Title Association
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATRR	Alternative Technology Regulation Resource
BESS	Battery Energy Storage System
BI	Business Interruption
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMS	Building Management System
BT&I	Bank, Trade and Infrastructure
BTM	Behind-the-Meter
CAISO	California Independent System Operator
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
COD	Commercial Operation Date
CP	Coincident Peak
CPS	Clean Peak Standard
CPUC	California Public Utilities Commission
CSA	Capacity Services Agreement
CSR	Corporate Social Responsibility
DA	Data Acquisition
DARD	Dispatchable Asset Related Demand
DCSSA	Demand Charge Shared Savings Agreement
DERMS	Distribute Energy Resources Management System
DOD	Depth of Discharge
DOE	Department of Energy
DOER	Massachusetts Department of Energy Resources
DRESA	Demand Response Energy Storage Agreement
EB	Equipment Breakdown

ECM	Engineering and Construction Mode
EOL	End of Life
EPC	Engineering, Procurement, and Construction
EPRI	Electric Power Research Institute
ERCOT	Electric Reliability Council of Texas
ERO	Electric Reliability Organization
ESA	Energy Storage Agreement
ESR	Energy Storage Resource
ESS	Energy Storage Systems
EST	Energy Storage Technology
FAT	Functional Acceptance Test
FCM	Forward Capacity Market
FEMP	Federal Energy Management Program
FERC	Federal Energy Regulatory Commission
FIBO	Financial Industry Business Ontology
FM	Factory Mutual
FMEA	Failure Mode Effects Analysis
FTM	Front of the Meter
GADS	Generator Availability Data System
GIA	Generator Interconnection Agreements
HUD	Hours of Use Demand Rates
HVAC	Heating, Ventilation, and Air Conditioning
IE Report	Independent Engineering Report
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IRP	Integrated Resource Plan
IRS	Internal Revenue Service
ISO	Independent System Operators
ISO-NE	ISO New England
ITC	Investment Tax Credit
KPI	Key Performance Indicators
LCOS	Levelized Cost of Storage
LD	Liquidated Damage
LFP	Lithium Iron Phosphate

LLC	Limited Liability Company
LMO	Lithium Manganese Oxide
LMP	Locational Marginal Price
LOC	Letter of Credit
LTO	Lithium Titanate
MISO	Midcontinent Independent System Operator
MTAC	Energy Storage and Micro-grid Training and Certification
MRI	Magnetic Resonance Imaging
NASA	National Aeronautics and Space Administration
NCA	Nickel Cobalt Aluminum Oxide
NCP	Non-Coincident Peak Demand Charges
NEC	National Electrical Code
NECA	National Electrical Contractors Association
NEIS	National Electrical Installation Standard
NEMA	National Electrical Manufacturers Association
NERC	North American Electric Reliability Corporation
NFPA	National Fire Protection Association
NGR	Non-Generator Resource
NMC	Nickel Manganese Cobalt Oxide
NMLS	National Multistate Licensing System and Registry
NRE	Non-Recurring Engineering
NRTL	Nationally Recognized Testing Laboratory
NTP	Notice to Proceed
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
O&M	Operation and Maintenance
OAT	Operational Acceptance Testing
OSHA	Occupational Safety and Health Administration
PCS	Power Conditioning System
PDR	Proxy Demand Resources
PJM	PJM Interconnection
PennDOT	Pennsylvania Department of Transportation
PNNL	Pacific Northwest National Laboratory
PPA	Power Purchase Agreement
PTC	Production Tax Credit
PUCN	Public Utilities Commission of Nevada
PV	Photovoltaic

QOF	Qualified Opportunity Fund
QOZB	Qualified Opportunity Zone Business
QOZBP	Qualified Opportunity Fund Business Property
R&D	Research and Development
RA	Resource Adequacy
RDRR	Reliability Demand Response Resources
RFI	Request for Information
RNS	Regional Network Services
ROI	Return on Investment
RPS	Renewable Portfolio Standards
RTO	Regional Transmission Organization
SB-DATA	Solar Bankability Data
SCADA	Supervisory Control and Data Acquisition
SDO	Standards Developing Organization
SGIP	Self-Generation Incentive Program
SGIP	Small Generator Interconnection Procedure
SIR	Standardized Interconnection Requirements
SMLD	Sterling Municipal Light Department
SNDA	Subordination, Non-Disturbance and Attornment (Agreement)
SNL	Sandia National Laboratories
SOC	State of Charge
SOO	Sequence of Operations
SOR	Scope of Responsibility
STEM	Science, Technology, Engineering and Math
T&D	Transmission and Distribution
TOU	Time-of-Use
TRL	Technology Readiness Level
TüV	Technischer Überwachungsverein
UPS	Uninterruptable Power Supplies
V2G	Vehicle-to-Grid
VAC	Volts Alternating Current
VoLL	Value of Lost Load
XBRL	eXtended Business Reporting Language

Figures

Tables

ACES Working Group

Overview

The Advancing Contracting in Energy Storage (ACES) Working Group was formed in 2018 to document existing energy storage expertise and best practices to improve project development and financing efforts across the energy storage industry. Through this combined effort, the ACES Working Group developed a library of educational resources to strengthen the fundamental understanding of energy storage project development for those developing and investing in energy storage projects.

This Energy Storage Best Practice Guide (Guide or BPGs) covering eight key aspect areas of an energy storage project proposal. Each BPG contains three to seven chapters, and each chapter follows the same format for systematic coverage, and ease of navigation. This Guide documents the industry expertise of leading firms, covering the different project components to help reduce the internal cost of project development and financing for both project developers and investors.

Energy Storage Best Practice Guide	
BPG 1	Project Development
BPG 2	Engineering
BPG 3	Project Economics
BPG 4	Technical Performance
BPG 5	Construction
BPG 6	Operation
BPG 7	Risk Management
BPG 8	Codes and Standards

The Guide is structured in a standard outline format so that no matter what their background or familiarity with the subject, readers will be able to grasp important aspects of energy storage more quickly and have at hand a library of useful resources for future reference.

Each BPG was developed by committees of subject matter experts to document and organize available expertise on different project components. Committee Coordinators were responsible for ensuring the development of all chapters in their individual BPG. Chapter Leads were responsible for coordinating the necessary effort required to write and produce BPG chapters.

Committee Coordinators and Chapter Leads

BPG 1: Project Development

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3. Permitting	Kyle Wamstad, Eversheds Sutherland
4. Regulatory	Robert Fleishman, Kirkland & Ellis
5. Incentives	Buck Endemann, K&L Gates
6. Offtake Agreements	Bill Holmes, K&L Gates
7. Tax	Elizabeth Crouse, K&L Gates

BPG 2: Engineering

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2. Independent Engineering Report	Mark Manley, Black & Veatch
3. Bankability Study	Mark Manley, Black & Veatch
4. Interconnection Studies	Dan Sowder, Sound Grid Partners
5. Warranty	Davion Hill, DNVGL

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2. Applications	Mike Jacobs, Union of Concerned Scientists
3. Rate Design	James Bride, Energy Tariff Experts
4. Project Proforma	Richard Baxter, Mustang Prairie Energy
5. Case Study	Ray Byrne, Sandia National Laboratories

BPG 4: Technical Performance

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2. Data Interoperability	Dixon Wright, USI Insurance
3. Degradation / Augmentation	Richard Baxter, Mustang Prairie Energy
4. Performance Measurement	Scott Daniels, Schneider Electric

BPG 5: Construction

Committee Coordinator	**Richard Baxter, Mustang Prairie Energy**
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2. EPC Contract	Richard Baxter, Mustang Prairie Energy
3. Commissioning	Richard Baxter, Mustang Prairie Energy
4. Electrical Contractors	Richard Baxter, Mustang Prairie Energy

BPG 6: Operation

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2. Operation and Maintenance	Joe Krawczel, Strata Solar; Matt Koenig, DNVGL
3. Performance/Availability Guarantee	Matt Koenig, DNVGL
4. End of Life	Richard Baxter, Mustang Prairie Energy
5. Thermal Management	James Hunt, Hotstart

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3. Exotic Insurance	John Mooney, Hugh Wood
4. Surety	Dixon Wright, USI Insurance

BPG 8: Codes & Standards

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Chapter Leads	
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2. Safety	Dave Conover, PNNL
3. Reliability and Performance	Ryan Franks, CSA Group

The objective of the ACES Working Group is twofold: help project developers craft higher quality project development packages more quickly and inexpensively; and help investors reduce their time reviewing proposals through their evaluation process.

While project developers may be familiar with the many parts comprising a project package, they are, however, often unsure as to how energy storage systems will impact each part. For their part, investors interested in the returns predicted from energy storage projects are often hesitant to invest because legal, financial and regulatory guidelines have not been clearly defined, detailed, and explained. This Guide is structured so that all readers, no matter their background or familiarity with the subject, can (1) understand the issues and challenges that exist for energy storage, (2) benefit from current industry insights and (3) know where to turn for additional resources.

The development of the Best Practice Guide was guided by asking a simple question:

What do you need to do your job better, faster, and cheaper?

BPG Goals

- Reduce the internal cost of project development and financing for both project developers and investors.

- Help project developers craft higher quality project development packages faster and cheaper.

- Help investors reduce their time reviewing proposals through their evaluation process.

- Document the industry expertise inherent in the different project development components.

- Be structured so that all readers can understand the issues and how energy storage impacts these issues; provide current insights and show how to find additional resources.

Covering different areas of a project development package, each Guide section consists of three to seven chapters which cover a specific topic of the project development process. Each chapter following the same sectional pattern: Background, Energy Storage Challenges, Best Practice, and Resources.

BPG Benefits

Multiple groups across the energy storage industry will benefit from the Best Practice Guide.

- Project developers will benefit through higher quality project documentation, interaction with more financial industry firms, and the ability to ensure that the resulting industry-accepted project documents will allow lenders to make decisions in a timelier manner. In addition, project developers will benefit from reducing their own internal costs and time to complete projects while increasing the success rate of those projects in process.

- Investors will receive higher quality proposals, thereby allowing them to make investment decisions more quickly, and with greater insight, via better supporting documents.

- System integrators will benefit through an increase in the rate of successful project completions, and by ensuring that the industry grows to recognize the value of quality electrical design and fabrication to reduce the risk-adjusted cost of system integration.

- Engineering, Procurement, and Construction (EPC) firms will benefit from refining risk management strategies so they can be adequately compensated for taking on construction components of project risk.

- Insurance firms will benefit through a greater number of projects being completed, thereby allowing for a clearer understanding and appreciation by developers of the need for better risk management in the project development process.

- Equipment manufacturers will benefit through an increased level of visibility into both the entire project development process and the players involved. As with system integrators, these providers of high-quality equipment will help ensure that the industry grows to recognize the value of quality manufacturing processes—processes that help reduce the risk-adjusted cost of energy storage equipment components.

Executive Summary

BPG 1: Project Development

Overview

Project development documents help frame how an energy storage project is legally designed and how it interacts with external legal and financial frameworks. Since the energy storage industry has been maturing rapidly over the last few years, lessons learned in contract design and structure is extremely valuable. However, as in other energy project markets, commonality for project framework at all levels is highly valued as it assists project developers execute with a higher success rate on their project pipelines.

Chapters: BPG 1 – Project Development	
1.	Overview
2.	Real Estate
3.	Permitting
4.	Regulatory
5.	Incentives
6.	Off-Take Agreements
7.	Tax

Insights

Project development documents are designed to provide a legal structure for the project, identify revenue for the project for performance, and define what structural remedies (and their structure) are needed for non-performance. A well understood framework is necessary since it forms the basis for how creditors will be repaid. Therefore, these documents need to highlight any conditions that directly affect the possibility of non-payment. They also help define the method of how projects can be structured (or not structured), such as the opening of existing loan documents, and the viability of retroactively fitting energy storage into existing renewable energy projects which might cause problems.

Challenges

A number of challenges remain with respect to developing a common framework for energy storage project development. For instance, if the project is not financially viable due to a regulatory change, how is this dealt with in the credit agreement? How do you define—and value—the experience of project developers? Finally, although the push for uniformity exists, project documents must consider the variability of different jurisdictions' policies, mandates and other requirements and their impact on the project development process. For instance, local jurisdictions have an impact on real estate and permitting issues. Indeed, easements, building codes and other safety restrictions are always site specific.

Next Steps

There remains the need for significant education by new project developers as to what is needed in order to successfully install and operate an energy storage system. Similarly, commonality between jurisdictions would allow easier translation of experience from one jurisdiction to another to take place more readily.

BPG 2: Engineering

Overview

Engineering analysis is the basis for any fundamental understanding of the capability and potential of the unit. The basis for the project's success hinges on its future cash flows—the return on, and return of, capital invested in the project. Understanding the viability and risk related to those cash flows is, in large part, an exercise in understanding the technical aspects of the project. It must be designed in a well-planned manner, use proper equipment, and follow appropriate operating and maintenance (O&M) protocols in order to last its expected lifetime. Returns come from net income (revenue less expenses), so the project must be able to produce what is contractually expected and have O&M costs that align with budgets; both are subject to technical risks such as up-time, grid availability, equipment failures, resource constraints, fuel costs, and market prices.

Chapters: BPG 2 – Engineering	
1.	Overview
2.	Independent Engineering Report
3.	Bankability Study
4.	Interconnection Study
5.	Warranty

Insights

The independent engineering report is important to investors in that it defines design and operating characteristics and costs, provides an opinion about degradation and the life of the project, and defines the risk for catastrophic failure. Battery degradation curves are critical to estimating the project's working lifespan, and different groups on a project often have different expectations. Finally, system interconnection is a critical point from a project development perspective.

Challenges

Continued refinement of the engineering analysis for energy storage systems will be fundamental to improving the ability to value use cases and applications under various real-world conditions. This understanding of the different degradation curves of the various technologies under assorted use cases is also a key part in understanding the relative value of different energy storage technologies under different operating conditions. Energy storage is a more complex technological system than solar, so it will require more technological performance confidence.

Next Steps

A key next step will be the development of metrics for different performance characteristics specific to different applications so that they are easily understood and incorporated into contracts.

BPG 3: Project Economics

Overview

When a project developer intends to develop an energy storage project, he or she must be closely attuned to the requirements of the party providing project financing. These requirements can be financial (return on investment or ROI), policy-driven (procurements), technical (storage as best resource), programmatic (storage as part of a solution set), and others.

Anticipating that increasing numbers of energy storage projects will be driven by ROI, it is important that project developers, project financiers, solution providers, and other market participants clearly understand the different applications for storage—cost savings, revenue streams, and other benefits including resiliency. And for the benefit of the industry itself, energy storage needs to build up case studies of such applications and projects employed in the market.

Chapters: BPG 3 – Project Economics	
1.	Overview
2.	Applications
3.	Rate Design
4.	Project Proforma
5.	Case Study

Insights

Many external inputs are important to project economics: demand charge, standby charge, capacity charge, etc. Different utility tariff structures make the project economic determination dependent upon utility and RTO / ISO location. A proforma model is important to provide clarity into assumptions and expectations for developers and investors.

Challenges

A number of challenges exist for improving the economic case for an energy storage project. For instance, determining the proper risk adjustment for the proforma model relies on a clear understanding of technology performance and market rules. Investors continue to be more conservative about revenue streams than developers. As the market expands, case studies will have added importance by showcasing assumptions in action.

Next Steps

Some key next steps identified by participants in the ACES Working Group include having more standard definitions of market rules that would be tremendously beneficial to developers across jurisdictions. Also critical is having clarity that the regulatory environment will not change abruptly during the mid-life of project—and having protective adjustments in project contracts if they do.

BPG 4: Technical Performance

Overview

The technical performance of the energy storage system is central to the ability of the developer to design and operate a successful system for the project. The various performance metrics are used in a number of ways, including driving the management of the operation of the system, deciding on any needed augmentation to fulfill service requirements, and serving as the basis for communicating performance and control of the system by the coordinating entity. Performance metrics also serve as the basis for other project contracts such as O&M contracts, and as a way to determine if the system stays within warranty.

Chapters: BPG 4 – Technical Performance	
1.	Overview
2.	Data Interoperability
3.	Degradation / Augmentation
4.	Performance Measurement

Insights

In order for the system's performance metrics to be representative of the project, performance needs to be understood and linked at the battery, module and system level. This detailed data analysis allows cell level warranty limits to be expressed at full system operation limits. In this way, the system-level operational metrics can be designed to maintain these cell level warranty limits. For system management and control, this system level performance measurement can then be seamlessly shared through communication systems up to even the utility's distribution management system.

Challenges

At all levels of the industry, a number of challenges still exist for technical performance measurement regarding energy storage systems. Fundamentally, the question is: *What is the correct performance metric and how is it measured?* The value of different performance metrics depends on what usage profile the energy storage system is attempting to follow. This is important to the various stakeholders because the value of different applications varies depending on market roles, along with the current operating condition of the energy storage system. This is also critical if stakeholders are trying to compare the performance of different energy storage technologies for the same use cases.

Next Steps

The industry needs to develop applications based on performance requirements that can be applicable to different energy storage technologies. This would allow for a more standard framework to provide commonality between application requirements for project contract development. As the market matures, best practices are leading to operation and maintenance contracts that are designed to be flexible yet provide a clear understanding of what is needed to keep equipment both within warranty and support contract requirements.

BPG 5: Construction

Overview

The construction phase of a project is the critical period where all the design and engineering elements are brought forth into a final system at the intended site. All aspects of this phase, including the Engineering, Procurement and Construction (EPC) contract, commissioning the system, and the choice in electrical contractors, are required to support the successful installation of a system at the customer's site.

Chapters: BPG 5 – Project Economics	
1.	Overview
2.	EPC Contracts
3.	Commissioning
4.	Electrical Contractors

Insights

EPC contracts govern the installation design and construction process for an energy storage project. For this reason, the experience of the firm providing these services is critical. EPC contracts are designed to clearly state the requirements for the parties involved in the development of the energy storage projects. To that end, the contracts support the successful execution of deployment, lay the foundation for profitable operation, and are a key component in attracting lenders by clearly stating and dealing with the primary areas of project risk.

Commissioning an energy storage system ensures that all components and the integrated system itself are installed, tested, and ready for operation according to the OEM's and system integrator's checklists. This process does not simply start when the construction is completed but reaches back into the design phase where the commissioning team becomes familiar and comfortable with the equipment vendors' commissioning procedures. The team does this by reviewing the equipment specifications and applicable codes and standards that the system is required to meet, and then reviews or develops an integrated Sequence of Operations (SOO) for the commissioning process.

Using experienced electrical contractors can reduce construction time and outages during operation. As systems become larger and more complex, the expertise and experience of the electrical contractor is of critical importance for developers when choosing a firm.

Challenges

Credit worthiness is a concern with EPC contractors. Therefore, it's imperative to get an established firm to stand behind warranties provided by the EPC wrap. That involves getting solid answers to the following questions: *How do you compare the experience of different EPC firms? What types of EPC wraps are provided? How do you ensure that you know where the limitations are in the contracts?*

Next Steps

Based on documented failures and successes, the industry needs to continue refining standard construction and commissioning procedures.

BPG 6: Operation

Overview

Understanding the operational capabilities and requirements of an energy storage system is central to maximizing the value of the system over its lifespan. Because of the integrated nature of the system in both design and integration, lessons learned from operational experience will prove invaluable towards improving the ability of these systems to support the usage profile over a system's planned lifespan.

Chapters: BPG 6 – Operation	
1.	Overview
2.	Operation and Maintenance
3.	Performance/Availability Guarantee
4.	End of Life
5.	Thermal Management

Insights

Energy storage systems, like all capital equipment, face critical issues based on system operation parameters. Indeed, every element of the project's success relies on the ability of the unit to maintain its expected performance and availability. Therefore, it is imperative to have a well thought out allocation of responsibility among various parties in the O&M agreement. Other key factors, including operator experience, continue to gain in importance as to how the project will deliver the promised cost savings.

Challenges

A number of challenges exist in developing and maintaining the desired performance of the energy storage system during operation. One of the most important performance aspects is to establish a clear scope of responsibilities for all parties as to what systems and subsystems they are responsible for operating, maintaining, and replacing if required. Another important item is to understand that, as the system ages, the initial specifications of the system will change, and it will be up to the operator to adjust the operational plan of the current system's capabilities in order to maintain the required output and performance.

Next Steps

A number of key operational procedures still require more definition and refinement. These are predicted to improve with time as the industry gains more and better experience. These improvements will help to improve standard O&M contracts so there will be less ambiguity concerning responsibility when critical issues arise. These issues include end of life considerations and the impact on warranties by usage patterns and maintenance.

BPG 7: Risk Management

Overview

Risk management strategies incorporate understanding and managing the technical design and operational aspects of an energy storage system that can impact the exposure for loss by the different parties involved in the project. Insurance is a means for protecting against financial loss. For a complex and highly integrated issue such as energy storage project development, insurance is also a means to design risk management strategies that expand opportunities at a lower cost through leveraging the financial assets of the insurance firms.

This risk management and allocation focus is especially important for energy storage project development. Project developers and lenders both generally agree that energy storage projects are not fundamentally different than a typical power industry project finance transaction, especially with relation to risk allocation. The deal will not close until the known risks have been addressed and safeguards put in place for unknown risks. However, energy storage is somewhat different than other power projects. Therefore, the risk management strategy will need to take account of the unique energy storage project's technology, policy and regulatory mandates, and market issues.

Chapters: BPG 7 – Risk Management	
1.	Overview
2.	Project Risk Insurance
3.	Exotic Insurance
4.	Surety

Insights

Insurance companies reduce their own risk exposure through a detailed understanding of a system's technology, operation, and interaction with the power market. Insurance policies are an important component of any energy storage project development, providing a cost-effective means to reduce the need to design and oversize the system. This is attractive to investors who also benefit from the insurance company's requirement for a formal design review and adherence to standards that ensure the project will be done on time, ahead of budget, and without surprises.

Challenges

A number of key challenges exist for insurance providers to design products and strategies that bridge the gap between the understood capability of the system and the expectations of the unit during operation. For instance, how do you define and value the different possibilities of project interruption and failure? As the market matures, risk management firms need to ensure that those entities best suited to handle particular risks are adequately compensated.

Next Steps

As the industry matures through a growing body of project development and operational history, the cost of insurance should continue to decline as additional performance data and loss experience help refine the loss potential evaluation of these projects. Lacking sufficient data in emerging industries such as energy storage, insurance firms have long been a driver for promoting better testing and standards development (in both equipment, installation, and operation) to reduce insured loss through performance degradation or failure. Better information provides these firms with the ability to determine the actual risk premium cost for a variety of project development choices. As the industry gains more experience, re-insurers (insurance for insurance firms) will get involved, reducing further the cost for insurance coverage.

BPG 8: Codes and Standards

Overview

Codes and Standards are critical to the successful development of energy storage projects at all levels of the industry. First, these rules have a direct impact on the cost of the energy storage project through the requirements of specific equipment to be used, and the labor practices performed during construction. Second, these rules establish the procedures by which safety, performance and reliability are documented and verified. Failing to achieve signoff on these guidelines during construction can cause significant delays in a project achieving the required approvals needed for the facility to begin operation.

Chapters: BPG 8 – Codes and Standards	
1.	Overview
2.	Safety
3.	Reliability and Performance

Insights

Currently, there are two key areas of focus for Codes and Standards in the energy storage market: safety, and reliability and performance. The energy storage industry has well defined safety standards but needs better reliability and performance standards. Many of the issues driving codes and standards in the energy storage market are cross-cutting issues that are relevant to many parts of the industry in general. First, they have significant impact on the timing of the approval process for the facility. Second, the more investors understand the existence and importance of codes and standards, the greater the likelihood they will invest in a project that adheres to requirements that ensure the project will not have any unforeseen delays—and therefore be ready on time for market operation.

Challenges

Of the two areas of focus, safety standards are more mature, with reliability and performance in a relatively earlier stage of development and adoption. There is a great need to advance this aspect of the industry. Indeed, the DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA (updated in 2015) highlighted the fact that a lack of standards was one of the key challenges hindering the adoption of energy storage technologies.

Next Steps

It is imperative for the industry to develop common reliability and performance standards to promote more reliable operation of energy storage systems. These actions will accomplish little, however, unless the Authorities Having Jurisdiction (AHJ) becomes a partner in documenting and adopting these standards for wider industry use.

ENERGY STORAGE
BEST PRACTICE GUIDE 1:

PROJECT DEVELOPMENT

Project Development

Chapter One: Overview

Chapter Lead: Bill Holmes, K&L Gates

Background

Energy storage has advanced to the point where original equipment manufacturers, independent storage developers, utilities and their advisors have accumulated significant practical experience in developing, financing, building, and operating energy storage projects. This Guide focuses on the lessons learned and structures developed over the course of nearly a decade of energy storage deployment in the United States. This Guide will discuss these points in connection with the deployment of stand-alone energy storage—both grid-connected and behind the meter—and the development of co-located or "hybrid" energy storage projects (solar + storage or, less commonly, wind + storage).

Energy storage systems do not require as much land as wind or solar projects and are not likely to be controversial, except in certain circumstances with respect to fire safety. Still, the process of securing property rights and permits is key to the basic blocking and tackling of storage development. When the storage project is ready for financing, the prospective lenders will be fully immersed in understanding the technology, its risks and how it produces revenue. To that end, the property rights and permits need to be in line with expectations so that they do not distract from more important matters. *See* Chapters 2 and 3.

Incentives will remain important to storage project economics. The energy storage industry has evolved significantly from the days of one-off pilot projects, but it still benefits from a number of incentives. The federal level offers tax incentives such as the Investment Tax Credit (ITC), with respect to hybrid solar + storage projects; the Production Tax Credit (PTC), with respect to stored wind energy; and the prospect that energy storage projects—even standalone energy storage—can be structured to qualify for the new federal Opportunity Zones incentive. States may incentivize energy storage by using mandates requiring the deployment of specified capacity, MWhs, or other types of storage, by offering investment and deployment incentives (such as California's Self-Generation Incentive (SGIP) program), or by requiring utilities to carefully consider the use of storage in their integrated resource planning. *See* Chapters 5 and 7.

The regulatory environment in which the storage project will be developed is also key. The Federal Energy Regulatory Commission's (FERC) Order 841, issued in February 2018, is intended to remove barriers to energy storage participation in the Regional Transmission Organizations (RTO)/Independent System Operators (ISO) wholesale markets. In December 2018, RTOs and ISOs made compliance filings with FERC in order to achieve this objective, and implementation of most new RTO/ISO tariffs is expected to begin in December 2019. The good news is that federal regulators seem committed to designing RTO/ISO markets that will enable energy storage to participate fairly; the challenge lies in the complexity of the technology and its potential uses, which will require continued regulatory activity at both federal and state levels. *See* Chapter 4.

The versatility of energy storage—as well as its complexity—is reflected in the emerging structures of long-term agreements for the procurement of energy storage services, both in front of and behind the meter, and for stand-alone and hybrid energy storage projects. The continuing development and refinement of these agreements will enable independent storage developers to enter into long-term contracts with creditworthy counterparties, which will in turn facilitate the financing of energy storage projects. *See* Chapter 6.

Project Development

Chapter Two: Real Estate

Chapter Lead: Kyle Wamstad, Eversheds Sutherland

Background

Property rights are an oft overlooked aspect of energy storage development. A successful energy storage project, whether paired with generation resources or operating as a stand-alone resource, requires a suitable site to meet intended uses.

In securing property rights, a developer’s top priority should be to ensure long-term control of land or a site that allows for all necessary uses, access for maintenance, and rights that allow for placement or modification of energy storage systems over the intended useful life of the system. Failure to do so may result in unanticipated restrictions on development, and additional costs that could make the project uneconomic.

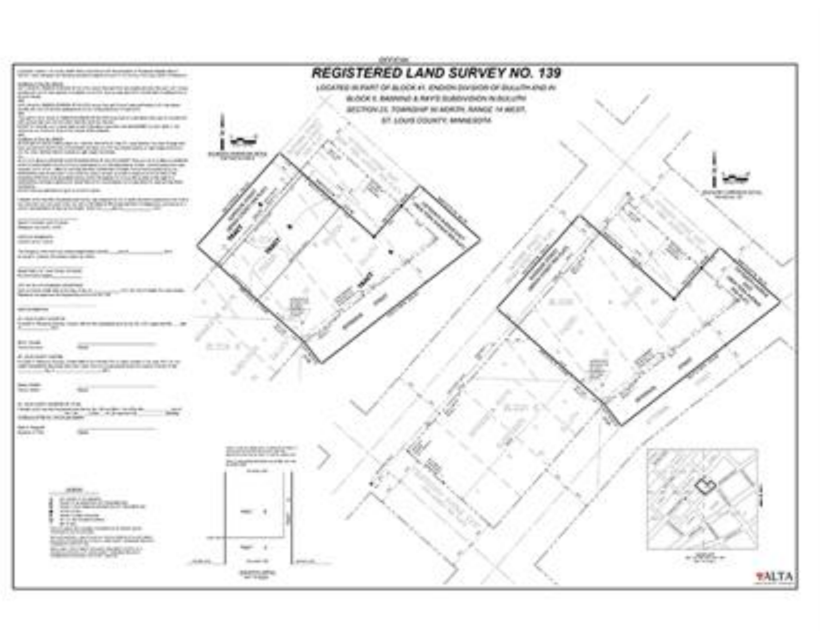


Fig. 1.2.1
Example of an ALTA land survey.
Source: © 2019 Alta Land Survey Company.

Energy Storage Challenges

The most significant challenge for energy storage developers is ensuring that the scope and duration of a property right is sufficient to cover the intended use and useful life of the project.

The appropriate form of property rights will vary depending on the type of energy storage system to be deployed. It may also need to accommodate existing uses, including:

- Co-location with grid-scale generation, either new or modified
- Host-sited energy storage system
- Location inside building
- Location at meter
- Utility-sited energy storage system (e.g., at substation)

Best Practice

Property Types

Not all property rights are created equal. From fee simple ownership to leases to revocable licenses, the property rights secured by a developer should reflect the needs and duration of the planned project. Property rights that are not sufficient to meet the developer's intended project create an opportunity for owners or lessors to extract additional compensation. Property rights that are overly inclusive might limit the availability of otherwise suitable project sites, and also increase overall project costs unnecessarily.

Fee Title

Fee title is the most secure form of property right. However, in light of costs and benefits, it is rarely the most beneficial form of property right for a developer. There may be limited circumstances where fee title of property may be required, including where certain other rights such as access or water rights are limited to fee title holders. Generally, the rights necessary for development of an energy storage project are available under another form of property rights, and at less expense.

Lease

A lease is the most flexible form of property right and is the most commonly used form for renewable generation projects. An ideal lease should provide the developer with unrestricted access to and from the property, exclusive right to the lease property for energy storage and any other applicable form of development, and limited restrictions (if any) on assignability or transferability of such property rights. Commercial terms of a lease agreement are highly negotiated. Payments may be periodic (e.g., monthly or annual), subject to escalation, lump sum (though less likely in the renewable generation context), or even associated with revenue or generation of the project at the site. Scope of use may be broadly stated—which is most favorable to a developer and future owner—or limited to defined uses that may limit the ability of the project to be expanded or modified over time.

Easement

A grant of certain property rights for a particular use, easements are more typical for host-sited projects or small-scale projects when the developer shares a larger space dedicated to uses other than energy. Examples may include easements within substations, parking garages or building basements, or within a warehouse or manufacturing facility. Easements are also appropriate for securing access to a project site or to permit interconnection between a project and a local distribution system, substation, or other point of delivery or receipt. An ideal easement would be one granted directly from the property owner, not be revocable during the stated term, and secured for a defined space on the overall property for the exclusive use of the developer. As with a lease, other commercial terms of the easement are highly negotiated. Unlike a lease, risk of loss associated with acts or omissions of other third parties authorized to access the property of the grantor is a concern typically addressed through a contract or insurance. Also important to a developer are limitations in the easement on the scope of the developer's liability as it relates to the remainder of the property.

License

A license is a right conferred by an entity that has a property right at the site. However, a license is often revocable at will. A license may be appropriate under certain circumstances; for example, deployment of a skid-mounted or otherwise mobile energy storage system. It may also be appropriate where the entity granting the license is contractually obligated to perform other obligations if the license is revoked or modified, including an obligation to purchase the energy storage project. A project secured by a license may not be financeable if there is uncertainty of developer's property rights over the expected duration of a project.

Public Lands

Public lands are another option for project developers. Solar and wind developments sited in the western United States are the projects most likely to require public lands, especially for interconnection lines. Federal land is predominantly managed by the Bureau of Land Management (BLM), which has established a process for evaluating and granting rights of way to applicants for specific uses of public lands. State land is managed by individual land departments, and a project located on city or municipal property will require leases or licenses from the appropriate departments. In many ways, the lease or license issued by governments is similar in scope to a private lease. However, there are often terms that are more prevalent in agreements for public land use, including environmental assessment obligations, bonds or other security requirements, rights of revocation or modification, or provisions addressing sovereignty.

Tribal lands, which are not public lands, are managed by the Bureau of Indian Affairs (BIA), with significant deference given to affected or potentially affected tribes.

The BIA's application process is in addition to any specific laws or rules established by a tribe that may apply to a project. If a developer intends to use tribal land, then consultation with any affected or potentially affected tribes should be an early part of diligence and development efforts.

Option

An option is not a form of property right; it is a way to secure a property right for a period of time without making the commitment. A developer will be required to pay a fee—typically upfront—to secure such rights, and another fee to exercise the option. But this approach is still viewed as a more economic means of securing property rights. An option may also allow a developer to defer negotiations over the scope of the property rights to be conveyed until the project has taken on a more definitive form.

Avoiding Property Right Pitfalls

As valuable as securing property rights for the development of an energy storage project is having an understanding of what property rights there already are and how those existing property rights may or may not affect your project.

Survey

A survey is a detailed map supplemented by notes. Prepared by a surveyor, the survey can have as much or as little information as requested by the party commissioning the survey—for example, property rights, flood plains, and topographic information. The standard survey for developers is an American Land Title Association (ALTA) survey or the American Congress of Surveying and Mapping (ACSM) survey. Depending on which one is used, the survey will have all information required by the certification organization. The survey will provide a developer with ample information on what property rights there are and who holds them.

Title Insurance

Not all property surveys are accurate, and the claim of rights for a given property may be convoluted. Title insurance is a type of indemnity insurance which insures the policy holder against financial loss caused by a defect in the real property's title. Title insurance is only issued after a title company has conducted an extensive title search of the property to be insured and has prepared a title commitment—which often includes exceptions to the insurance policy to be issued. A project developer may or may not obtain title insurance, though it is advised. Project lenders will require title insurance. Purchasers of a project will often require issuance of an acceptable title insurance policy as a condition to closing.

Subordination and Non-disturbance Agreements

Simply, subordination is a legal right of priority among creditors and, in the context of real estate, property right holders. For example, a developer may hold a lease that permits development of an energy storage project, but the lease will have a lower priority than a mortgage on the property.

To protect the property rights held by a lease, the developer should require an agreement with the property owner and the property owner's lender. The most commonly used agreement is a Subordination, Non-Disturbance, and Attornment (SNDA) agreement, the purposes of which are (1) to agree that the lease is subordinate to the mortgage, (2) provide assurance from the lender to the lessor that the right of the lessor shall remain even if the borrower defaults on the mortgage, and (3) acknowledge that any new owner of the property will be the new landlord—even if this new owner acquires the property through foreclosure. Without an SNDA or similar agreement with the entity that has a superior property right, the developer's rights are not protected.

Assignment

Just as a developer will scrutinize an Engineering, Procurement and Construction (EPC) contract, services agreements, or financing agreements for acceptable terms, real estate agreements should be reviewed closely to ensure that the terms are reasonably acceptable to the developer. One clear example of a provision that should be verified is an assignment provision. The ability to assign a lease agreement or easement agreement (as opposed to a license, which may not be assignable) is important for a developer planning to sell a project.

What Translates from Solar/Wind Markets

As with solar and wind facilities, an initial step in developing an energy storage project is the securing of property rights. Without the appropriate rights to construct, operate, and maintain a project, the developer has limited ability to secure a commercial interest for early stage development, or for financing projects to be developed.

Similar to solar projects, property rights for energy storage projects should allow for exclusive use of property. This is because siting, access, and interconnection of an energy storage system are not typically compatible with other uses. Furthermore, third party access to an energy storage project creates potential risk of interference.

Also, whether or not they are paired with other generation resources, energy storage projects require suitable property rights for interconnection to the project. This interconnection may be to the host's distribution system, the local utility grid, or the system of a transmission provider. In any case, an easement or other rights of use and access should be obtained.

What Does Not Translate from Solar/Wind Markets

Property rights for wind projects are often secured by wind leases, which allow for a commitment of specific turbine sites across broad areas of land, and easements for collection and transmission lines. A wind lease typically permits compatible uses of the land on which the wind turbines are constructed. While energy storage systems are not land-intensive in terms of the amount of land required for an installation, exclusive rights and use are important. Where a developer pairs energy storage with a wind project, siting of the energy storage system should be secured by property rights similar to the property rights that would be used for a project-sited substation.

Unlike solar or wind projects, economic models for most forms of energy storage systems consider replacement, modification, or an upgrade of components of the energy storage system over time. Some of the changes considered include module replacement to counteract degradation of lithium ion cells, replacements to account for upgrades in efficiency, and the replacement of worn-out pumps or seals in a flow battery system. The property rights obtained by the developer should include rights—ideally without consent to replace, modify, or upgrade the energy storage system.

Resources

- James P. McAndrews, published on American Bar Association, *Commercial Real Estate: Survey Requirements*, Aug. 15, 2017, https://www.americanbar.org/groups/gpsolo/publications/gpsolo_ereport/2013/february_2013/commercial_real_estate_survey_requirements/
    - A reference regarding different types of surveys and the ALTA/ACSM Survey Requirements

- Natalie Holmes, published on JLL, *Energy storage advances amp up real estate*, Feb. 14, 2019, https://www.jllrealviews.com/trends/sustainability/energy-storage-advances-amp-real-estate/
    - A commercially oriented description of how energy storage deployment affects real estate trends

- Watchdog - Real Estate Project Management, http://watchdogpm.com/blog/phases-of-real-estate-project-management/
    - Website and blog on project management for real estate

PROJECT DEVELOPMENT

Chapter Three: Permitting

Chapter Lead: Kyle Wamstad, Eversheds Sutherland

Background

Permitting requirements are, by definition, project specific. Permitting helps ensure the safety and compatibility of the permitted activity or use at the intended location with other existing activities or uses. Permitting by federal or state authorities regulates the soundness of a project from a cost-benefit perspective. This chapter will focus on permit requirements related to project siting.

Understanding which permitting requirements apply, and how concerns of the permitting agencies may be addressed, are essential steps in the early stages of project development. Assumptions by developers as to what a permitting agency will accept—or should accept—creates a potential pitfall if sufficient attention is not paid to permitting requirements during the early part of the development process.

Determining the relevant Authority Having Jurisdiction (AHJ) is a critical step early in each project development. Multiple AHJs can be involved at the local, state, regional and federal level. Additionally, due to the nascent development of the energy storage industry, some AHJs may be dealing with storage for the first time and not have developed processes. Providing benchmark processes for reference is an extra step no longer commonly needed in the more standard renewable energy project developments. (Best Practice Guide 8: Codes & Standards, provides a more detailed description of many of the applicable references.)

Energy Storage Challenges

The biggest mistake developers face in permitting is not dedicating sufficient resources in order to understand the codes, regulations, and statutes that apply to a project. It is essential that developers engage with permitting agencies early and often to supply requested information and to relieve any potential concerns there may be about a proposed project. Materials that actually present imminent risk of fire or harmful exposure—gasoline, propane, chlorine, and oxygen—are managed through compliance with established codes and management. Organizations tasked with establishing acceptable codes for lithium-ion, lead acid, or other forms of energy storage have made significant advances in defining acceptable precautions for energy storage systems, but there is often a gap until local permitting agencies gain comfort with them.

Except as applicable to the interconnection of an energy storage project (addressed in BPG 2: Chapter 4), permitting obligations typically increase as the potential for conflict with other existing or intended uses increases. The greatest permitting concerns for energy storage projects are safety and emergency response. Whether based on accurate data or anecdotal events, there is a concern that energy storage projects increase the risk of fire and, more significantly, fires that cannot be put out using conventional methods. Permitting problems have kept some energy storage projects from being sited within urban settings because their installation and use is either not compatible with existing building codes or has been opposed by fire and rescue departments.

Another important aspect is the scale of, and compatible use with, the environment in which the energy storage system is located. Areas zoned for commercial or industrial use are more appropriate for large-scale projects that use materials which may be considered hazardous.

Best Practice

A permit is issued by a governmental agency with jurisdiction over a project based on a public interest: one which focuses on safety, appropriate use, and qualification of the applicant. A permit allows a developer to construct, develop, install, operate, and maintain an energy storage project subject to conditions that often require continued compliance while the permit remains in effect. Furthermore, because a permit may be subject to modification or revocation by the issuing agency, it is important to understand the scope of authority of the issuing agency, the laws and regulations that may be incorporated into a permit by reference, and any project-specific conditions included in a permit.

A permit typically applies to the specific project described in an application. Revisions or other changes to project design may require an amendment to the permit, even if the proposed revision or change does not seem to be material. Failure to update the permitting agency on such changes could be considered a violation of a permit and might subject the developer or subsequent owner of the project to penalties or remedial compliance.

Communication with the permitting agency is key. Direct, in-person communication between engineering and permitting contacts can help ensure that the specific concerns of the permitting agency are addressed and, if modifications are required, accommodations are possible without restarting the permitting process.

What Translates from Solar/Wind Markets

First, an energy storage developer should recognize that an energy storage project is a development subject to the same requirements—imposed by the state, county, or city—that would apply to any other development. Zoning restrictions, grading restrictions, curbside cutout requirements, property setbacks, stormwater drainage requirements, and other government-imposed restrictions on development may apply as equally to an energy storage project as they would a new gas station or grocery store. Development requirements tend to be fewer in more rural locations, though there may be other types of limitations applicable to rural development that are not applicable to development in locations that have existing development activities.

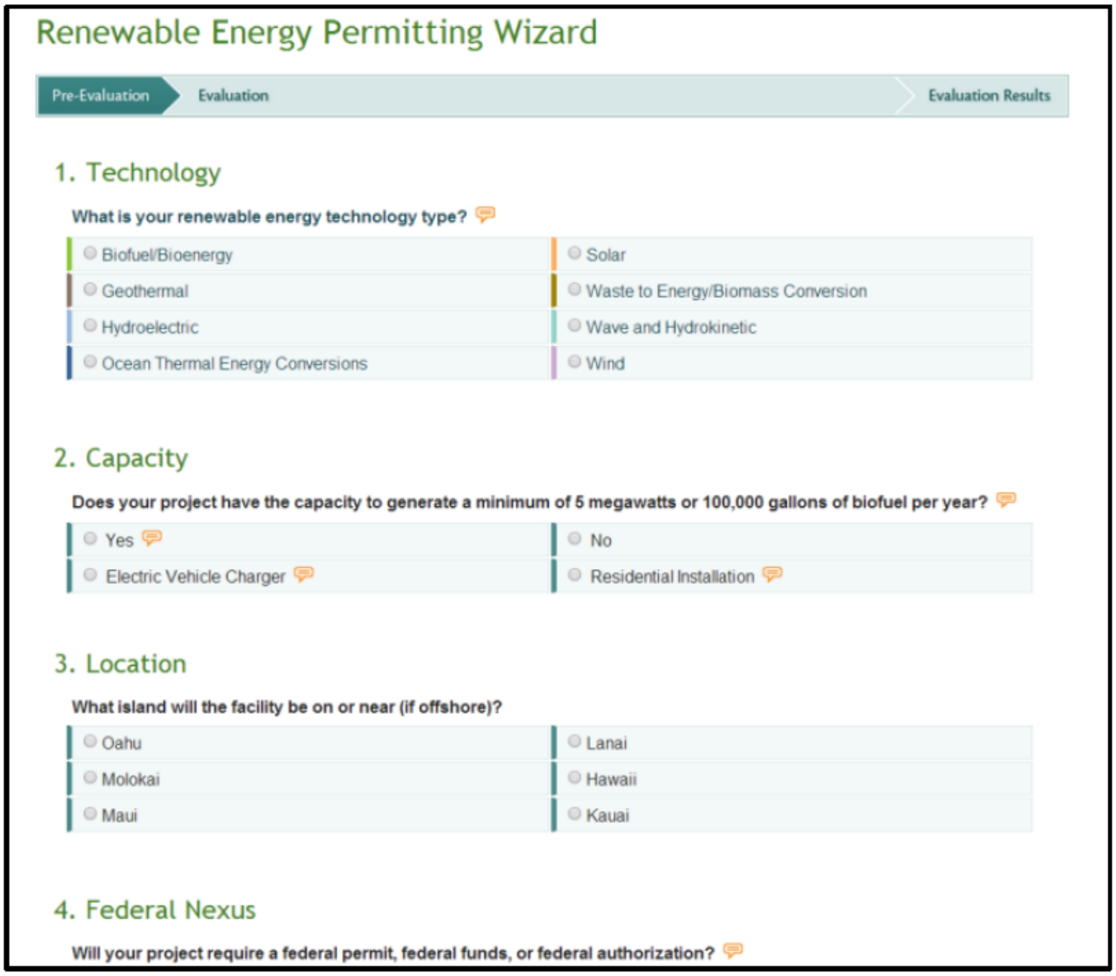
Second, an energy storage project to be located on public lands will likely need to undergo environmental review and may require modification of land use plans established by federal or state government agencies. A wind or solar project to be located on public lands would also require the same review process.

Third, certain states, including Oregon, Washington, and Massachusetts, have energy facility siting boards which have the authority to weigh the purpose and benefit of new projects. The size and nature of the project will determine if approval from a siting board is required or if a project is eligible for review at the state level. A developer may want to participate in an energy facility siting board proceeding as it may offer a more unified alternative to local permitting requirements.

What Does Not Translate from Solar/Wind Markets

Wind and solar projects are subject to compliance with permit requirements, but each type of project is different. For wind projects, there are height restrictions (imposed for navigation), fall areas, or factors related to third party enjoyment of property. For solar projects, there are restrictions on glare, endangered species, and the conversion of agricultural property in some locations. Energy storage projects have their own set of permit restrictions. As noted in the Challenges section of this chapter, these restrictions focus on safety and appropriate use. There is not yet one best approach for energy storage systems, but some of the restrictions that have been implemented to date include fire suppression systems, appropriate signage for first responders, mandatory ventilation or setback requirements, and prohibition on siting energy storage systems in basements or sub-basements. As evident from the types of limitations described, the permit requirements specific to energy storage systems have focused overwhelmingly on projects sited in higher density areas in which space availability may be a limiting factor.

In many jurisdictions, governmental authorities have delegated permitting obligations for small scale energy storage systems to the utility interconnection process.



Source: Renewable Energy Permitting Wizard,
Hawaii Department of Business, Economic Development & Tourism

Fig. 1.3.1
Renewable Energy Permitting Wizard used in Hawaii to facilitate permitting.
Source: Renewable Energy Permitting Wizard, Hawaii Department of Business, Economic Development and Tourism.

Resources

- Distributed Generation (DG) Hub, *Energy Storage System Permitting and Interconnection Process Guide for New York City Lithium-Ion Outdoor Systems*, pub. April 2018. https://nysolarmap.com/media/1911/lithium-ion_energy-storage-systems-permitting-process-guide-final4_26v1.pdf
  - A detailed description of the permitting requirements for installation of a lithium ion outdoor system in New York City

- City of Boulder, Colorado, *Behind-the-Meter Solar+Storage Permitting and Interconnection Guide for Boulder, Colorado*, pub. 2018, https://www-static.bouldercolorado.gov/docs/Boulder_Solar_Storage_Permitting_and_Interconnection_Guide_final-1-201810151427.pdf
    - A good description of the permitting process generally applicable to behind-the-meter energy storage installations. ***Note:*** Specific requirements will vary by jurisdiction.

- National Association of State Energy Officials, *NAESO Best Practices Review: Streamlined Renewable Energy Permitting Initiatives*, https://www.ourenergypolicy.org/wp-content/uploads/2014/01/NASEO-Best-Practices-Review-Streamlined-RE-Permitting-Initiatives.pdf
    - A study in the permitting process in three states - Colorado, Hawaii, and Vermont -- for renewable energy projects.

- *New York State Battery Energy Storage System Guidebook*, https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Siting/Battery-Energy-Storage-Guidebook
    - NYSERDA reference released in April 2019 that contains a sample Battery Energy Storage System Model Permit.

Project Development

Chapter Four: Regulatory

Chapter Lead: Robert Fleishman, Kirkland & Ellis

Background

The regulatory framework for energy storage is both nascent and dynamic. At the federal and state levels, a range of emerging regulations and policies are likely to spur increased deployment of energy storage. For example, the Federal Energy Regulatory Commission (FERC), multiple states, and the RTOs and ISOs that operate the electric grid have taken several steps to assist market participants in deploying and dispatching energy storage resources in a more efficient and cost-effective manner. These regulations and policies focus on both the physical and operational needs of the market, and the necessary development of economic valuation approaches tailored to this increasingly popular resource.

This chapter will summarize: (1) relevant FERC Orders addressing energy storage resources; (2) specific state-level laws and policies designed to encourage energy storage resource deployment; and (3) RTO/ISO rules and tariff revisions facilitating the development and deployment of energy storage resources. Although this chapter presents them separately, many of these regulations, policies, and programs are interactive and overlapping. This interaction and overlap can create complexity, but it also has the potential to yield stackable "value" for investors and project developers. (For purposes of this chapter, the terms "energy storage" and "electric storage" are referred to as "Storage" unless a particular term is in a title or part of a direct quote.)

Key FERC Regulations and Orders

1.1.1 Order No. 841 - Electric Storage Participation in RTO/ISOs

On February 15, 2018, FERC issued a final rule, Order No. 841 (*Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*), addressing Storage resources in RTO/ISOs. This rule largely sets up a federal framework that establishes a timeline and set of requirements for regional grid operators to establish specific rules tailored to the unique assets and needs in their jurisdictions.

Order No. 841 removes barriers for Storage resource participation in various wholesale markets, such as capacity, energy, and ancillary services. This order requires the RTO/ISOs to amend their tariffs to develop a participation model that more fully incorporates Storage into the market, taking into consideration the physical and operational characteristics of Storage resources. Further, Order No. 841 defines electric storage resources as "a resource capable of receiving energy from the grid and storing it for later injection of electric energy back to the grid." In addition, Order No. 841 mandates that Storage resources should pay the wholesale locational marginal price (LMP) for electric energy that the resource buys from the RTO/ISO and is then resold back into the RTO/ISO market. Order No. 841 mandates the RTO/ISO tariff revisions to include the following:

- Ensure that Storage resources using the RTO/ISO's participation model are eligible to provide all capacity, energy, and ancillary services that the resource is technically capable of providing.
- Ensure that Storage resources under the participation model can be dispatched and set the wholesale market clearing price as both a wholesale seller and a wholesale buyer.
- Account for Storage resources' physical and operational characteristics through either bidding parameters or other means.
- Set a minimum size requirement, not to exceed 100 kW, for Storage resources' participation in the RTO/ISO markets.

Order No. 841 required that all RTO/ISOs file a compliance tariff no later than December 3, 2018 with an effective date of December 3, 2019 which incorporated the mandated changes.[1] All of the RTO/ISOs subject to FERC jurisdiction have filed their proposed amended tariffs and are awaiting FERC approval. These filings are discussed in Section 1.2.

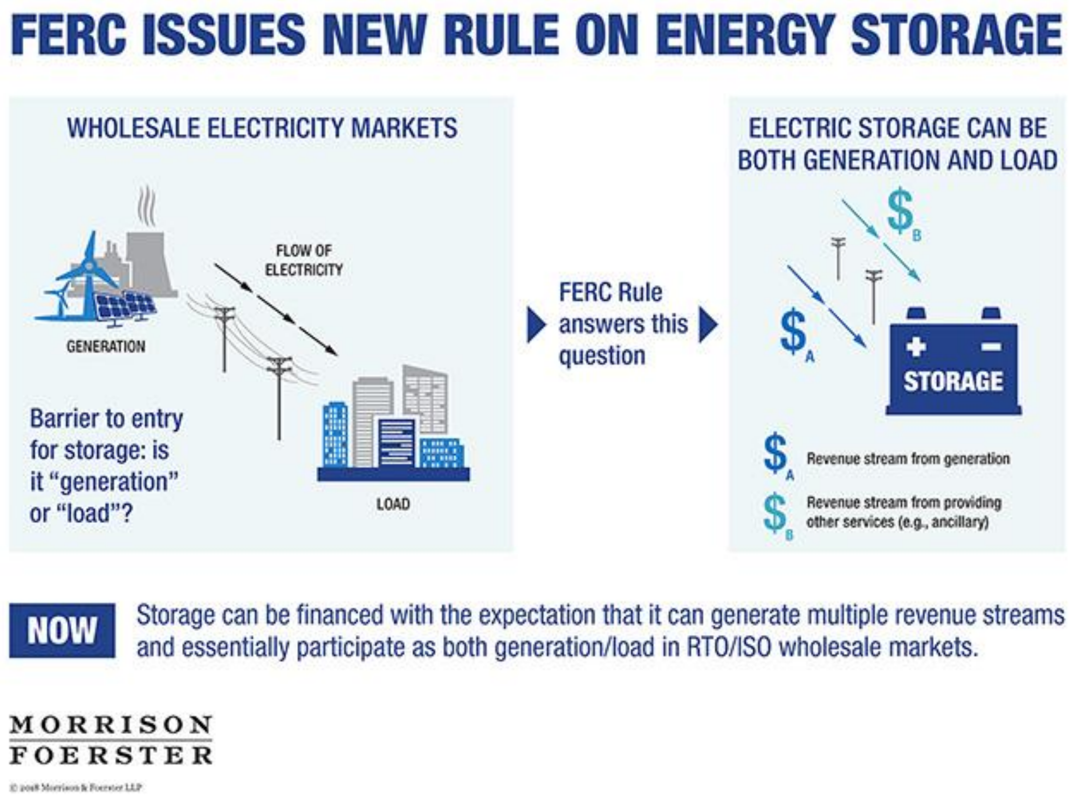


Fig. 1.4.1
Recent FERC rule regarding energy storage.
Source: Morrison & Foerster 2018.

1.1.2 Order No. 845 - Reform of Generator Interconnection Procedures and Agreements

Order No. 845 reformed the pro forma interconnection agreements and procedures for large generators to include Storage in its relevant definitions. In addition, this order allows customers to interconnect at less than nameplate capacity and capitalize on excess capacity already available on the grid.

1.1.3 Order No. 890 - Opportunities for Non-Generation Resources

Order No. 890, which FERC issued in 2007, opened energy and ancillary services markets to non-generation resources (including Storage resources) capable of providing reactive supply, voltage control, regulation, frequency response, imbalance, spinning, and supplemental reserve services.

1.1.4 Order Nos. 719 and 745 - Demand Response

Order No. 719, issued in 2008, directed RTO/ISOs to make reforms to ensure comparable treatment of demand response resources into the organized energy markets. The reforms included a requirement to create new bidding parameters and accept bids from demand response resources in ancillary services markets. Demand response resources include Storage resources. Then in 2011, Order No. 745 required RTO/ISOs to ensure that demand response resources participating in the organized energy markets were compensated at the same rate as generation. After Order No. 745 was challenged by generators, the U.S. Supreme Court found that the Federal Power Act authorized the regulation of demand response at issue in Order No. 745, and that the Order did not impinge on state jurisdiction.

1.1.5 Order No. 1000 - Energy Storage Resources in Transmission Planning

Order No. 1000 required transmission providers to consider the use of "non-transmission" alternatives as part of their regional transmission planning on a comparable basis with transmission solutions. These alternatives include Storage resources, demand response, and distributed generation.

1.1.6 Policy Statement on Cost Recovery for Electric Storage Resources

In January 2017 FERC issued a policy statement to clarify that Storage resources may provide transmission or grid support services at a cost-based rate while also participating in the RTO/ISO markets and earning market-based revenues. According to the policy statement, Storage resources seeking to provide transmission or grid support services need to address the following:

- The potential for double recovery if the Storage resource provides services at both cost-based and market-based rates.
- The potential for the Storage resource's combined rate recovery to cause adverse market impacts.
- The level of control an RTO/ISO may have over operating a Storage resource without jeopardizing independence.

FERC has subsequently explained that the policy statement "…does not provide guidance for determining whether a particular electric storage resource is a transmission facility eligible for cost recovery through transmission rates."[2] FERC emphasized that whether it will approve cost-based rate recovery, whether through transmission rates or otherwise, is a separate matter that must be addressed on a case-by-case basis, because "an electric storage resource may not readily fit into only one of the traditional asset functions of generation, transmission, or distribution."[3]

1.2 Regional Transmission Operators (RTOs) and Independent System Operators (ISOs)

Most of the RTOs and ISOs which manage the various electric grids and wholesale electric markets across much of the nation have taken steps to assist market participants regarding the inclusion of Storage resources in their transmission planning and distribution services by updating their rules and tariffs to accommodate cost recovery methods and wholesale markets for Storage resources. However, Storage resources could face disparate requirements in some regions under proposed tariff revisions filed by RTOs and ISOs in their Order No. 841 compliance filings. For example, in capacity markets, which usually require a resource to be available for a certain minimum time, ISO-NE's tariff would require 2 hours, NYISO would require 4 hours, and PJM would require 10 hours. Further, not all RTO/ISOs have capacity markets, making the treatment of Storage resources different from region to region across the country.

1.2.1 California Independent System Operator (CAISO)

According to the May 2018 U.S. Energy Information Administration ("EIA") report on U.S. Battery Storage Market Trends ("Battery Storage Report"), Storage installations in CAISO territory accounted for 18% of existing U.S. large-scale battery storage power capacity in 2017, but they accounted for 44% of existing energy capacity. CAISO has developed three participation models for resources capable of receiving energy from the grid, storing it, and later injecting energy back.

1.2.1.1 NGR Model - "Non-Generator Resource"

Established in 2011 for storage resources, CAISO states this aspect of its tariff is equivalent to the participation model required by Order No. 841.[4]

- *CAISO's specially designed model for storage*. In its tariff, CAISO defined "Non Generator Resource" as "Resources that operate as either Generation or Load and that can be dispatched to any operating level within their entire capacity range but are also constrained by a MWh limit to (1) generate Energy, (2) curtail the consumption of Energy in the case of demand response, or (3) consume Energy." Technologies such as lithium-ion and sodium sulphur batteries typically fit within CAISO's definition of "Non-Generator Resource." This model may also benefit other energy constrained resources such as dispatchable demand response or micro-grids with limited ability to generate or consume energy continuously for wholesale market participation purposes.

1.2.1.2 Pumped Storage Hydro Units

CAISO describes Pumped Storage Hydro Units as hydroelectric dams capable of producing electricity and pumping water between reservoirs at different elevations to store such water for the production of electricity. CAISO states that these resources can operate in the mode of Generating Unit or Participating Load and can submit bid components for both modes.

1.2.1.3 Demand Response Providers

Demand Response Providers often combine Storage resources located behind a retail customer meter ("behind-the-meter" or "BTM") and other small-scale resources to create a larger aggregate resource. According to CAISO's tariff, this includes Proxy Demand Resources (PDR) (a load or aggregation of loads that has the characteristics of a PDR set forth in Sec. 4.13.5[5] and is capable of measurably and verifiably providing Demand Response Services) and Reliability Demand Response Resources (RDRR) (a Load or aggregation of Loads that has the characteristic of a RDRR set forth in Sec. 4.13.5[6] and is capable of measurably and verifiably providing Demand Response Services).

1.2.2 Electric Reliability Council of Texas (ERCOT)

ERCOT is responsible for operating the transmission grid and wholesale markets for energy and ancillary services in Texas. Although not subject to FERC jurisdiction for wholesale sales of electricity, ERCOT and Texas have been at the forefront of renewable energy and Storage activities. ERCOT's grid supplies electric energy to approximately 75% of Texas consumers.

ERCOT provides that, within its territory, Energy Storage Resources (ESR) carry Wholesale Storage Load, which is limited to batteries, flywheels, compressed air Storage, pumped hydroelectric power, electrochemical capacitors, and thermal Storage. ERCOT's rules state that the parameters of Energy Storage Resources must allow for ESR participation in the Regulation Services market as well as outline the make-whole calculation processes for ESRs.

1.2.3 Midcontinent Independent System Operator (MISO)

MISO defines Energy Storage Resource the same as it is defined in Order No. 841. Order No. 841 states that an Energy Storage Resource is intended to include all technologies and/or storage mediums, including but not limited to, batteries, flywheels, compressed air, and pumped-hydro. However, in its tariff, MISO also proposed a new term—Electric Storage Resource Transaction—defined as "Market Activities associated with an ESR's charging and discharging process, consisting of the withdrawal of Energy, including any associated Energy purchases, from the Transmission System, and the future injection of Energy, including any associated Energy sales, to the Transmission System under MISO's Tariff." MISO deems this term necessary to delineate the appropriate treatment of Storage, due to its unique characteristics, as distinct from end use consumption of Energy provided by Load Serving Entities.

1.2.4 ISO New England (ISO-NE)

ISO-NE defines Energy Storage Facility (ESF) as a facility that is capable of receiving electricity from the grid and storing the energy for later injection of electricity back to the grid. ISO-NE's definition adds "the energy" to the FERC's definition. In ISO-NE, all Storage resources must register as an ESF in one of two categories based on its physical characteristics: as either a Binary Storage Facility or a Continuous Storage Facility. These two categories were approved by FERC in February 2019 as a complementing part of ISO-NE's Order No. 841 compliance proceeding. Descriptions of the two categories, as provided by ISO-NE, are as follows:

- **Binary Storage Facility**: ESFs that are more physically constrained (like pumped-storage hydroelectric facilities), *e.g.*, that cannot switch nearly instantaneously from charging to discharging or operate continuously across the boundary between their negative and positive MW ranges. Binary Storage must have a minimum commitment of 1 hour.

- **Continuous Storage Facility**: ESFs that can transition seamlessly between charging and discharging and that can charge or discharge at any MW level within their range (like batteries). This type of ESF will register as a dispatchable Generator Asset, a Dispatchable Asset Related Demand (DARD), and as an Alternative Technology Regulation Resource (ATRR). Continuous Storage Facilities have no minimum commitment because the software deployed can automatically switch the resources between charging and discharging.

1.2.5 New York Independent System Operator (NYISO)

NYISO defines Energy Storage Resource as "Generators that receive Energy from the grid at a specified location, and are capable of storing that Energy, for later injection back onto the grid at the same location. Resources that cannot inject Energy onto the grid cannot be Energy Storage Resources. In order to qualify for wholesale market participation, Energy Storage Resources must be able to inject at a rate of at least 0.1 MW for a period of at least one hour. Energy Storage Resources are 'Withdrawal-Eligible Generators,' which is a new sub-category of generators in the NYISO tariff that are 'eligible to withdraw energy from the grid at a price for the purposes of recharging or refilling for later injection back to the grid.'"

1.2.6 PJM Interconnection, Inc. (PJM)

According to the latest EIA Electric Generator Report, PJM runs energy and capacity markets and the transmission grid in 13 eastern states and the District of Columbia. In 2012, PJM created a new frequency regulation market product for fast-responding resources, the conditions of which were favorable for battery storage. The EIA stated that most existing large-scale battery storage power capacity in PJM is owned by independent power producers providing power-oriented frequency regulation services. However, the EIA report indicated that recent changes in PJM's market rules have slowed battery installations in the region.

PJM permits two types of resources to participate in its frequency regulation market: (1) Reg D for fast responding resources such as batteries, and (2) Reg A for conventional resources such as gas turbines or hydropower. To create equivalence between these two different types of resources, PJM set a benefits factor floor. This floor provides for the growth in Storage resources deployed within PJM. In June 2017, FERC rejected a PJM proposed rule to eliminate the benefits factor as unreasonably discriminatory against

Storage resources. PJM is preparing to revisit that effort by providing a different approach to its rules on frequency regulation.

PJM defines Energy Storage Resource to have the same meaning as in Order No. 841 and its tariff states that Storage resources are eligible to provide all services for which they are technically capable of providing in the PJM Capacity, Energy, and Ancillary Services markets.

1.2.7 Southwest Power Pool (SPP)

SPP currently has no rules regarding Storage in its wholesale electric system, although it has proposed such rules in its Order No. 841 compliance filing. In that compliance filing, SPP defined Energy Storage Resource (ESR) to be the same as in Order No. 841. However, in its Order No. 841 compliance filing, SPP also added to its definition two exceptions that FERC created in Order No. 841: "A Resource is not an ESR if it is (1) physically incapable of injecting electric energy to the Transmission System due to its design or configuration or (2) contractually barred from injecting electric energy to the Transmission System."

1.3 State Laws, Regulations, and Policies

Several states have taken an active approach towards the utilization of Storage resources. In addition to solar+storage and wind+storage, some states are looking towards the idea of a Clean Peak Standard (CPS). CPS is a policy tool designed to increase the delivery of kilowatt-hour sales from clean peak resources during system peak demand periods. In 2018, Massachusetts became the first state to establish a CPS. The primary leaders in the utilization of Storage resources among the states are summarized as follows.

1.3.1 Arizona

The Arizona Corporation Commission (ACC) has moved forward through administrative action to promote the development and deployment of Storage resources in Arizona, primarily at the retail level.

In an ongoing proceeding, the ACC is considering changes to its Renewable Energy Standard and Tariff to increase the state's Renewable Portfolio Standard from 15% in 2025 to 30% in 2030. In addition, the ACC is considering changes to its Tariff rules to incorporate the development and use of Storage resources in order to benefit ratepayers.

The ACC has also used utility mandates to spur Storage technology development in Arizona. For example, in September 2017, ACC ordered the state's largest utility to develop a residential demand response/load management program to facilitate residential Storage technology. More recently, in January 2018, the ACC proposed a CPS program that includes a 3,000 MW Storage procurement target by 2030, and then, in March 2018, the ACC placed a moratorium on the procurement of capacity from new gas plants over 150 MW for the remainder of 2018. In March 2019, the Arizona Public Service Co. announced plans to install approximately 850 MW of additional battery storage within its service territory beginning in 2021.

1.3.2 California

According to the EIA Battery Storage Report, California has introduced the most state-level measures related to Storage.

- In September 2010, California passed Assembly Bill 2514 which set a mandate for California investor-owned utilities to procure 1,325 MW of Storage across the transmission, distribution, and customer levels by 2020. All of that capacity must be operational by 2024.

- In May 2017, California passed Assembly Bill 2868, requiring all California investor-owned utilities to procure up to an additional 500 MW of distributed Storage (all of which must not be connected to transmission sources and is completely separate from the previously required procurements of AB 2514), including no more than 125 MW of customer-sited Storage.

- In spring 2017, California also extended its Self-Generation Incentive Program, which provides financial incentives for installing customer-sited distributed generation via rebates for residential storage systems 10 kW or smaller, as well as for storage systems larger than 10 kW.

- Also in the spring of 2017, California introduced a CPS bill to require the deployment of clean energy during peak demand. This bill ultimately did not become law; however, as California continues to pursue its aggressive clean energy goals, this issue will likely reach the legislature again.

The EIA also stated that more than 60% of the existing battery storage power capacity in California was installed in response to a leak at the Aliso Canyon Natural Gas Storage Facility outside Los Angeles in October 2015, demonstrating to the California Legislature that Storage resources can be deployed in a fast, efficient, and economical manner.

1.3.3 Colorado

In March 2018, Colorado passed a new law that required the Colorado Public Utilities Commission to begin developing rules to allow for the installation, interconnection, and use of Storage systems by utility customers. This new law stated that electric customers have a right to install, interconnect, and use Storage systems without unnecessary restrictions or regulations, and without discriminatory rates or fees. In addition, a second recent law directs the CPUC to develop rules for integrating Storage resources into the planning process. This rule was adopted in October 2018. During the pendency of the rulemaking, the law authorized utilities to apply for rate-based Storage projects with a maximum capacity of 15 MW.

1.3.4 Hawaii

In June 2015, Hawaii passed a law known as the Hawaii Clean Energy Initiative that directed the state’s utilities to achieve 100% of their electrical sales from renewable resources by 2045. Storage resources will likely play a key role in achieving this goal. As a result, according to the Hawaii Public Utility Commission, Hawaii’s utilities have been active in procuring solar+storage on the islands of Oahu, Maui, and the Big Island. In addition, to further advance battery storage technology (a key component in achieving its goal for 100% renewable electric supply by 2045), Hawaii is investing in public-private partnerships to develop battery Storage systems used in frequency regulation, peak shifting, voltage support, and power smoothing applications.

Most recently, in early 2018, Hawaii Electric Company, as ordered by the Hawaii Public Utilities Commission in November 2017, launched “Smart Export,” a program directed toward owners of combined rooftop solar-battery storage systems. This program will allow system owners to export any unused energy to the grid and receive monetary credits toward their bills.

1.3.5 Massachusetts

In June 2017, the Governor of Massachusetts, under direction from the legislature, announced an “aspirational” target of 200 MWh of Storage resources by January 1, 2020. Then, in August 2017, the Massachusetts Department of Energy Resources (DOER) adopted the SMART program for Massachusetts that will guide the state’s industry for the next 1,600 MW of solar and over 80 MW of storage. Specifically, the program offers Storage resources that are paired with solar an incentive of between 2.5 cents/kWh and 7.5 cents/kWh based on the size of the solar system relative to the Storage resource and the Storage resources’ discharge duration. Based on this program, the Massachusetts market is expected to see 54 MW of Storage deployed in 2019, compared with 0.9 MW in 2017 and 5.4 MW in 2018. The SMART program provides an important case study for solar programs that promote Storage because its requirements are simple, and it adds an incentive based on solar system output rather than Storage resource performance.

The following are the parameters for Storage resources under the SMART program:

- Nominal capacity must be at least 25% and not more than 100% of the nominal capacity of the solar system.
- Discharge duration of at least two hours.
- Roundtrip efficiency of at least 65%.
- Provide 15-minute interval performance data to the SMART program administrator.
- Discharge at least 52 cycles annually.

In March 2018, Massachusetts became the first state to pass a CPS. The CPS requires the delivery of a minimum percentage of kilowatt-hour sales to come from clean peak resources during system peak demand. The DOER is currently working on regulations to implement this new standard. Responses to questions posed by the DOER were due on February 5, 2019.

1.3.6 Nevada

In 2017, the Nevada legislature passed a bill directing the Public Utilities Commission of Nevada (PUCN) to investigate the use of Storage systems in Nevada and determine if that use would be in the public interest. That law also stated that Nevada customers are guaranteed a right to interconnect solar-plus-storage systems in a timely manner. The PUCN was scheduled to make a determination by December 2018, but no decision has been made. However, a PUCN-commissioned report, released in October 2018, has indicated that up to 175 MW of utility-scale battery storage could be deployed cost effectively in Nevada by 2020 under the right conditions and that, by 2030, cost-effective battery storage deployment potential could range from 700 MW to more than 1,000 MW, depending on the pace of declines in battery costs and changing market conditions. The study also found that if Nevada were to adopt incentives for behind-the-meter resources, commercial and industrial battery storage could add an additional 70 MW to the total by 2030.

1.3.7 New Jersey

In May 2018, New Jersey became the first state within the PJM Interconnections territory to set a Storage target, which is non-binding but motivating for utilities within the state. New Jersey set a goal of 600 MW of Storage by 2021 and 2,000 MW by 2030, making it one of the most aggressive goals in the United States. The new law requires the New Jersey Board of Public Utilities (BPU) to (1) conduct an analysis of how Storage resources can benefit ratepayers and (2) prepare a report within one year. The analysis must also consider the need for integrating distributed energy resources into the distribution grid.

1.3.8 New Mexico

In 2015, New Mexico released a new, comprehensive energy plan, which recommended, among other things, “promot[ing] New Mexico as ‘the’ place to develop and test energy storage technologies” and “pursu[ing] energy storage technology development and demonstration projects such as advanced batteries and flywheel/hydraulic energy storage systems.” Then, in February 2017, on its own motion, the New Mexico Public Regulation Commission initiated a rulemaking on including Storage in Integrated Resource Plans. Most recently, in March 2019, the New Mexico legislature passed a bill that, if it becomes law, will require all publicly regulated utilities to produce 100% of their electricity from carbon-free sources by 2045. To achieve that goal, it is estimated that New Mexico would need to increase its renewable generation capacity five-fold, which will require accompanying storage capacity.

1.3.9 New York

In 2017, the New York legislature unanimously passed new legislation supporting the development and deployment of Storage resources. The new deployment program has a target of 3 GW for Storage procurement by 2030 and is developing programs to help the state meet that target. Eligible Storage resources include any mechanical, chemical, or thermal process that stores energy generated at one time for use at a later time, including the storage of thermal energy for use in heating and cooling systems that avoid using electricity for those systems.

In June 2018, Governor Cuomo laid out his goals for Storage capacity of 1,500 MW across New York by 2025. His plan proposes making $350 million available for Storage projects, adding Storage to the NY-Sun program for solar-plus-storage projects, and making changes to regulatory rules and permitting to reflect the environmental benefits of Storage systems.

In September 2018, the New York Public Service Commission accepted the environmental review of the Governor's goals as complete and, in December 2018, approved the 3 GW Storage goal by 2030 with an interim goal of 1,500 MW by 2025 as proposed by the Governor.

1.3.10 North Carolina

Energy Intelligence Partners (EIP) has developed a CPS that focuses on leveraging Storage resources in North Carolina. While North Carolina has yet to adopt EIP's proposed CPS, the energy storage-centric CPS would apply to the three major electricity retailers and proposes to satisfy 5% of their system peak load by 2025 and 10% of their system peak load by 2028.

1.3.11 Oregon

In June 2015 the Oregon legislature passed HB 2193 which implemented a statewide Storage mandate that requires each electric company with 25,000 or more retail customers to procure one or more Storage systems with capacity to store at least 5MWh of energy. The guidelines for this mandate require the Storage projects to be operational by January 1, 2020.

In January 2017, the Public Utility Commission of Oregon released a set of guidelines designed to encourage the utilities to submit proposals using a request for information process for multiple projects that test varying technologies. Following this mandate, Portland General Electric announced that it would spend up to $100 million to acquire approximately 39 MW of Storage resources across existing generator, distributor, and customer sites.

1.3.12 Texas

Despite not being subject to FERC jurisdiction, and thus not subject to Order No. 841, Texas has been a leader in energy storage's ability to provide grid reliability and efficiency. Due to its unique dynamic of unregulated and regulated electric utilities, and a climate that is ideal for both solar and wind energy, Texas is an important test site for energy storage technology with respect to utility scale battery projects as well as microgrid and community storage deployments.

In February 2018, the Public Utility Commission of Texas (PUCT) initiated a rulemaking proceeding entitled "Rulemaking to Address the Use of Non-Traditional Technologies in Electric Delivery Service." The purpose of this rulemaking is to consider whether Storage resources can be owned by transmission and distribution companies in Texas. Under Texas law, transmission and distribution companies remain fully regulated by the PUCT and are not allowed to own or operate generation resources. Due to the dual nature of Storage facilities as both a consumer and generator of energy, the PUCT opened the rulemaking to solicit public comment and further study how Storage resources may be utilized. This proceeding is still ongoing with public comments submitted in November 2018 and no clear timetable for a decision from the PUCT. As a demonstration of the complexity of this issue, the comments filed in the rulemaking were split as to whether or not a transmission and distribution company in Texas may own Storage resources.

In January 2019, following the comments received in the rulemaking, as part of its Competition in Electric Markets report to the Texas legislature, the PUCT asked for help in clarifying whether Storage resources may be owned by transmission and distribution companies in Texas. To date, the Texas legislature has provided no clarification.

1.3.13 Washington

In 2013 Washington's Department of Commerce developed a clean energy fund to assist in grid modernization and Storage development. This fund has provided grants for experimental projects using a 500-kWh lithium-ion battery, a 6.4 MWh flow battery, testing of utility scale batteries, and the development of microgrid technologies. Washington requires each eligible Storage project to incorporate technology to integrate the Storage system performance with grid operations. Washington regulators have recognized that Storage is a "key enabling technology" for decarbonizing the grid.

Energy Storage Challenges

Key challenges include:

- Coordination between federal and state regulations, polices, and mandates.

- Uncertainty regarding judicial appeal and implementation of Order No. 841 in organized wholesale markets.

- Ability of BTM Storage resources to participate in wholesale organized markets.

- Functional classification and cost allocation issues in various states as energy storage resources are technically capable of providing services in each of the functional classifications of production (generation), transmission, and distribution.

- The extent to which utilities may own and operate Storage resources.

- Ability of storage resource owners to receive multiple revenue streams from a storage resource by using that resource to provide multiple services—*e.g.*, energy, capacity, frequency regulation, demand response, and transmission congestion relief—whether simultaneously or at different times.

Best Practice

First and foremost, developers should recognize that there is not a uniform regulatory framework for storage resources. There are multiple regulatory frameworks across the various federal and state jurisdictions, and those frameworks are still in their infancy. Accordingly, from a regulatory perspective, the most important best practices for storage project developers at this time are perhaps to acknowledge that fact, monitor the ongoing regulatory changes, and understand that each project will need to be developed with a jurisdiction-specific regulatory analysis.

FERC's Order No. 841 was an important step in formalizing and standardizing, to some degree, certain regulatory aspects of storage resources' participation in wholesale markets at the federal level. However, that rule only covered the regions of the U.S. that have an organized wholesale market overseen by an RTO/ISO, and FERC provided the RTO/ISOs with flexibility to develop rules tailored to their unique regional circumstances. Further, there is even more disparity in the regulatory frameworks at the state level.

Although there is no comprehensive, one-size-fits all set of best practices, many of the issues that FERC addressed in Order No. 841, and FERC's determinations on those issues, provide a good starting point for identifying some of the high-level regulatory considerations that project developers should keep in mind:

- Whether the resource is located at the transmission level, distribution level, or behind-the-meter may have implications for the resource's interconnection process, costs, technical capabilities, and the types of services it is able to provide.

- A resource's technical capabilities will affect its economics.

- Technical capabilities include not only physical and operational characteristics, but also a resource's ability to meet particular performance requirements, such as a minimum run time necessary to qualify as a capacity resource.

- A resource's technical capability can be limited by commercial arrangements, *e.g.*, an interconnection agreement limiting a resource's discharge limit may be treated similarly to a limit on the resource's physical and operational capability.

- Even if a resource is participating in a wholesale market, under a FERC-jurisdictional RTO/ISO tariff the state or other retail authority retains authority over retail services and distribution system matters, including distribution system design, operations, power quality, reliability, and system costs.

- Resources potentially can provide a range of services, some of which are compensated at market rates and some of which are compensated on a cost-of-service basis. Examples of market-based services include energy, capacity, and some ancillary services (*e.g.*, frequency regulation). Examples of cost-of-service based services are blackstart service, primary frequency response, and reactive power.

- De-rating or constraining the operation of a resource could be considered physical withholding under certain circumstances and could run afoul of market manipulation rules.

- Assuming must-offer obligations may limit the amount that a resource owner can de-rate a resource by establishing a floor for de-rating purposes.

- In order to be eligible to set the market clearing price in an RTO/ISO, a storage resource must be available to the RTO/ISO as a dispatchable resource.

Resources

- EIA Report *U.S. Battery Storage Market Trends* (May 2018) https://www.eia.gov/analysis/studies/electricity/batterystorage/pdf/battery_storage.pdf

- *Deploying Distributed Energy Storage: Near-Term Regulatory Considerations to Maximize Benefits* – This report by the IREC identifies key regulatory policy considerations to guide regulators and other stakeholders as they seek to evaluate and unlock the benefits of Storage. (February 2015).

  http://www.irecusa.org/publications/deploying-distributed-energy-storage/

- *DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA*– A how-to guide for utility and rural cooperative engineers, planners, and decision makers to plan and implement Storage projects, sponsored by the U.S. Department of Energy and the Electric Power Research Institute in collaboration with the National Rural Electric Cooperative Association. (February 2015).

  http://www.sandia.gov/ess/publications/SAND2015-1002.pdf

- *Energy Storage Valuation in California: Policy, Planning, and Market Information Relevant to the StorageVET Model* – As part of documentation by the Electric Power Research Institute (EPRI) of their Storage Valuation Estimation Tool (StorageVET) model, this report includes descriptions and technical details related to the valuation of Storage operated in the California electric power system, and it reviews policies, programs, and markets relevant to the use and treatment of Storage implemented by the California Public Utility Commission (CPUC), California Independent System Operator (CAISO), electric utilities, and others—important for understanding lessons learned from the first state to make significant progress on Storage. (December 2016).

http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002008901

- Market and Policy Barriers to Energy Storage Deployment – This report by Sandia National Laboratories identifies regulatory and market-based hindrances to deploying Storage and discusses possible solutions to address the current challenges. (September 2013).

  http://www.sandia.gov/ess/publications/SAND2013-7606.pdf

- State of Charge: Massachusetts Energy Storage Initiative Study – As part of the Massachusetts Energy Storage Initiative to evaluate and demonstrate the benefits of deploying Storage technologies, the Department of Energy Resources (DOER) and the Massachusetts Clean Energy Center (MassCEC) partnered to conduct a study to analyze the economic benefits and market opportunities for Storage in the state. (September 2016).

  http://www.mass.gov/eea/docs/doer/state-of-charge-report.pdf

- Technology Roadmap: Energy Storage – This report by the International Energy Agency provides a roadmap to understand and communicate the value of Storage to energy system stakeholders. (March 2014).

  https://www.iea.org/publications/freepublications/publication/technology-roadmap-energy-storage-.html

- The Economics of Battery Energy Storage – Produced by the Rocky Mountain Institute, this report discusses the impact of Storage location on the range of potential services it can provide and delves into examples of value-stacking, with a focus on customer-sited Storage. (October 2015)

  https://www.rmi.org/insight/economics-battery-energy-storage/

- U.S. Department of Energy Global Energy Storage Database – An open-access resource that provides detailed information on Storage projects and policies in the U.S. and around the world.

  http://www.energystorageexchange.org/projects/data_visualization

- Energy Storage Procurement Targets Could Work for Nevada, PUCN-commissioned Study Says - Energy Storage News October 4, 2018.

  https://www.energy-storage.news/news/energy-storage-procurement-targets-could-work-for-nevada-pucn-commissioned

- Brattle Economists: At Least 700 MW of Energy Storage Can be Deployed Cost Effectively in Nevada by 2030 - The Brattle Group October 3, 2018.

http://www.brattle.com/news-and-knowledge/publications/the-economic-potential-for-energy-storage-in-nevada

- New Mexico Regulators Amend Resource Plan to Include Energy Storage - Utility Dive August 15, 2017.

  https://www.utilitydive.com/news/new-mexico-regulators-amend-resource-plan-to-include-energy-storage/449009/

- FERC Order No. 841 Tariffs
  - CAISO (Docket No. ER19-468)

    https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109137
  - ERCOT - Order No. 841 is not applicable to ERCOT.
  - MISO (Docket No. ER19-465)

    https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109007
- ISO-NE (Docket No. ER19-470)
  - https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109190
  - https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109193
- NYISO (Docket No. ER19-467)
  - https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109127
  - https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109129
  - https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109130
- PJM (Docket No. ER19-469)
  - https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109175
  - https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109176
  - https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15109177
- SPP (Docket No. ER19-460)
  - https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15108860

References

[1] Several entities filed requests for rehearing and clarification of Order No. 841. On May 16, 2019, FERC issued an order denying the rehearing requests, and denying in part and granting in part the clarification requests. *Elec. Storage Participation in Markets Operated by Reg'l Transmission Orgs. and Indep. Sys. Operators*, 167 FERC ¶ 61,154 (2019).

[2] *Nevada Hydro Co., Inc.*, 164 FERC ¶ 61,197, at P 24 (2018).

[3] Id.

[4] CAISO presented this argument to FERC in CAISO’s Order No. 841 compliance filing. As of the date of this writing, FERC has not yet ruled on CAISO’s compliance filing.

[5] Minimum Load curtailment shall be no smaller than 0.1 Mw. Loads may be aggregated together to achieve the 0.1 Mw threshold. There is no upper limit on the maximum Load curtailment of a PDR.

[6] Minimum Load curtailment shall be no smaller than 0.5 Mw. Loads may be aggregated together to achieve the 0.5 Mw threshold. The maximum Load curtailment of a RDRR that selects the Discrete Real-Time Dispatch Option shall be no larger than 0.5 Mw. There is no upper limit on the maximum Load curtailment of a RDRR that selects the Marginal Real-Time Dispatch Option.

Project Development

Chapter Five: Incentives

Chapter Lead: Buck Endemann, K&L Gates

Background

Incentives for energy storage technology investment are available at the federal, state, and local levels. They are embedded in the tax code, paid as direct benefits from states and utilities, and/or encapsulated in mandates or utility requirements.

Federal

Federal incentive programs for investment in renewable energy projects center on tax incentives. While stand-alone energy storage resources are not yet eligible for federal tax incentives, energy storage equipment that is paired with eligible wind and solar resources may qualify for tax credits if it stores a certain percentage of renewable energy before then sending it back into the grid. Another federal incentive mechanism is the Modified Accelerated Cost Recovery System (MACRS) depreciation deduction. MACRS allows a project owner to accelerate depreciation of energy storage equipment that is paired with eligible solar or wind facilities.

In addition to beneficial tax treatment, the U.S. Department of Energy has provided grant money and other incentives for early-stage technology demonstration programs. As energy storage technologies have matured, the need for simple operational demonstration programs has receded, replaced with demonstration programs targeting applications—especially those highlighting multiple applications—and economic performance.

Finally, FERC policy has evolved over the years to incentivize the better performance of those resources providing frequency regulation and ancillary services. These FERC policies are often implemented as market rules in each of the ISOs and RTOs. Energy storage resources are well suited to provide energy markets with quick response, fast-ramping energy products.

State

State policymakers and regulators are responsible for developing incentives for energy storage project development in their states. State incentives include mandates, grant funding, and incentive programs aimed at developing different parts of the energy storage market.

States including California, Oregon and New York require their utilities to procure a certain number of MW of energy storage by a particular deadline. These mandates act to guarantee a buyer for energy storage projects or associated energy products, and have the effect of socializing the costs of new technology over a wide customer rate base. Other states like

Massachusetts create financial ladders for renewable energy projects that incorporate energy storage components.

Many states make grant funding available to energy storage projects, with some grants being offered to advance certain segments of the energy storage market, or for certain technologies. For instance, Massachusetts has awarded more than $9 million in grants to projects that have demonstrated a "clear and innovative" business model. The New York State Energy Research and Development Authority (NYSERDA) has established a funding program for commercial energy storage systems (ESS) that can stack at least two value streams. This can be accomplished by executing two or more services for retail electric customers. Taken together, these grants have allowed companies additional flexibility in exploring energy storage use cases and technologies.

Some states offer pure incentive programs for energy storage projects. For instance, California's Self-Generation Incentive Program (SGIP) received a significant overhaul in 2017 to prioritize the development of distributed energy storage resources. If an SGIP application is accepted, an energy storage developer will receive some portion of the funds upfront and realize the remaining incentive during the operating life of the project. Eligibility is restricted, however, based on efficiency and the availability of other revenue streams.

Finally, some states have provided general support to the energy storage industry by commissioning studies and holding stakeholder workshops. For instance, Massachusetts' Energy Storage Initiative was commissioned to develop policy recommendations and advance the state of the market.

Local

Local incentive programs typically leverage the support for accelerating siting, permitting, and interconnection of the energy storage projects. These programs may be additionally supported by municipal utilities. Sterling Municipal Light Department in Massachusetts deployed a 2MW/3.9MWh energy storage system with the support of both the U.S. DOE and Massachusetts Department of Energy Resources incentives, as well as with local support for expedited siting and interconnection.

Energy Storage Challenges

The multi-tiered incentives and, often, the multi-revenue stream nature of energy storage projects, make incentive alignment and coordination a key challenge. Incentives for energy storage technology investment come at the federal, state, and local levels, with sometimes competing operational requirements or restrictions. The most significant restriction is with the federal solar Investment Tax Credit (ITC).

Federal

ITCs do not currently exist for standalone energy storage projects. At this point, the only way energy storage projects are able to qualify for an ITC is through the existing solar ITC, meaning that a storage project must be paired with a solar project. Limitations exist, however, as to the usefulness of the solar ITC for energy storage systems. For example, public entities are not eligible for tax-based incentives as they are not subject to federal income taxes.

The primary limitation on the applicability of the solar ITC for the energy storage system is the source of the power to charge the battery.[1] The eligibility of the energy storage system to claim the ITC is based on a proportional scale of this source of power. Energy storage systems that are charged by the PV system 100% of the time are eligible to claim the full value of the ITC. Energy storage systems that are charged by a PV system from 100% to 75% of the time are eligible for that portion of the ITC.[2]

For example, a system charged by renewable energy 85% of the time is eligible for 85% of the 30% solar ITC—meaning 85% times 30% for a total of 25.5%. The level of energy that is cycled through the energy storage system is critical to realizing full eligibility as the tax credit is vested over a 5-year period. Recapture by the IRS can apply in out years if the percentage of the energy cycled through the energy storage system declines from the initial total. This eligibility applies to PV and energy storage systems that are installed at the same time.

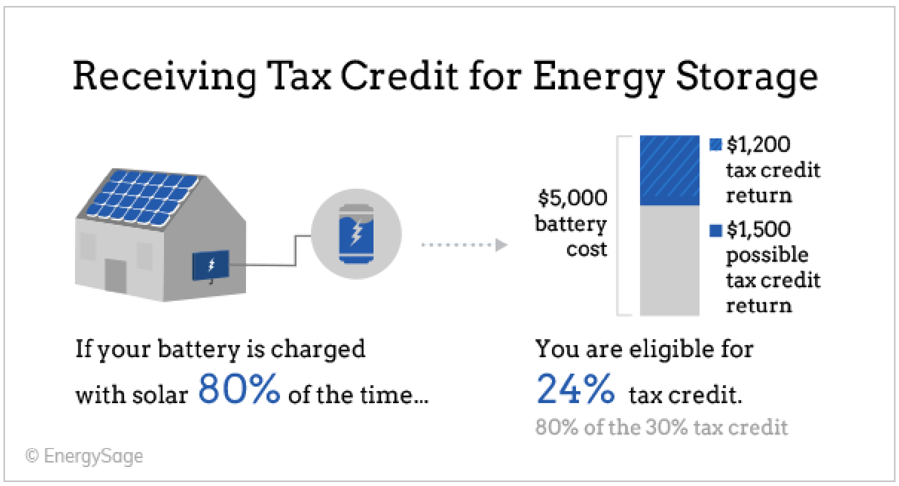


Fig. 1.5.1
Energy storage tax credit computation.
Source: Energy Sage .
https://www.energysage.com/solar/solar-energy-storage/energy-storage-tax-credits-incentives/

Under the Modified Accelerated Cost Recovery System (MACRS), an ESS is eligible for a seven-year depreciation schedule. If the energy storage system is charged by a renewable energy resource, the ESS is typically eligible for the five-year MACRS depreciation schedule.

With regard to FERC incentives, it is important to remember that FERC rules incentivizing fast-ramping, quick response resources are supposed to be nondiscriminatory. While battery storage projects may be well-suited for certain energy products, how each RTO/ISO dispatches those energy projects can uniquely impact energy storage resources. For instance, technical changes to PJM's fast ramping "Reg D" frequency regulation market had the effect of increasing wear and tear on battery resources relative to gas turbine resources. This operational risk must be considered when evaluating the value of these incentives.

State

State energy storage incentives and policies make use of a variety of tools to provide incentives for energy storage. Unfortunately, as different states enact different incentive programs, economies of scale issues prevent developers from approaching smaller states with customized solutions. Large states such as California and New York are seen to have an embedded advantage when it comes to enticing developers to participate in their markets.

Some state incentive programs are seen as either artificially limiting the market opportunities for energy storage resources or forcing developers to reveal more information than they are accustomed to. For instance, in California, the California Public Utilities Commission has issued a set of guidelines for determining how energy storage resources can stack revenues. Certain distribution- and transmission-connected storage assets are prohibited from providing non-reliability services, and in response to utility RFPs, energy storage developers are required to list all additional services that the energy storage resource will provide.

Local

Different local governments sometimes do not immediately upgrade to the most recent National Electrical Code and other local ordinance drives. Developers are thus sometimes presented with a patchwork quilt of slightly different requirements for the deployment of electrical equipment. The NFPA is making great strides to incorporate the most up-to- date requirements for siting and installing energy storage systems, and so the different releases of the NEC (available every 3 years) can provide a significantly different treatment for newer technologies. Version differences between the codes used by localities and other AHJs, when compared to those required by insurance and finance project partners, can lead to conflicts of code compliance. Developers should budget time and funding to work through these differences in the early stages of a project in order to reduce costly delays and changes occurring closer to project commercial operation. See Guide 8, Codes and Standards, for more detail.

Best Practice

When developing and deploying energy storage resources, certain incentives make some markets more attractive than others. Understanding the timing and certainty of incentive payments is a key aspect of project bankability—particularly in programs having few or no projects as precedents.

Federal

An energy storage ITC has long been sought by the energy storage industry as a clean approach to incentivize the deployment of energy storage projects. Most proposals contemplate basing any potential energy storage ITC on the existing Solar ITC program. This would provide for a 30% ITC for current systems, with the incentive declining to 10% by 2022. Currently, however, to the extent tax incentives are available, energy storage resources must be paired with renewable energy generation.

State

Stand-alone Mandates

State PUCs have utilized mandates to drive the deployment of energy storage systems into the State's utility power grid. Typically, these take the form of a target of "X" MWs or MWhs of energy storage systems, deployed along the utility power system (transmission to residential) with the intent of supporting a specific economic benefit or system resiliency target. Targeting states with a stand-alone energy storage mandate helps guarantee a market for your storage resource.

Renewable / Storage Mandate

State PUCs also have the option of mandating the incorporation of energy storage systems into renewable energy system deployments. As the resulting hybrid system will always come in at a higher production cost (on a $/kWh basis), the benefits of these hybrid systems are typically an enhanced dispatchability or reliability of the renewable energy system over the straight renewable system.

Integrated Resource Plans

While a few states have storage mandates, many more states require their utilities to periodically draft Integrated Resource Plans (IRPs) that provide a roadmap for investment in generation, transmission, and distribution resources over a particular period of time. Incorporating energy storage systems as a viable alternative into utility IRPs will provide structural and long-term support for further energy storage project development. Technology options that have been approved through these plans are typically more widely available for deployment as compared to selected programs.

Investment/Deployment Incentives

Typically taking the form of a $/kW incentive payment, these programs, with the goal of supporting the accelerated deployment of energy storage systems, have found success in many states. California's SGIP is an example of one such program, and states with such incentives usually have more experience permitting and interconnecting storage resources.

Grants

State programs providing grants have found some success in promoting energy storage system deployment into specific areas for programs that have a less defined economic benefit—such as resiliency or regional disaster preparedness / hardening.

- **Loans:** State economic development agencies are another pathway to provide customer incentives for deploying energy storage systems.

- **Rebates:** Incorporating energy storage systems into existing energy efficiency rebate programs is an emerging method of directing existing incentive programs to be available for energy storage deployment.

Local

Local jurisdictions are rapidly gaining a better understanding of energy storage technologies, with an eye toward supporting their local deployment. Steps such as adopting the latest editions of the National Electrical Code (which is beginning to cover energy storage systems) provide these governments with the proper tools to safely promote the proper deployment of energy storage systems. Additionally, local governments often act as partners to secure state and federal incentives, particularly those focused on resiliency.

Resources

- K&L Gates, *Energy Storage Handbook*, Version 3 (November 2018), available at http://www.klgates.com/epubs/Energy-Storage-Handbook-Vol3/

- Center for Sustainable Energy, *Self-Generation Incentive Program Handbook*, (Dec. 18, 2017), available at https://www.selfgenca.com/documents/handbook/2017 for California projects.

- Massachusetts Energy Storage Initiative, https://www.mass.gov/energy-storage-initiative.

- New York State Energy Storage, NYSERDA, https://www.nyserda.ny.gov/All%20Programs/Programs/Energy%20Storage

References

[1] Oluwaseum Akeyo, Huangjie Gong, Vandana Rallaband, Nickolas Jewell, Dan. M. Ionel. "Power Utility Tests for Multi-MW High Energy Batteries," 2018 7th International Conference on Renewable Energy Research and Applications (ICRERA), 2018. Available at https://www.researchgate.net/publications329623268_Power_Utility_Tests_for_Multi-MW_High_Energy_Batteries

[2] https://www.gao.gov/assets/700/691983.pdf

Project Development

Chapter Six: Offtake Agreements

Chapter Lead: Bill Holmes, K&L Gates

Background

Many early energy storage projects were developed as merchant facilities, particularly in MISO, PJM, and ERCOT, or were supported by incentive programs that are no longer available for an industry that is rapidly commercializing. In recent years, a growing number of energy storage projects have entered into long-term, structured contracts for the offtake of storage services. Because such contracts can provide the storage project with a predictable, long-term revenue stream from a creditworthy offtaker, they are often critical for project financing.

Although these long-term agreements are sometimes referred to casually as "energy storage PPAs," this omnibus term is a misnomer because several different forms of agreement have been developed to take advantage of the way energy storage systems perform as both generator and load (i.e., both discharging and charging). While each form of energy storage agreement has its own peculiar features, several forms of agreement currently in general use are summarized in this chapter.

Energy Storage Challenges

There are a number of challenges that will confront the development of successful offtake agreements for developing projects. Each of the different applications will have specific challenges as they pertain to different market segments. However, two key challenges are at the core of all offtake requirements:

- How can an energy storage project secure a predictable revenue stream over a term of years to facilitate the development and financing of an energy storage facility?
- How can an energy storage project manage the risk of a change in the law, or market design, that supports the economics of an energy storage facility?

Best Practice

Energy Storage Tolling Agreement

California utilities pioneered the use of energy storage tolling agreements in connection with their A.B. 2514 procurement of utility-scale storage projects that are interconnected to the transmission or distribution system. Under a tolling agreement, the energy storage system developer is responsible for obtaining site control, permits, interconnection rights, equipment, and construction contracts for the storage facility. Similar to solar and wind power purchase agreements, the tolling agreement will require the developer to construct the project and achieve agreed upon milestones, usually including both target and guaranteed commercial operation dates. The developer will be liable for delayed liquidated damages if the storage project does not achieve commercial operation by the target commercial operation date. In addition, the agreement may be terminated by the buyer if, by the guaranteed commercial operation start date, the storage facility has failed to be operational.

The structure of the energy storage tolling agreement will be familiar to those who have worked on gas tolling agreements, which provided the basis for the *pro forma* agreements used by the California utilities. The utility buyer pays for the electricity used to charge the battery storage system and receives the right to instruct the developer to charge or discharge the system, subject to specified operating parameters. In exchange, the storage provider receives a capacity payment, plus a variable O&M payment for energy dispatched from the system. The buyer may use the system to provide ancillary services, and for other purposes within the buyer's discretion (subject to operating parameters), usually without any additional compensation to the seller beyond the capacity and variable O&M payments.

The agreement will require the storage developer to achieve certain performance parameters. As a result, the capacity payment will be adjusted for the storage system's tested capacity, availability and round-trip efficiency. "Round-trip efficiency" is the difference between the amount of energy used to charge the system and the amount of energy available for discharge, a concept that is analogous to a heat rate in a gas tolling agreement. "Availability" and "capacity" provisions generally perform a similar function under both types of agreement. Deviations in capacity or availability usually result only in downward adjustments to the capacity payment, but round-trip efficiency may be structured to reward the storage developer for operating the system at a higher-than-expected efficiency. The performance standards may be adjusted over the course of the term to reflect expected degradation in system performance.

Because the buyer owns the energy stored in the battery, tolling agreements usually prohibit or restrict the developer's use of the storage system for station service. As a result, the developer is obliged to enter into a retail service contract for the system's non-storage load.

The tolling agreement will include an exhibit that sets out operating parameters to constrain the buyer's use of the storage system. Among other things, the exhibit would define the maximum number of full cycles per day, the maximum number of full cycles per year, maximum daily discharge, maximum annual discharge, and maximum partial discharges, as well as procedures for issuing, accepting and executing discharge instructions or default charging/discharging strategies. Buyer charging or dispatch instructions inconsistent with the operating parameters may be rejected by the storage developer or may provide the developer with an excuse for failing to meet the performance standards that are set out in the agreement. The agreement may set different operating parameters for different use cases and include mechanisms for converting use cases into equivalent operating parameters. It may also set different operating parameters for accommodating changes in market structure that facilitate alternative use cases during the term of the agreement.

Capacity Services Agreement (CSA)

CSAs are used for utility-scale energy storage projects that will be interconnected with the transmission or distribution systems. Under a CSA, the developer is responsible for developing, installing, and operating the energy storage system—and will charge the system at its own expense. The offtaker (usually a utility) pays a capacity charge for the system, subject to adjustment for availability, and uses the storage system's capacity attributes to satisfy the offtaker's Resource Adequacy (RA) requirements.

The CSA typically allows the developer to market certain products from the energy storage system to third parties as long as the delivery of such products does not interfere with the developer's obligation to deliver RA to the offtaker. To enable the utility to monitor the multiple uses to which a given energy storage system is being put, the utility may require the developer to give notice of the services being offered. Although this flexibility may enable the storage developer to take better economic advantage of the "value stack" offered by an energy storage system, it also represents an uncontracted merchant revenue stream that a lender may be inclined to heavily discount.

Demand Response Energy Storage Agreement (DRESA)

If a developer provides on-site, behind-the-meter storage to a number of customers or "site hosts," it will be able to aggregate the storage capabilities of those customers and enter into a DRESA. A DRESA between a utility and the developer allows utilities to compensate the developer for providing demand response energy storage services, essentially giving the utility access to a virtual battery.

Each site host will enter into an agreement with the developer to install the storage system in exchange for the developer receiving some combination of a fee or a share of the savings produced for the site host via the use of the storage system. The agreement will also give the developer the right to use the storage system to reduce the site host's demand at the direction of the utility offtaker.

The developer then enters into a long-term DRESA with a utility buyer under which the developer agrees to cause its customers to switch to energy storage for the duration requested by the utility (again, subject to the operating parameters of the aggregate system). During this period, the developer's customers will rely on energy discharged from the storage system instead of electricity from the utility, thus reducing load on the grid. A DRESA may allow demand response assets to be deployed without capital expenditures by either the site host or the local utility, thereby providing advantages to several stakeholders at once.

Hybrid Agreements (Solar + Storage, Wind + Storage)

Energy storage systems can be combined with other renewable generators—most commonly solar systems, but occasionally wind generators. The storage system will be eligible for the ITC if it is properly integrated with the solar generator (i.e., drawing at least 75% of its charging energy from the solar generator rather than the grid). For this and other reasons, the storage system and solar generator are usually located at the same site, and the storage system will be charged from the renewable generator rather than from the grid until, in the case of solar, the five-year recapture period has ended.

A hybrid agreement may be structured so that the developer is paid a per-MWh purchase price based on the electricity delivered at the interconnection point. In this case, to maximize revenue produced by the hybrid facility's output, the developer will manage and pay for the energy storage system's charging and discharging. If this structure is used, the developer does not receive a capacity payment and the offtaker does not control the charging or discharging of the storage system. This structure is sometimes used in island environments.

Other hybrid agreements are structured so that they more closely resemble the tolling agreement structure just described. The offtaker purchases solar or wind energy on a per-MWh basis, and the developer delivers the generation to the offtaker and/or charges the storage system in accordance with the offtaker's charging instructions. The offtaker decides when to discharge the system. The agreement will include mechanisms for determining the amount of energy sold and stored, round-trip efficiency, the amount of energy discharged, and the total amount of electricity sent to the delivery point. In addition to a per-MWh payment for energy produced by the generator, the developer receives a capacity payment that is typically adjusted to reflect the actual availability, capacity, and round-trip efficiency of the ESS. The stored electricity is owned by the utility and thus is not available for station service. The developer's availability, capacity, and round-trip efficiency guarantees will affect the capacity payment received by the developer and will be tied to the system's operating parameters. The operating parameters are, in turn, structured to account for the system's expected uses case(s).

Behind-the-Meter Projects

In several states including Hawaii, California, and New York, energy storage systems have been installed on the customer's side of the meter, allowing the customer to charge the system in off-peak hours and then release that stored energy during peak hours. These systems can be dispatched in response to demand response price signals to reduce the customer's usage of peak power or to shave peaks and thus reduce peak demand charges.

The agreement between the developer and its "behind-the-meter" customer may take the form of a third-party PPA, particularly if the storage system is combined with a solar installation, with payments to the developer based on electricity delivered to the customer. Another type of agreement shares the savings that the customer achieves when the customer is able to shave its peak demand (and thus its peak demand charges). To date, such agreements exist primarily in states that offer one or more unique market conditions such as high retail electricity prices, time of use rates that allow charging at off-peak prices and discharging at on-peak prices, market design such as peak demand charges in California or demand response markets in New York, and incentive programs such as California's SGIP.

Developers and utilities are continuing to create new forms of financeable agreements applicable to their fast-growing sectors—similar to where solar PV market players were ten years ago.

A brief review of the most common behind-the-meter storage financing agreements available is as follows.

Operating Leases

An operating lease is an arrangement whereby the owner of an energy storage system grants the host the right to use the system in exchange for a monthly fee that covers the rental of the energy storage system and (in most instances) its operation and maintenance fees, software access fees, installation costs, permitting costs, and sales and property taxes. The energy storage company, acting as the lessor, uses third-party financing to purchase the energy storage asset; therefore, it is essential that the lease provides for the owner's ability to assign the lease to its financing party.

During the lease period, which is usually 10 years from its commercial operation date (although terms as short as three years have been used) and often comes with the option for another ten-year term subject to the particular lease terms, the energy storage system remains the property of the owner/lessor—who will operate, manage, repair, and maintain it. The owner/lessor provides a long-term (again, often for 10 years) limited equipment warranty. The value proposition for the storage system typically will focus on reducing high time-of-use electricity rates or demand charges and providing backup power to the host/lessee in the event of grid outages. In most cases, the host/lessee will be granted an option to purchase the energy storage system, before the lease terminates, for its fair market value.

Concurrently, the energy storage system owner/lessor may operate the energy storage system to provide supporting services to the electrical grid, thereby offering the storage system owner/lessor potential additional revenues from such activities.

Demand Charge Shared Savings Agreements

Similar to the Energy Savings Performance Contract structure used for energy efficiency projects, a Demand Charge Shared Savings Agreement (DCSSA) between a host and a third-party energy storage system owner or operator allows the host to enjoy lower energy consumption costs due to reduced demand charges achieved both by discharging the energy storage system during peak hours and by performing energy arbitrage by drawing power during off-peak periods. With the DCSSA, third-party financiers rely on some combination of a fixed fee and an allocated portion of the energy cost savings from the reduced tariff-specific demand charges that will be distributed by the host to the project financing providers. The most significant advantage to the host is access to the cost reducing third-party energy asset, with little or no upfront capital expenditure on the host's part. Under the DCSSA, the host is provided energy storage-related services on a storage-as-a-service basis.

Table 1.6.1.

Demand Charge Agreement parameters.
Source: ACES Working Group.

Front of The Meter Projects	Behind The Meter Projects
Energy Storage Tolling Agreement	Operating Leases
Capacity Services Agreement (CSA)	Demand Charge Shared Savings Agreements (DCSSA)
Multi Use Projects	
Demand Response Energy Storage Agreement (DRESA)	
Hybrid Agreements (Solar + Storage, Wind + Storage)	

What Translates from Solar / Wind Markets?

General PPA Structure

Energy storage agreements share many of the provisions typical of a long-term solar or wind power purchase agreement. These include a long-term agreement by the buyer to purchase energy storage services; construction and commercial operation milestones; a force majeure clause; provisions governing defaults, cures and termination payments; collateral assignment and lender protection clauses; and dispute resolution provisions. Given the complexities of energy storage however, long-term agreements must address a number of categories of risks associated with new technology, business management, market and regulatory evolution, and credit profiles.

Change in Law and Regulatory Risk.

One of the most difficult issues in an energy storage agreement is allocating change in law risk, which is an issue similar to that addressed by wind and solar projects in connection with renewable portfolio standard (RPS) compliance clauses. Utilities will often procure energy storage so that they can meet targets or other procurement mandates, as well as satisfy resource adequacy (RA) requirements. If, however, after the agreement is signed, there is a change in the laws or tariffs governing the targets, RA qualifications, or other key operational features or attributes of the energy storage facility, which party bears the effects of that change?

Developers strongly prefer to shift the risk to the offtaker, arguing that the procuring utility is in the best position to manage changes in the laws, rules, and tariffs governing energy storage systems and how they count in meeting procurement targets or satisfying RA. A utility will often resist a full assumption of this risk, arguing that the small risk of an adverse change in law is better borne by the developer than the ratepayers. Developers, for their part, prefer to avoid provisions that merely excuse its performance when a change in a law occurs. Developers want any law change to give it the right to terminate the long-term agreement if that change makes it uneconomic to continue operating the storage system in accordance with the terms of the long-term agreement. Such a termination right offers some protection that the developer will not be trapped in an uneconomic long-term contract, but a termination right alone would increase the risk that the energy storage system could end up as a merchant plant, thus making it difficult to finance the system. Force majeure clauses are not adequate for the task of addressing change of law risk, and agreements need to address change of law risk allocation head on.

Not surprisingly, compromises are developing along the same lines as the change of law provisions affecting RPS compliance in solar and wind PPAs. In some instances, utilities will agree to accept the risk of a change in law. In others, the parties will agree to allocate the risk so that the developer bears compliance costs up to a certain point, after which the utility may decide if it wants to incur additional costs to cause the system to comply with the new law. From the developer's standpoint, the important outcome is that the utility cannot treat as a default the developer's failure to comply with the change after the cost threshold, if any, is reached. Nor can the utility refuse to continue to receive and pay for the contracted energy storage services specified in the agreement.

What Does Not Translate from Solar / Wind Markets?

Energy storage is a much newer and more complex technology than wind or solar, and it functions both as a load and a generator. Just as FERC Order 841 requires RTOs and ISOs to address a host of issues to enable energy storage to operate effectively in the organized markets, long-term energy storage agreements need to account for a number of dispatch, performance, use case, and operating parameter issues that are not encountered in wind and solar power purchase agreements.

Operating Parameters

Energy storage agreements usually include a detailed exhibit that sets out the system's operating parameters. These provisions are especially important in a tolling agreement or any other contract in which the buyer has the right to charge and dispatch the facility. If the storage system is operated within the agreed upon operating parameters, the storage provider is required to meet the capacity, availability and round-trip efficiency standards set forth in the agreement. On the other hand, if the system is operated outside its agreed-upon parameters, the developer may have the right to refuse a dispatch instruction or a contractual defense to damages or price adjustments imposed due to deficient performance. Experience with PJM and MISO teach that tariff or rule changes that change the way a storage system operates in the market can adversely affect the system's performance and may also limit warranty claims under the storage system's procurement contracts.

Use Cases

The operating parameters set out in the long-term agreement should also consider the offtaker's expected use case(s) for the energy storage system. For example, if the system is being used to store peak solar generation for discharge during the evening hours, the determination of whether the number of full cycles conforms to what is allowed in the operating parameters will be fairly straightforward. If the offtaker plans to use the system to address varied use cases, it may be more challenging to reconcile the system's actual use with the operating parameters. The uses case(s) may also change during the term of the agreement when new rules are adopted or new services are recognized, in which case the parties may want to include a process that allows the offtaker to implement new use cases, either by making appropriate adjustments to operating parameters or translating the new use cases into existing parameters.

Technology Risk

Lurking behind the performance guarantees set out in a long-term energy storage agreement is a concern that the energy storage technology will not perform as expected and/or that operation and maintenance costs will be greater than anticipated. Today, lithium-ion batteries are generally perceived as bankable, although concerns about fire safety remain an issue. Because successful project financings depend on long-term manufacturer warranties backed by creditworthy entities, it is normal today for equipment manufacturers to stand behind their products with warranties that range from three to ten years. Performance ratings and performance guarantees are increasingly being used to mitigate the technology risk posed by the lack of long-term energy storage system performance-related data. Insurance products are being developed to address the risk that the developer or supplier(s) of system components will, at some point during the term, be unable to stand behind their performance guarantees— particularly if a credit risk materializes. See Guide 7, Chapter 2 for additional information.

Safety

Safety risks continue to be a major area of focus. The DOE and Underwriters Laboratories are continuing to work on establishing codes and standards for avoiding project technology failures and the resulting health and property impacts, and financial liabilities. As in the solar industry, the practice of conducting bankability studies to support financing is taking root for storage. Performed by technical consultants with access to extensive databases of prior projects, such bankability studies can provide detailed due diligence on project technology, reliability and durability; manufacturer; supply chain; operations; asset management; software controls; and maintenance going forward. See Guide 8, Chapter 2 for additional information.

Asset Management Risk

Energy storage must be effectively managed and controlled to interface optimally with generation sources and the grid, particularly with respect to operating parameters and associated use cases. Software technology uncertainties and the need to rely on sophisticated asset management services over time create additional risks that must be assessed.

Credit Risk

There is always a risk of default by the borrower, who may be unable to service the debt as contracted or stand behind performance guarantees in the energy storage agreement. Prospective lenders are cautious about entering the storage market, as it is still considered immature, despite the fact that several lenders, over the past few years, have been actively supporting certain developers deploying energy storage systems. Credit risk assessment for energy storage also extends beyond the project’s counterparties to third-parties such as equipment manufacturers, software suppliers, and asset managers—parties that the project may be relying on for warranties, guarantees, and operational effectiveness going forward. Insurance covering project assets and operations, along with insurance supporting performance guarantees, will often be required.

Resources

- K&L Gates, *Energy Storage Handbook, Version 3.0* at 50-59 (November 2018) available at http://www.klgates.com/epubs/Energy-Storage-Handbook-Vol3/

- Sripradha Ilango, "Open Letter to Developers: How to Navigate Solar-Plus-Storage Project Finance," GTM (March 14, 2019) https://www.greentechmedia.com/articles/read/open-letter-to-developers-how-to-navigate-solar-plus-storage-project-finance

- Deanne Barrow, "Southland Charges Up Battery Storage Financings," *Norton Rose Project Finance Blog* (September 27, 2017) available at https://www.projectfinance.law/blog/southland-charges-up-battery-storage-financing

- Les Sherman and Rohit Sachdev, "Key Energy Storage Contract Issues," *Energy Today* (September 5, 2018), https://www.energytoday.net/economics-policy/preparing-for-the-revenues-from-battery-energy-storage/https://www.energytoday.net/economics-policy/preparing-for-the-revenues-from-battery-energy-storage/

Project Development

Chapter Seven: Tax

Chapter Lead: Elizabeth Crouse, K&L Gates

Background

Federal Tax Incentives

For many years, federal tax incentives have played an important role in developing preferred conventional and renewable energy resources. Energy storage resources can also benefit from certain federal tax incentives, including accelerated depreciation. And when storage is developed alongside qualifying renewable energy facilities, resources can benefit from both the Investment Tax Credit (ITC) and Code Section 25D residential credit. Although not clear, it appears that electricity that qualifies for the Production Tax Credit (PTC) should continue to qualify after storage, at least in certain circumstances. In addition, investments in energy storage—even standalone storage—may be structured to qualify for the new federal Opportunity Zones incentive.

Depreciation Deductions

For federal income tax purposes, the basis of tangible property, including energy storage equipment, is recovered over a specified useful life using one of several methods. The favored method is the Modified Accelerated Cost Recovery System (MACRS), which generally provides for accelerated depreciation deductions in the earlier years of a property's useful life. Energy storage equipment incorporated into an ITC-qualified solar facility and placed in service concurrently with that facility can be depreciated over five years using the MACRS method. Otherwise, energy storage equipment is generally depreciated using the MACRS method over seven years.

Renewable energy property that is placed in service before 2023 generally should qualify for immediate expensing, sometimes referred to as "bonus" depreciation. After 2022, bonus depreciation will continue to be available through 2026, but at reduced rates. While bonus depreciation also applies to used property, used property may not account for 20% or more of the value of renewable energy property that is incorporated into a project intended to qualify for the ITC.

Energy Storage Challenges

Qualification of Energy Storage Property for Federal Credits

At the federal level, energy storage technologies do not have an independent credit in the tax code. As such, storage is inherently dependent in its relationship to other technologies, specifically solar PV and wind.

Tax Credits for Renewable Energy Property

Section 48 of the Internal Revenue Code (the "Code") provides a 10% or 30% ITC for an investment in certain renewable energy facilities in the year in when such facilities are placed in service. Solar facilities currently qualify for a 30% ITC, provided that construction of the facility began in 2019 or earlier and certain other requirements are met. Code Section 45 provides for PTCs when electricity produced by certain renewable energy facilities (usually wind) is sold to a third party during the ten years after the facility was "placed in service." The PTC rate is adjusted annually but is currently being phased out for most technologies. (The maximum PTC rate applies to facilities where construction began in 2016 or earlier, and that meet certain other requirements.) Note: for solar projects with a construction start date in 2020 or later, the ITC will soon begin phasing out in a manner similar to the phase out of the PTC rate. All solar projects must be placed in service by the end of 2023 to qualify for an ITC rate greater than 10%.

ITC Qualification

Energy storage property should generally qualify for the ITC when the storage equipment is placed in service at the same time as an ITC-qualified facility (generally, solar), provided that at least 75% of the power stored in the battery comes from qualified resources. The amount of ITC available is prorated to account for the amount of energy stored in the battery that is generated by qualified resources (e.g., solar panels).

Energy storage property also should qualify for the ITC when the storage equipment is placed in service at the same time as a repowered facility, provided that the requirements previously mentioned are met *and* the value of the used equipment incorporated into the facility is worth no more than 20% of the total value of the facility. This provides opportunities to claim the ITC for energy storage devices installed at proven qualified energy facilities. This may be useful in the secondary market for facilities that have been operating longer than the ITC or 1603 grant recapture period (five years following placement in service).

Although energy storage technologies that store electricity produced by a qualified energy facility should independently qualify for the residential solar energy credit under Code Section 25D, it is not clear that they would qualify for the ITC.

Standalone storage does not qualify for the ITC, but other incentives may apply. (See the upcoming section regarding Opportunity Zones.)

Energy Storage and the PTC

The PTC is available only for electricity produced by a "qualified facility," which generally includes all property that is functionally interdependent and is used to produce electricity using a qualified resource (e.g., wind). This property generally includes, for example, equipment used for power conditioning, which may include voltage regulation (which may, in turn, be provided by certain energy storage systems). However, because the PTC is available only for electricity *produced* by a qualified facility, there is some uncertainty about whether the PTC is available for power stored in, and later released from, on-site energy storage equipment that is independent of the power generated from a qualifying facility. In addition, many offtakers will not pay for power lost during storage, which would therefore reduce the amount of PTC available.

Best Practice

Energy Storage in Opportunity Zones

For investors wishing to maximize their capital gains, the incentives linked to Opportunity Zones (OZ) deliver generous tax benefits. And unlike the ITC, OZs are technology agnostic and available for standalone storage. The program is available for investments in qualifying assets located in one of the more than 8,700 geographic areas that are designated as an OZ. For storage-plus facilities, the OZ incentive can also be combined with the ITC and PTC. In addition, *any* U.S. person and certain non-U.S. persons can invest in a qualified opportunity fund ("QOF") and use the OZ incentive. This includes individuals, corporations, partnerships, and trusts. Partners investing capital gains from a partnership have a longer window to invest in a QOF than the partnership would.

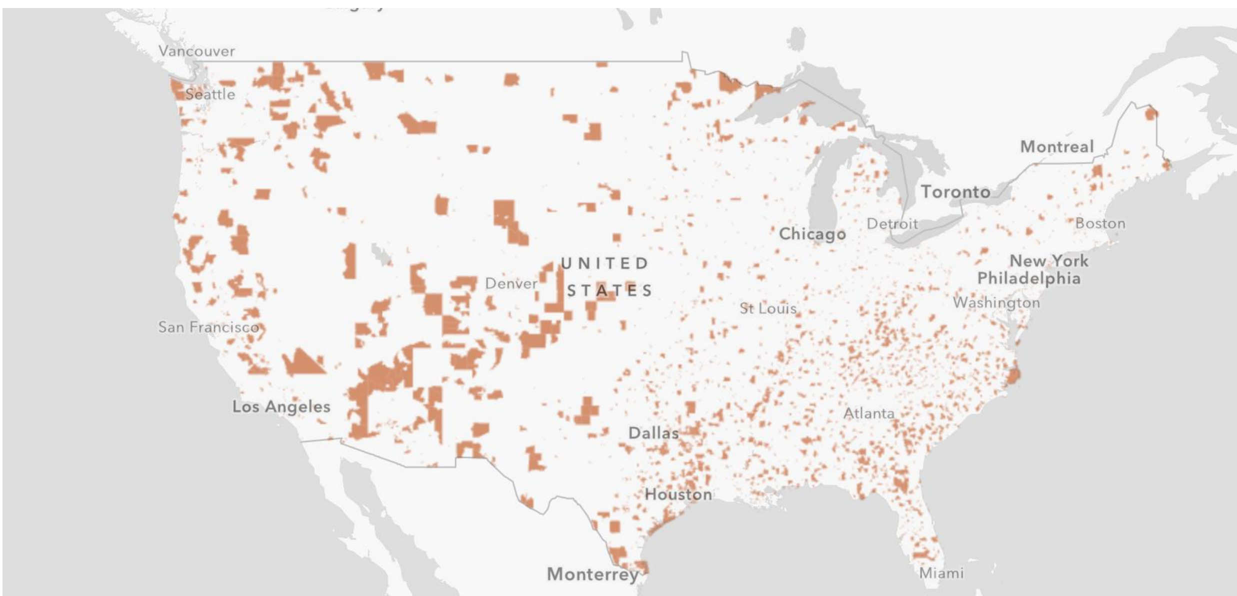


Fig. 1.7.1
Map of US Opportunity Zones (as of May 15, 2019).
Source: ESRI –
"https://esrimedia.maps.arcgis.com/apps/View/index.html?appid=77f3cad12b6c4bffb816332544f04542

The benefits of the OZ incentive are available when a taxpayer disposes of a capital asset and, within 180 days, invests the proceeds in QOF that invests in OZ property, either through a direct investment in tangible business property ("QOZBP") or a newly-issued equity interest in a partnership (including an LLC) or corporation operating a business in an OZ ("QOZB"). For U.S. federal income tax purposes, a QOF can be a corporation or a partnership (including an LLC) and may function as an investment fund, a private investment entity, or many options in between. A variety of requirements apply to QOFs and QOZBs. For example, at least 90 percent of the QOF's assets (measured by cost or value, depending on the applicable facts) must be invested in OZ property, and at least 70% of a QOZB's tangible assets must be located in one or more OZ areas.

The OZ incentive consists of three tax benefits for investors:

- First, federal taxes on capital gains invested in QOFs may be deferred up to the 2026 tax year.
- Second, if the taxpayer holds the QOF investment for at least five years, the gain ultimately recognized may be reduced by 10%. The gain may be further reduced by another 5% if the taxpayer holds the QOF investment for at least seven years.
- Third, if the taxpayer holds the QOF investment for at least 10 years, capital gains realized upon disposition of the investment are free from federal income tax due to a step up in basis of the investment to its fair market value at the time of disposition.

As attractive as the program is, owning storage and storage plus systems through a QOF must be carefully structured in order to both ensure compliance with applicable regulations and maximize tax benefits and the investors' rate of return. In addition, the facts and circumstances applicable to each investor require that QOF structures be somewhat tailored to different investors to account for other U.S. federal income tax limitations.

Resources

- Database of State Incentives for Renewables & Efficiency®
  - A continuously updated database of incentives for renewable energy. Search specifically for "energy storage" - http://www.dsireusa.org/
- Solar Energy Industries Association Storage ITC Factsheet
  - https://www.seia.org/sites/default/files/2019-03/SEIA-Storage-ITC-Factsheet-2019March_2.pdf
- IRS *Opportunity Zones Frequently Asked Questions,*
  - https://www.irs.gov/newsroom/opportunity-zones-frequently-asked-questions
- Economic Innovation Group – A bi-partisan public policy organization based in Washington DC with a state-by-state resource list of Opportunity Zone support.
  - https://eig.org/opportunityzones/resources

ENERGY STORAGE BEST PRACTICE GUIDE 2:

ENGINEERING

Engineering

Chapter One: Overview

Chapter Lead: Mark Manley, Black & Veatch

Background

A project's success hinges on its future cash flows—the return on and return of capital invested in the project. Understanding the viability and risk related to these cash flows is, in a large part, an exercise in understanding the technical aspects of the project. The project must be designed in a deliberate manner, use reliable equipment, and follow appropriate operating and maintenance (O&M) protocols so that it will last its full expected life. Returns come from net income (revenue less expenses), so the project must be able to produce what is contractually expected, while having O&M costs that align with budgets. Production and costs are subject to technical risks including up-time, grid availability, equipment failures, resource constraints, fuel costs, and market prices.

Chapter 2 discusses independent engineering reports. Independent Engineers (IEs) can prepare these reports on behalf of owners (typically new or minority equity investors), lenders, or tax equity providers to help these parties understand the technical aspects of a project, ensure that all contracts connect in terms of schedules and physical requirements, and quantify the spending and market risks within typical industry ranges.

Chapter 3 deals with bankability reports. A bankability report is typically produced by an independent engineer on behalf of the equipment manufacturer to support the manufacture's claims of product quality and reliability. Bankability reports are specific to one technology (a battery model or inverter series, for example); they are more generic when covering the product outside of the context of a specific project installation; and are often prepared prior to project financing reports. Bankability reports provide lenders and other investors with a deeper review of the manufacturing process, manufacturing standards adhered to (e.g. ISO 9001), and specific product certifications that would not typically be reviewed in a project due diligence report.

Chapter 4 discusses the review of interconnection requirements and interconnection agreements. This activity, typically included in the IE Report, comprises a review of:

- The upgrade schedule, and how it aligns with the project construction schedule.
- Upgrade costs, if any, and if these are included properly in the financial model.
- The interconnection design to check for safety and operability.

Chapter 5 examines the typical warranty provisions of Battery Energy Storage OEM equipment and the full wrap EPC contract, if applicable.

Engineering

Chapter Two: Independent Engineering Report

Chapter Lead: Mark Manley, Black & Veatch

Background

In order to place boundaries around the technical aspects of the investment decision, the Independent Engineering (IE) Report has long been a requirement by lenders as part of electric power industry project financing. The independent technical assessment provided by the IE Report is a central part of the lenders' risk management process in their credit approval process for project development. IE Reports cover the design, contracting, engineering, construction, and performance predictions for the facility.

The IE Report covers many of the aspects of the aforementioned bankability study, but typically in a less thorough overview. However, as many of the systems now deployed are based on lithium-ion (a widely accepted and proven technology), the focus and need of the IE Report is more geared toward system design and operating expectations. As the market moves towards a more commercial level, it increasingly needs more IE Report support than bankability study insight.

Project Documentation and Contract Review

A first step in project evaluation is to review the existing project documentation and contracts with regards to the technical aspects and performance requirements for the project. This review is to ensure the technical adequacy and consistency of contracts while conforming to good engineering and construction standards practices. Documents and contracts for review include: EPC contract, OEM equipment supply agreements, O&M and asset management contracts, warranty contract (if separate from EPC or supply agreements), utility interconnection (if applicable), construction (civil and electrical work), Power Purchase Agreement (PPA), and the Energy Storage Agreement (ESA).

Regulatory and Revenue Evaluation

Evaluating both the existing market rules under which a facility will operate, and its expected revenue generation potential, is critical to proper debt service coverage and positive returns for project sponsors. This is done in part to fact-check the assumptions in the previously mentioned contracts. Depending on the market segment in which the facility will operate, there may be a number of different regulatory jurisdictions that will have oversight or impact. This review takes on additional importance because of the changing nature of the market rules for energy storage, and the resulting potential for revenue generation (or loss of opportunity). For energy storage projects, the regulatory and market rule reviews have a similar goal as to the resource assessment typical of wind and solar projects—both give greater confidence in the revenue expectations. Unlike resource assessments, regulatory and market reviews are done by regulatory experts rather than technical groups within IEs.

Safety

Safety is an area of increasing focus across all portions of the energy storage industry: manufacturing, installation, and operation. Key safety concerns often brought up with independent engineers are fire risk and suppression systems. For years, the U.S. Department of Energy's (DOE) Energy Storage Program has made safety a focus in its effort to highlight this critical component of both a successful operation and an underpinning of risk management to lower the cost of equity capital raising and project development finance. Indeed, a key description of the layout of the U.S. DOE's safety program can be found in the *Energy Storage Safety Strategic Plan*, published in December 2014.

Permitting and Local Ordinances

Permitting and local ordinances are designed to promote the safe installation and operation of deployed equipment. The National Electrical Code (NEC), also known as NFPA 70, is a regionally adoptable standard for the safe installation of electrical wiring and equipment in the United States.[1] In 2017, the NEC added Article 706, which covers energy storage assets, to its annual edition. Complying with these local regulations is a component of the overall safety program of any energy storage project. The IE Report will focus its review on the project design and compliance with the NEC. The IE Report review might also include environmental, soil, construction and/or building permits.

Plant Design and Performance

A core function of the IE Report is to review system design in regard to key metrics such as energy rating (in kWh), power rating (in kW), charge / discharge rate, and temperature characteristics. The system design will cover all major components of the energy storage system: storage module (i.e., battery), balance of system (i.e., containerization), thermal management, power conversion system, and the energy management system (software and communication). If the IE Report also covers the grid integration component, this information would include the additional electrical interconnection equipment and SCADA system interface, etc. For these components, the IE Report will review their integration and evaluate the track record of the different OEMs. Extending beyond the manufacturing quality of the equipment, the IE Report will also review the equipment's rated performance capability and estimated lifespan (individually, and integrated) against the stated usage profile for the system. This can also include independently verifying expected performance through functional testing.

Performance Testing and Valuation

A key aspect of validating IE Report findings is the ability to review independent tests of the equipment against the expected performance requirements. This validates that the chosen technology was installed properly and is suitable for the target application. The results of the testing process can be used in both the equipment acceptance test prior to commissioning and to validate the operating lifespan and capability assumptions in the financial model. If the engineering firm is not able to undertake the testing themselves, they must cite third-party test results undertaken at another testing lab. On behalf of investors, and prior to financial close and Notice to Proceed (NTP), an independent engineer will review, and possibly recommend, changes to the testing protocols outlined in EPC contracts.

Through the development of tests and metrics, the energy storage industry has been supporting the efforts of firms to evaluate and define the performance of energy storage technologies in different market applications. Much of this effort has been included in the joint PNNL / SNL report *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems* (PNNL-22010)—often referred to as the "*Protocols Report*." As the industry continues to advance its understanding of the operation of these assets, this report will be updated (currently on revision 2, released April 2016), and provide the "foundational basis for developing an initial standard for the uniform measurement and expression of energy storage system (ESS) performance."[2] New standards are also being promulgated by the International Electrotechnical Commission (IEC), National Electrical Manufacturers Association (NEMA), American Society of Mechanical Engineers (ASME), and other institutions interested in ESS performance.

Construction and Commissioning

The IE Report will review the construction and commissioning plans to gauge if they adhere to industry practices and reasonable costs, and that the scheduled completion milestones seem achievable. As the project progresses, the engineering firm can also perform construction monitoring and audit the work in progress—including civil and electrical construction work. Site conditions can be a critical issue with regard to cost and schedule over-runs, so a proper geotechnical survey remains critical.

The all-important commissioning and start-up plan serves to ensure that the unit operates as planned. A review of this important plan, along with performance testing and acceptance criteria, will be compared to independent testing performed by the third-party testing facility. Typically, the IE Report will include a review of the project completion date. Indeed, the EPC firm has an incentive to be accurate in estimating the Commercial Operation Date (COD) date. The IE firm may also review EPC certificates to confirm that the facility will be in compliance with local codes and ordinances. As evidence of the maturation of the industry, these issues have recently been compiled and integrated into the new Article 706 of the 2017 edition of the National Electrical Code that covers energy storage systems. Additionally, the forthcoming NFPA 855 Standard for the Installation of Stationary Energy Storage Systems 2020 edition covers commissioning reports.

Warranty

Equipment warranties are a critical component of project financing risk management, and thus their review with consideration of the usage requirements is one of the key aspects of the IE Report. As the level of technology is still evolving rapidly, and the usage opportunities expand, OEMs are challenged to provide clearer guidelines for what performance results can and cannot be expected from the product. Critically then, this review must contain an analysis of the stated warranties for components that make up the storage asset and confirm that the expected usage profile can safely be performed by the proposed project.

Operation and Maintenance

Review of the operation and maintenance plan will allow the IE Report to ascertain if sufficient monitoring, field maintenance, and preventive maintenance effects are included. The levels of this maintenance will bear directly on the adequacy of the preventive maintenance and scheduled equipment replacement program needed to support the unit—lasting through the term of the contract. A well thought out and executed O&M program reduces total project costs. This will include estimation of the cost of routine and unscheduled maintenance and on-site inspection and replacement parts.

Project Economic Model Assumptions

The value of a project economic model to provide a useful financial projection for the project is based heavily on the market data and technology cost assumptions that are used. The IE Report does not typically review the project economic model itself, but it does review many of the fixed and variable technology-related costs that drive the project economic model. The report also reviews such technical assumptions as project size and output. By clearly presenting the results of the different cost related items that are used, lenders and project developers can see the soundness of the project's parameters, and their impact on the project's financeability. If the engineering company is able to compare the cost segments (i.e., equipment, O&M, etc.) to typical ranges, then the lenders and project developers will be able to have more confidence in the relative competitive position this particular energy storage project will have versus other energy storage projects and alternatives in the market in general.

Table 2.2.1
Example of IE Report Contents.
Source: Black and Veatch.

(Note: This sample is not comprehensive, nor are all elements shown always included.

Project/Portfolio Overview	
Deal Structure and Summary	
Key Participants	Developer Experience and Qualifications EPC and Equipment Supplier Qualifications
Design and Construction	Design and Equipment Review Construction and Equipment Supply Contracts Construction Status and Costs Liquidated Damages Analysis
Operating Agreement Review	PPA / Energy Storage Agreement O&M Agreement Asset Management/Management Services Agreement Other Operating Agreements
Performance Estimate / Assessment	
Useful Life and Residual Value Assessment	
Financial Model Review	
Market Assumptions and Review	Demand Response, Grid Services, Energy Prices

Energy Storage Challenges

For utility-scale wind or solar projects, IEs do not typically look at local code (e.g. fire codes) in their permitting reviews as these codes mostly do not apply to industrial projects. But lithium-based energy storage projects may require a high-level review of fire codes and suppression equipment since the perception of risk and potential impacts around fire is greater.

With power potentially flowing in both directions for energy storage projects, closer attention to interconnection agreements and requirements for delivery and pricing of power from the grid, if contemplated in the design, will be required.

Unlike other energy infrastructure projects which typically deliver power when they can (due to resource availability or based on market signals), energy storage cycling is typically governed by a software algorithm that considers external and internal factors. Cycling frequency, depth, and duration can impact both project economics, maintenance schedules, and expected life, so investors may also want a software design review in order to have a comfort level re: these long-term effects. Depending on the depth of this type of review, a bankability report on the battery control systems may be better suited to satisfy investor confidence.

IRS rules on ITC eligibility in solar-plus-storage projects may also dictate a software review in order to give investors' confidence that the design will comply with charging source limitations. All in all, an energy storage system's operational and economic characteristics are more complex than similarly sized renewable energy projects.

Best Practice

A critical decision for a project developer is the hiring of an independent engineering firm that understands the technology and, preferably, has the actual design and construction experience in the field that can be leveraged during the review. The project developer should engage the IEs early enough in the process so that they are not rushing to complete their work. Typically, IEs can be contacted once property rights, PPAs, and Generator Interconnection Agreements (GIAs) are secured, and EPC agreements are near or past final draft stages. If a production estimate is required, ensure that all parties (e.g. sponsor and lenders) agree that the system design (e.g. 30%, 60% or 90% drawings) used is advanced enough to satisfy each user's needs. It may be prudent to budget for an initial estimate, with another estimate update later in the process.

The project developer should ensure that there are no conflicts between IE and the team designing and constructing the project. If so, the developer should work to resolve them during the early stages of the project. For example, if the transaction involves other investors (e.g. tax equity versus debt), or a seller has issued a sell side IE Report, then those IEs may be in conflict. Reconciling conflicts between the different sides of the transaction will fall to the project developer.

The project developer should establish clear modes of communication during the review process, including key points-of-contact, regular status meetings, and well documented data requests. A structured request for information (RFI) logs and electronic data rooms is highly beneficial for this purpose.

Site visits are recommended both for pre-construction and, in particular, operating projects, as this gives the investor and IE a chance to meet development or operating personnel, drill down with questions on any issues, and see the site terrain, access points, potential for drainage or civil issues, proximity to transmission, etc.

If the project includes a construction monitoring phase, additional site visits during construction are beneficial to track progress, meet construction managers and owner representatives, and learn about any challenges, delays, procurement, equipment, and environmental or safety issues that may have occurred. Finally, construction financing drawing reviews by IEs help lenders check that costs were spent on appropriate project labor and equipment. In addition, these reviews help monitor progress as well as tracking to budgets.

Resources

- Institute of Electrical and Electronics Engineers, *IEEE Std 1547.*1a™-*2015 (Amendment to IEEE Std 1547.1-2005) Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems; Amendment 1*- (2015). Available at: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7100815.https://standards.ieee.org/standard/1547 1a-15.html. (Content available for purchase – free for subscribers.)

- Working Group Meeting, Institute of Electrical and Electronics Engineers, *IEEE P1547.1 Draft Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces*, (Oct. 27, 2016). Available at: http://grouper.ieee.org/groups/scc21/1547.1_revision/mtgMinutes/P1547%201-20161027_intro_and_concluding_slides.pdf. (Content available for purchase – not otherwise available online.)

- Electric Power Research Institute, *ESIC Energy Storage Test Manual 2016*, 3002009313 (2016). Available at: https://www.epri.com/#/pages/product/3002009313/?lang=en-US.

- David R. Conover ET AL., *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems*-(PNNL-22010_Rev._2/SAND2016-3078 R) (Pacific Northwest National Laboratory and Sandia National Laboratories Apr. 2016). Available at: https://energystorage.pnnl.gov/pdf/PNNL-22010Rev2.pdf

- NFPA National Fire Protection Association, NFPA 70 National Electric Code (2017). Available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-of-codes-and-standards/detail?code=70

- National Fire Protection Association, *NFPA 855 Standard for the Installation of Stationary Energy Storage Systems (Proposed 2020).* Available at*:* https://www.nfpa.org/codes-and-standards/all-codes-and standards/list-of-codes-and-standards/detail?code=855 (Content available for purchase – free for subscribers.)

References

[1] http://dbpedia.org/page/National_Electrical_Code
[2] *Id*.

Engineering

Chapter Three: Bankability Study

Chapter Lead: Mark Manley, Black & Veatch

Background

Proving a storage technology is bankable has been a significant hurdle for many companies with emerging energy storage development technology. In this chapter, a bankability study will refer to the evaluation of the technology and the company developing the technology, while the Independent Engineering (IE) Report will focus on aspects of the project's viability—which may include aspects of the bankability of the technology and/or the company providing the technology. For certain products that are widely available and assumed to be sufficiently mature (e.g., certain lithium-ion batteries), the issue of bankability may be addressed by the product warranty. However, energy storage technologies evolve rapidly. New products continue to appear in the marketplace, and the issue of technology risk is ever present.

In the Sandia National Laboratories Report, Richard Baxter points out that:

> Time and again, investors stress the need for bankability studies to support the financeability of an energy storage project that utilizes an emerging technology. Bankability studies have been widely used in the solar PV industry, and provide a third-party technology risk assessment to gauge if the equipment will perform as predicted by the manufacturer over the project's life. However, a bankability study is more than just an engineering equipment report; it's a process to understand the potential risks from utilizing a technology from an emerging technology provider.

Undertaken to provide assurance that a project's cash flow will be secure, a bankability study assesses the technology design, performance, reliability, installation, operations, and maintenance. The study also assesses the manufacturers' ability to consistently deliver products that meet the manufacturers' own technical specifications. Such an analysis includes the evaluation of the product's full supply chain. Bankability studies can be designed to provide a full due diligence review on the Original Equipment Manufacturer (OEM), including the OEM's position as a going concern, its technology, manufacturing process and capability, supply chain, and potential competitors.

In order to ascertain default risks, Richard Baxter provides firm guidance:

> The bankability study will also contain an evaluation of the technology vendor. Many study participants believe that through these deeper dives into the supply chain, the bankability study can provide a clearer insight into other projects undertaken by the manufacturer. For example, has the manufacturer developed a robust enough set of internal controls to ensure that they will be able to consistently develop high quality energy storage systems? This last part is crucial for when unexpected problems arise—and they always arise—especially in emerging markets like energy storage. Lenders

want to know that there is capability to fix the problem, and that there are solid companies standing behind the product or workmanship.

Bankability studies are important for both lenders and manufacturers. For the lenders and other financial firms interested in participating in energy storage projects, rapid advancements in the technology have left little common knowledge about energy storage technologies. Bankability studies can also provide a deeper understanding of the capabilities of the technology and its value chain for the lending community. As the industry expands, the challenge for lenders grows as the number of global manufacturers—each with its own unique supply chain—grows. For manufacturers, engineering firms providing bankability studies act as an impartial technical evaluator that has had experience with other OEM firms in the market.

The bankability study can also help the engineering firm incorporate industry best-practices by identifying gaps in the manufacturer's product design, reliability, manufacturing and installation and maintenance. Other groups can also benefit from bankability studies—particularly Engineering, Procurement, and Construction (EPC) firms that are increasingly being called upon to provide some level of warranty wrap.

Bankability studies can have all, or only part, of the components discussed here to provide technical understanding for a lender. A prerequisite for an engineering firm to undertake a bankability study is to have deep domain knowledge about the energy storage technology in question.

Original Equipment Manufacturer (OEM) Corporate Review

Bankability studies cover many of the same aspects of a due diligence review undertaken for a capital raise on the firm. This is done in order to ascertain good corporate performance to support the emerging technology offering. These studies will cover a wide range of issues for the firm (the degree to which these are covered will vary as needed), including:

- **Corporate and financial documents**: These include the firm's articles of incorporation, bylaws, Board of Directors legal agreements, financial statements, auditor's reports, income tax returns, listing of subsidiaries and partnerships, current or pending litigation, and professional services currently or recently retained.

- **Corporate assets:** These include a list of all significant physical assets, major process equipment, real estate holdings, and intellectual property—including a general description of trade secrets and process knowledge.

- **Products and services:** These include a list of all products or services existing now or in development, major customers over the last three years, a description of the markets where the firm is active, and major competitors in each of these markets.

- **Operations:** These include a list of employee contracts and benefits, government licenses, environmental audits, and all insurance coverage.

Technology Evaluation

Undertaking a technical evaluation of a project's energy storage technology for a project is the core of a bankability study and the first stage in estimating the financeability of the technology's development company. This is of more concern for companies developing emerging energy storage technologies than for those manufacturing widely available products.

Referring once again to the Sandia National Laboratories report:

> A standard measure of technology development is the Technology Readiness Level (TRL). Used to track the early stage development for various technologies, the TRL scale has been deployed extensively in the energy storage market for various government funding programs. The TRL scale was developed by NASA in the 1980s and ranges from 1 (basic principles observed) through 9 (total system used successfully in project operations). The TRL scale is important as the rating implies adherence to a set of standardized technological progress milestones, thereby giving users confidence that there will be continual progress toward a working product.
>
> Over time, this scale was adopted by other U.S. federal government agencies as it proved superior both in identifying actual technology maturity and preventing premature deployment by the federal government.

Figure 2.3.1 shows the TRL scale for various energy storage technologies.

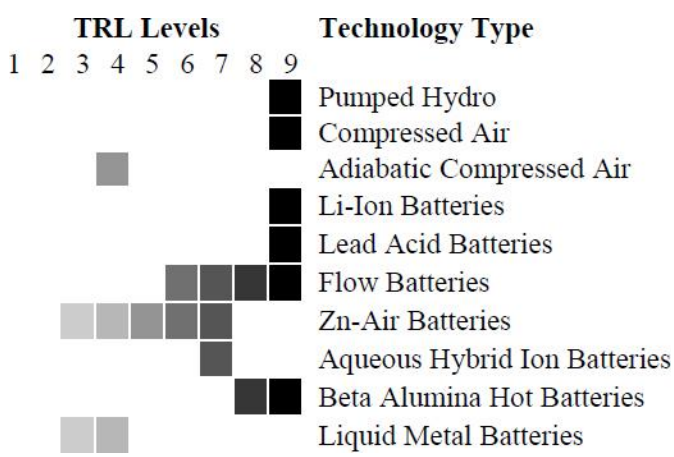


Fig. 2.3.1
Technology Readiness of Energy Storage Technologies.
Source: National Academic Press.

According to Mr. Baxter in the Sandia National Laboratories report:

> To provide a common framework to define the spectrum of maturity for technologies as they enter commercial readiness, the U.S. Department of Energy's ARPA-E (Advanced Research Projects Agency—Energy) has followed suit with a commercial readiness level (CRL) that provides a means for all parties to discuss the commercial

development of a technology. Like the TRL, the CRL is important as the rating implies adherence to a set of standardized commercial milestones, reassuring users that there will be continual progress toward a commercially ready solution.

As the TRL and CRL scales describe two different attributes of the system, they are not directly comparable, and typically overlap. As with the TRL, the CRL scale range goes from 1 to 9.

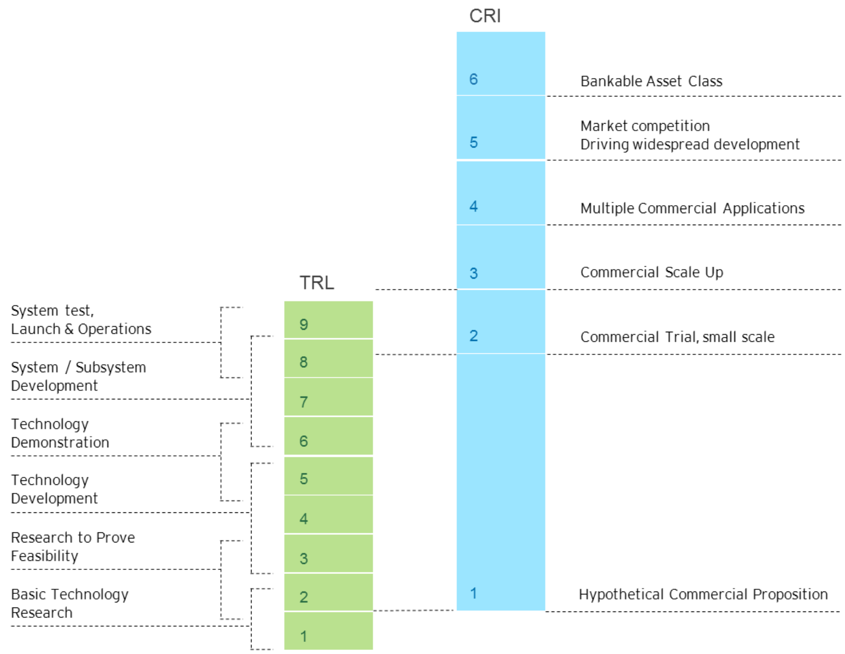


Fig. 2.3.2
Technology and Commercial Readiness Levels.
Source: Australian Renewable Energy Agency (ARENA).

Manufacturing Process

Once the technology is commercialized, a bankability study will also provide a deeper dive into the manufacturing process of the OEM (or its contract manufacturer), as well as visibility into the firm's production life cycle—including design work in progress.

The Sandia National Laboratories report lays out major elements of the manufacturing process abilities that the bankability study will focus on:

- Scale manufacturing to meet demand. Most production processes are limited by gating steps in the production process, with cost-effective production scale-up coming in discrete step changes. This is also linked to the ability to support manufacturing expansion with a sufficient number of trained manufacturing workers, especially highly skilled ones.

- Refine the manufacturing process to improve yield. With experience, manufacturing production can reduce waste and inefficiencies, thereby improving gross margins for the manufacturer. This is typically an iterative step that includes redesign of the product for better operation, while also improving the ability to manufacture it.

- Design the product and components to support the development of a full product line family. Manufacturers many times utilize a modular component design approach in order to support the multiple platforms that serve different markets while minimizing the number of components needed to be developed. For interoperability, manufacturers look to product standards so that they can continue to focus on the overall design of the system. This offers them the opportunity to purchase sub-components from outside vendors while still ensuring that these new components will fit and operate properly with the rest of the system.

- As the technology emerges from R&D labs during commercial production, manufacturing of emerging technologies such as energy storage typically suffers from a gap in innovation and funding as OEMs transition from low volume to higher volume production. This gap is not just in raw manufacturing capacity, but also in a design capability to scale production while maintaining high quality and stable margins. Often overlooked, the ability to achieve manufacturing at scale, with a high yield and in a cost-effective manner in order to allay the concerns of investors, partners, and customers, is an important focus of the bankability study.

The Sandia National Laboratories report goes on to note that:

> The growing level of interest and activity by contract manufacturers in the energy storage industry is another key signpost of the market's maturity. A number of partnerships between contract manufacturers and energy storage technology developers have been announced, bringing more interest by other groups. The establishment of product standards over the next few years will help to define the role of this group of firms, many of whom are already key to energy storage technology companies' business plans.[6]

As OEMs expand their operations to support very large capacity, customers will insist their suppliers adhere to industry standard guidelines. These include the ISO 9000 family of management system standards that are set up to provide a framework of quality management systems. (ISO 9001 deals with the requirements that firms wishing to meet the standard must fulfill). Third-party certification bodies provide independent confirmation that organizations meet the applicable requirements.

Supply Chain

Building off the evaluation of the manufacturing process, a deeper dive into the OEM's supply chain can show exposure to production risk. Here, the bankability study reviews how the OEM manages its supply chain, including any raw materials and components from suppliers in inventory.

For suppliers in general, the bankability study strives to determine the risk management strategy employed by the OEM to highlight potential disruptions in manufacturing. Reviewing supplier arrangements allows the study to determine issues such as the geographical distribution of suppliers, the level of sole sourcing for components (and what alternatives exist), the process of validating new suppliers, and the process of monitoring existing suppliers. The bankability study can also look for any past supply disruptions, as well as the current general health of the OEM's supplier network.

Competition

Finally, a bankability study will evaluate the competing vendors of a particular technology in order to provide some baseline capability index. Competitor intelligence is typically part of a due diligence process, but the process can also be undertaken as a separate endeavor to obtain information including sales numbers and details, marketing strategy, partnerships, and vendors.

- **Press analysis:** Significant amounts of information on competitors can be found in the public domain, including press releases, public presentations, financial statements (if public), etc. Increasingly, competitor websites hold invaluable information about their products, services, and market strategies.

- **Competitors:** Interaction with the target company's competitors is a key avenue for market intelligence. Especially in emerging industries such as energy storage, there are common areas where competitors will share information about the market in order to advance the industry. Trade groups such as the Energy Storage Association and the NAATBatt are also helpful.

- **Customer interviews:** Reaching out to existing and potential customers is a reliable, valuable, and often overlooked approach to determine competitor offering and market positioning. Issues with a manufacturer's product reliability and customer service quality can also be gauged more readily through customer interviews. Typically, in the hope of securing a superior product at a cheaper price, customers are far more willing to share insights with other vendors who compete with their own supplier.

- **Industry interviews:** Beyond customers, peers in the industry can provide significant insights and data on competitors. These other sources include suppliers, distributors, and industry experts who can provide insight into the supply chain for manufacturers of a certain technology.

Energy Storage Challenges

Energy storage technologies range from batteries using several different chemistries to kinetic devices such as flywheels or systems that use potential energy—either electric in the form of capacitors, or gravitational in the form of pumped storage. Therefore, providing bankability studies on these technologies, and understanding the competitive landscape, requires deep industry experience.

Bankability studies are intended to give investors comfort around a specific technology, including an overview of what independent product testing has been performed, standards met, and manufacturing quality assurance certifications achieved. They can also show, at a high level, the financial position of a company and an assessment of current market position. The studies are not, however, intended to provide a forecast of future prospects, industry trends, or in-depth competitive analysis.

Bankability studies are typically sponsored by the equipment manufacturers themselves since much of the data reviewed is not public and is only available from their internal quality assurance and quality control (QA/QC) processes or the certification and testing they have commissioned. Because of this, the reports are then only available from the manufacturer—and only if they should choose to distribute them.

Given the in-depth nature of the study, investors need to review extensive documentation as well as make one or several manufacturing or testing facility tours (which are often in foreign locations). In addition, they should review several cycles of report reviews, clarifications, and additional data. Bankability studies typically take a couple of months to complete. For project financing, this timeline is 1.5x to 3x longer than the quicker process of an independent engineering review.

Best Practice

Bankability studies consist of independent assessments of new products, processes or technologies which assess a technology's design, performance capability, reliability, installation, operation, and maintenance. The bankability study also assesses both the manufacturer's ability to deliver the technology. and the manufacturer's health as a company.

Key items covered in a bankability study are illustrated in the following table.

Table 2.3.1
Bankability study components.
Source: Black & Veatch.

Key Items – Bankability Study	
Design	**Manufacturing Quality**
〈 Design specifications	〈 In process quality control
〈 Major components and materials	〈 Manufacturing technology
〈 Performance and safety specifications	〈 Quality control of components and materials
	〈 Quality Assurance program
	〈 Supply chain
Performance and Reliability	**Company**
〈 Certification testing results	〈 Competition
〈 Comparison to industry benchmarks	〈 Financial standing
〈 Field performance data	〈 Management
〈 Performance track record	〈 Manufacturing capacity
〈 Performance advantage relative to competitors	〈 Warranty
〈 Reliability testing and simulation data	

When reviewing or requesting bankability studies, use an engineering firm that has deep experience with the technology and is familiar with global manufacturing testing and certification processes (e.g. ASTM, ISO, UL, CSA, TüV, etc.).

If a new bankability review is required, in order to arrange for the separate bankability review, be sure to work with the manufacturer in question several months in advance of the main IE Report. Also ensure there are no conflicts between bankability, IE and the team designing and constructing the project.

Understand that the bankability process, in order to allow deeper access to product data and facilities, is best done when sponsored directly by the manufacturer. While this might limit direction or access to data by a potential project finance investor, the manufacturer, however, is still incentivized to release the study to secure the project. All this being said, the final report will be a work product for the manufacturer, and remains theirs to release, or not release, to potential investors.

Resources

- Black & Veatch, *Energy Storage*, https://www.bv.com/markets/energy-storage
- Black & Veatch, *Renewable Energy Test Center Launch New Energy Storage Bankability Service*, BLACK & VEATCH: NEWS & EVENTS (Sept. 12, 2017) https://www.bv.com/markets/energy-storage-bankability-service
- National Renewable Energy Laboratory

- Presentation, Sarah Kurtz, Approaches to Demonstrating Bankability and Differentiating Product Quality (July 9, 2014), https://www.nrel.gov/docs/fy14osti/62406.pdf.
- Solar Bankability http://www.solarbankability.org/home.html

References

[1] Richard Baxter, Energy Storage Financing: A Roadmap for Accelerating Market Growth (prepared by Sandia National Laboratories 2016), https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2016/168109.pdf.
[2] *Id.*
[3] *Id.*
[4] *Id.*
[5] *Id.*
[6] *Id.*
[7] Pearlnet, *The Joint Commission Compliance Platform*, https://www.pearlnet.com/jccp.php.

Engineering

Chapter Four: Interconnection Study

Chapter Lead: Dan Sowder, Sound Grid Partners

Background

Process Definition and Overview

All grid-connected distributed generation projects—such as energy storage—are reliant on a connection with the local electric grid in order to operate and deliver services. Once connected, the distributed generator becomes part of the electric grid and impacts the technical functionality of the grid into the future. The complex functionality of the grid, including ensuring personnel safety, equipment protection, voltage management, and efficient energy delivery, must all be reconsidered when a new component is added to the system.

The interconnection study process is designed to fulfill two important purposes: (a) provide a safe, reliable grid operation by ensuring that distributed generation facilities are properly designed and connected to the electric grid; and (b) identify and fairly allocate costs for those grid upgrades associated with the interconnection.

This process is fundamentally a technical evaluation and is anchored on several different types of engineering studies (to be described shortly). However, the process also plays an important role in managing the economic implications of connecting a distributed generator to the grid. This includes identifying, quantifying, and allocating the grid equipment upgrades required to accommodate the connection of a new component to the grid. As such, the interconnection process is tightly linked to the utility regulatory process, which oversees the fair allocation of costs and grid access.

The interconnection process includes two primary parties: the distributed generator owner/developer and the entity (utility or RTO/ISO) that operates the grid to which the distributed generator is being connected. The process may include additional entities in cases where the generation connection point impacts multiple grid entities.

The participants and the nature of the technical studies are primarily determined by the distributed generation resource's size and the type of grid connection desired by the distributed generator. The first determinant is whether the distributed generator seeks to connect to the transmission system, a distribution circuit (generally 33 kV and lower voltages), or at a behind-the-meter (BTM) location. The study is also driven by the owner of the interconnection grid. In general, an ISO-controlled portion of the transmission grid requires an ISO interconnection process. Other portions of the grid, including all distribution system connections, require an interconnection process driven by state policies and administered by the local distribution utility.

The output capacity (kW or MW) of the distributed generator is also an important determinant in what type of analysis is needed. Most utilities have separate processes, including "fast-track" processes, for smaller generators since their technical impact on the grid is less than a larger generator.

Interconnection studies also vary greatly between the numerous utility jurisdictions in the United States. At the bulk power level, each RTO/ISO has a somewhat different interconnection process that reflects the unique characteristics of their grid region. Differing state laws and policies can make the interconnection rules different, even within a single regulated utility that operates in multiple states. This inconsistency is a challenge for energy storage developers who seek to implement storage in multiple jurisdictions.

The use of traditional interconnection studies and processes for energy storage has been challenging, primarily due to the unique and widely variable characteristics of energy storage installations. Energy storage is highly controllable, bi-directional (acts as a load and a generator from the grid perspective), includes inverter-based technology, and can rapidly change its output (e.g. ramp rate). While these technical capabilities are what makes energy storage such a valuable resource on the grid, they also make it difficult to apply traditional interconnection analyses and processes, many of which were developed using a simpler definition of a generator.

Overview of General Interconnection Study Process

Interconnection processes and studies vary based on FERC or state jurisdiction and the unique characteristics of different areas of the grid. In general, the process has three phases: establishing initial feasibility, conducting detailed system impact studies, and determining required grid upgrades—all followed by arriving at an agreed-upon Generator Interconnection Agreement and approvals for construction and operation.

Figure 2.4.1 is an example of the high-level interconnection study process from ERCOT.

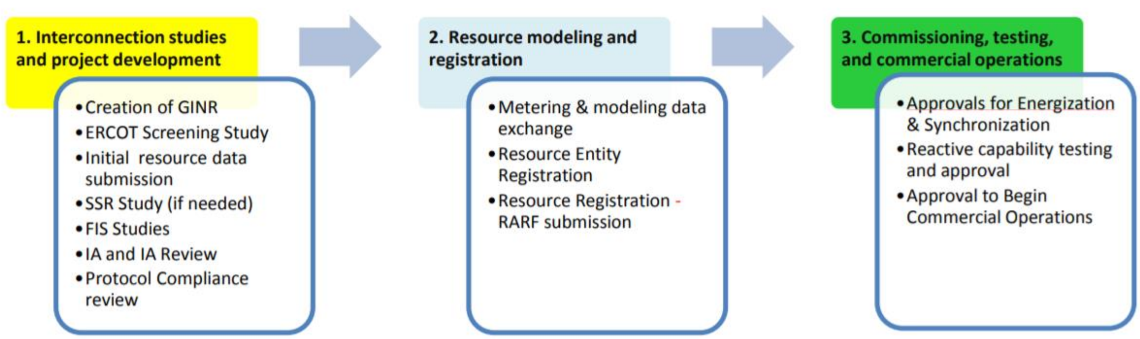


Fig. 2.4.1
ERCOT high-level interconnection study process.
Source:
http://www.ercot.com/services/rq/re/reg/GUIDE_TO_THE_INTERCONNECTION_PROCESS_v1_0.pdf

Three Common Interconnection Phases/Studies

Feasibility Study

In this phase, a new generator interconnection application is submitted to the grid operator. This includes project design information and technical information about the equipment to be installed. It also includes the preferred and potential connection points. The feasibility study phase focuses on gathering the necessary data and filtering for completeness prior to initiating detailed and costly technical studies in the subsequent phase.

System Impact Study

This is a technical study conducted by the grid operator to model and assess how the new generation facility will impact grid technical stability and power quality. Common technical studies include:

- Thermal studies: Analysis of how the flow of current on the grid will be impacted by the new generator's operation, and if these current flows result in reaching any thermal limits (caused by higher current flow) of grid conductors and other equipment.
- Voltage studies: A model of the grid's current voltage management capability and how it will be impacted by the new generator's operation. This includes the impact of new current flows on voltage and a determination if existing voltage management equipment can respond adequately to fluctuations in generator output.
- Short-circuit impacts: A study of how the new generator will affect the grid's short-circuit current (or fault current) that impacts the ability of grid system protection equipment to isolate a grid fault for equipment protection and reliability.
- Stability studies: An analysis of how the new generator will impact the grid's ability to manage grid frequency, switching operations, and power quality.

Interconnection Facilities Study

Includes a determination of whether any new facilities or grid upgrades are needed as a result of the generator interconnection. This phase typically includes an estimate of the cost of the new facilities, which are typically allocated to the generation developer. Examples of new facility requirements include upgraded conductors, the construction of new lines to reach a distributed generator, upgraded or new transformers, new voltage control equipment, and additional system protection equipment such as relays.

Energy Storage Challenges

Because most interconnection study processes were developed before distributed energy storage was commonly connected to the grid, grid operators and energy storage developers have faced numerous challenges in efficiently applying established interconnection study processes to energy storage. Fortunately, there have been many advancements in recent years to reform the interconnect process to appropriately evaluate and advance energy storage deployments.

The following sections describe some of the primary challenges faced by energy storage in the interconnection process and how these challenges are being addressed in some jurisdictions.

Dispatch Strategy

Existing interconnection processes were generally developed to evaluate generators that would be exporting power to the grid most of the time at or near their maximum (or nameplate) output capacity. Energy storage operates differently and can be controlled (or dispatched) to provide multiple services involving charging and discharging at varying power levels, according to the service being provided. Storage can also be programmed to not exceed certain dynamic constraints; for example, by not charging during times of high load when adding charging load (which can stress the grid). In other cases, a storage device may operate in a standby mode for the majority of the time while waiting for an outage event to occur, thereby rarely operating at maximum capacity.

Interconnection studies often assume that the generator being evaluated will be operating at its maximum capacity. For some studies this is appropriate and unavoidable since the worst-case scenario must be modeling to ensure grid reliability. However, some studies can be avoided or simplified based on knowing that an energy storage system will not always be operating at maximum capacity.

Flexibility

Many technical interconnection studies rely on assumptions about how an energy storage system will be operated, included parameters such as ramp rate (the rate at which power output can change), power factor (a ratio of active and reactive power), and the timing of charge and discharge operations.

Because energy storage can provide many kinds of services, these assumptions can be hard to determine and maintain across many years of system operation. An energy storage system may initially participate in an RTO/ISO energy market where it generally charges during times of low load discharges. After a few years, this system could be deployed in a frequency regulation ancillary service market where the system would now be rapidly changing between charge and discharge, frequently within a single hour.

This flexibility is an energy storage advantage; however, it makes it difficult to know how to study an energy storage system during an interconnection study process.

Ownership and Control

As with many different types of distributed generation, energy storage may be owned, dispatched, and connected to the grid by different entities. For example, a single energy storage system could be owned by a merchant generation fleet owner, connected to the local utility’s distribution grid, and dispatched via the local RTO/ISO ancillary service operations. Each entity is impacted by the energy storage system's operation in a different way; similarly, each entity has different interests in, when, and how the energy storage system can or should be dispatched. This multi-party coordination can result in a complex interaction in which multiple studies and constraints are applied to a single energy storage system.

Export and Peak Load Limitations

Energy storage can be sited and operated in a wide variety of configurations to support a myriad of applications. Some applications have little or no impact on the electric grid beyond the immediate vicinity of the energy storage device.

For example, an energy storage system that is co-located with load and solar in a behind-the-meter configuration could be programmed to only charge from co-located generation, thereby never increasing the facility's apparent load to the utility grid. With this control limitation in place, the electric grid would never see the combined load of the facility's native load plus charging from the energy storage system. In other words, the maximum load flow impact to the grid due to the energy storage system would not exceed maximum load flow caused by the original facility. Therefore, as long as the customer and utility can ensure that this dispatch protocol will not change, a load flow study at the worst-case load plus storage output (and the potentially expensive grid upgrades) is not needed.

Grid-Supportive Applications

Many traditional grid technical functions operate best when there are not rapid changes in load on the grid. An example of such a function is the distribution grid's ability to maintain voltage within an acceptable range. For this reason, traditional distributed generation interconnection agreements require a gradual change in generator output or other operating restrictions to minimize rapid changes on the grid.

Energy storage, due to its ability to rapidly adjust its output, is capable of providing grid management services that benefit from rapid changes in generator output. For example, a frequency regulation application, for which energy storage is often well suited, requires rapid fluctuations in charging and discharging in order to manage grid frequency. Many distributed energy storage projects are well-suited to provide such a service. However, in the interest of limiting rapid transients, the ability for an energy storage system to provide such services can be limited by the interconnection utility.

Another example of this pertains to reactive power voltage management. Traditionally, distributed generators were required to operate at a constant power factor (or ratio of active to reactive power output). Energy storage has the ability to rapidly vary its reactive power output in response to changing voltage conditions on the grid in order to support voltage management. Overly restrictive interconnection rules can constrain the ability of an energy storage system to provide such a service.

Sizing

Similar to distributed solar generation, energy storage can be deployed at a wide variety of scales, from single digit kWs to hundreds of MWs. The grid impacts of energy storage systems across this power capacity range varies greatly. Especially in the early days of energy storage, the interconnection study process often did not reflect this variance, sometimes resulting in small energy storage systems being subjected to the same interconnection studies as those large systems with a large grid impact.

Best Practice

Fortunately, the previously mentioned opportunities and challenges that occur with energy storage and the interconnection process have been recognized over the last few years by grid operators. In many jurisdictions there has been significant reform to the interconnection process to remove barriers to the deployment of energy storage in grid-supportive applications.

As described earlier in this chapter, FERC Order 841 has driven further incorporation of energy storage into RTO/ISO market functions, including asset classification and interconnection processes. It required all RTOs/ISOs to establish a participation model for energy storage so that they are eligible to provide all energy, capacity, and ancillary services they are capable of.[1] ISOs submitted required compliance plans in December 2018. FERC's review of these plans is in progress and implementation is expected by December 2019. These reforms are expected to improve the ability of energy storage to efficiently participate in RTO/ISO market functions, including the interconnection process.

The following sections summarize some of the most important reforms and policies that have been enacted to address past issues with energy storage and the interconnection process.

Fast Tracking for Smaller Systems

The interconnection studies process varies across the range of energy storage system capacities. Intuitively, as the energy storage system size increases, the level of grid impact, and therefore the robustness of system impact studies, increases. Most utilities have a threshold below which a fast-tracked interconnection process is required for energy storage. For example, New York has implemented Standardized Interconnection Requirements (SIR) for energy storage projects less than 5 MW, with special provisions for system that are less than 50 kW. Simplified or standardized interconnection studies for systems around this size are commonly and increasingly being implemented.

Process for Controls/Configuration Options

The proposed use of an energy storage facility materially impacts how it will affect the grid being incorporated into the interconnection study process. Some jurisdictions have implemented an interconnection process that differentiates between various energy storage system uses and prescribes different interconnection study processes accordingly.

For example, California has considered characterizing behind-the-meter energy storage into one of three categories based on its planned applications:

- Non-grid charging: the energy storage device only charges from an adjacent on-site generator.
- Peak shaving: the energy storage system may charge from the grid but will only do so at times where such charging does not increase the host facility's current peak load demand.
- Unrestricted charging: the energy storage system may charge and discharge at any time.

These different categories allow the interconnection process to include the appropriate studies for evaluating expected grid impacts.

Asset Classification Specifically for Energy Storage

Since the traditional definition of generation facilities often did not accurately apply to energy storage, there was ambiguity in how interconnection processes should be carried out. This primarily arose from the more diverse technical capabilities of energy storage relative to a traditional distributed generator such as a diesel generator.

Advancements have been made by either clarifying the definition of generation facility to include energy storage or by creating a new asset classification specifically tailored for energy storage. In 2013, the Federal Energy Regulatory Commission (FERC) revised the definition of applicability for the Small Generator Interconnection Procedure (SGIP) as a "device for the production and/or storage for later injection of electricity."[2] Multiple other jurisdictions have followed, thus removing ambiguity around the applicability of interconnection studies to energy storage.

The Energy Storage Association has proposed the following definition for a generation unit to ensure there is no ambiguity as to the inclusion of energy storage: "A device that converts mechanical, chemical or solar energy into electrical energy, including all of its protective and control functions and structural appurtenances. An Energy Storage Device can be considered a Generator."[3]

ISOs have implemented various methods of defining energy storage as a market participant. For example, the Midwest Independent System Operator (MISO) currently has an Energy Storage Resource Category I and II and may have more in the future.[4]

Resources

Note: Interconnection study processes vary greatly across different jurisdictions and across the spectrum of capacities and configuration of energy storage. This chapter provides a generalized description that is intended to be widely applicable. A variety of specific examples is included to illustrate how a diverse set of specific jurisdictions have implemented rules. Accordingly, there are hundreds of interconnection policies across the United States. The below references correspond to general resources and specific examples used in this chapter.

- PJM Manual 14A: Generation and Transmission Interconnection Process. https://www.pjm.com/-/media/documents/manuals/archive/m14a/m14av19-generation-and-transmission-interconnection-process-11-01-2016.ashx (19th rev. 2016)

- Energy Storage Association: Updating Distribution Interconnection Procedures to Incorporate Energy Storage. January 2018. http://energystorage.org/system/files/attachments/interconnection_final.pdf

- Interstate Renewable Energy Council (IREC): Model Interconnection Procedures (2019), https://irecusa.org/wp-content/uploads/2019/09/irec-model-interconnection-procedures-2019.pdf.

- Electric Reliability Commission of Texas (ERCOT): Planning Guide (includes chapter on Generation Resource Interconnection of Change Request). April 1, 2017. http://www.ercot.com/content/wcm/libraries/121664/April_1__2017_Planning_Guide.pdf

- California ISO: Energy Storage Interconnection – Issue Paper and Straw Proposal (2014). http://www.caiso.com/documents/issuepaper_strawproposal-energystorageinterconnection.pdf.

- California Public Utilities Commission: Rule 21 Interconnection. http://www.cpuc.ca.gov/Rule21/

- FERC: Standard Interconnection Agreements & Procedures for Small Generators. https://www.ferc.gov/industries/electric/indus-act/gi/small-gen.asp

References

[1] 18 C.F.R. § 35 (2013), https://www.ferc.gov/whats-new/comm-meet/2013/112113/E-1.pdf.
[2] Energy Storage Association: Updating Distribution Interconnection Procedures to Incorporate Energy Storage (2018).
http//energystorage.org/system/files/attachments/interconnection_final.pdf
[3] 18 C.F.R. § 35 (2013), https://www.ferc.gov/whats-new/comm-meet/2013/112113/E-1.pdf. -

[4] https://www.rtoinsider.com/miso-ferc-order-841-energy-storage-101405 (Content available for purchase).

Engineering

Chapter Five: Warranty

Chapter Lead: Davion Hill, DNVGL

Background

Product warranty coverage provides project developers with a means to ensure that the product meets specific manufacturing quality and performance capabilities. Warranties are important for two reasons. First, they provide assurance to developers to allow them to plan on what market applications the unit can reasonably support. Secondly, having the equipment remain under warranty during the duration of the facility's operating life is, many times, a requirement by lenders to ensure that the facility remains in good working order in order for the developers to repay the loan.

Warranty coverage typically focuses on two areas: manufacturing defect and performance. Both types of warranties are subject to usage in accordance with specified usage profiles: temperature, cycling, energy throughput, and State of Charge (SOC) limits.

The manufacturing warranty is typically limited to cover defects from manufacturing. This would provide relief to the owner for repair or replacement in case of defects in material or workmanship. If relief is needed, the vendor is responsible for making repairs or replacing the defective components.

The performance warranty covers the ability of the system to achieve a specified performance level per application metric for a defined usage profile during a specific period of time. The performance warranty is specified most commonly with respect to either available energy capacity of the system during its operating lifespan, or the energy throughput of the system over its operating lifespan. The performance warranty will cover the technical rating of the unit with respect to such issues as power, energy, efficiency, duration, and availability. Performance warranties vary by OEM provider but are generally centered on energy storage capacity (kWh) or energy throughput (kWh) provisions over the life of the unit.

The warranty period is fundamentally separate for the manufacturing and performance warranties. Generally, manufacturing warranties can range up to 15 years, and performance warranties are geared toward the market usage profile—generally anywhere from seven to fifteen years, including extended warranty periods. The performance warranty period typically corresponds to the expected end of life for the battery. Historically, the end of life for a battery was when it reached 80% remaining capacity (kWh) in the cell, after which the cell's capacity would decline at an increasing and sometimes unpredictable manner. With advancements in cell design and manufacturing, the reliable working life of the cells is being extended. Many providers now consider the end of life for the cell to be when the capacity reaches 70% or even lower—which helps to extend the operating life of the cell, but at a reduced energy capacity. Without the need for more significant system augmentation, this will impact the available applications for the system in later years.

Because ancillary equipment can have a major impact on the operational life of systems, these systems are coming under greater scrutiny in respect to overall performance. Since thermal control is a significant factor (for instance, to ensure that the modules be maintained below 75°F), the good working order of the thermal management system is important. Also, if a claim is to be made, the OEM will need to ensure that the modules were maintained and operated within the specified guidelines. Certifying this necessitates data monitoring and the collection of system parameters during its operating lifespan.

Since these ancillary systems are of such importance to the good working order of the overall energy storage system, the warranties for this system equipment have become important to include in overall project planning. Typically, much of the balance of plant equipment, including HVAC, fire suppression, and switchgear, will come with one to three years of product warranty, but generally without a way to easily purchase a warranty extension to 10 years or longer. Assurance of continuous operation of the balance of plant equipment falls under the EPC wrap and/or the continued operation and maintenance contract. Inverters and other equipment in the power conversion system can also initially come with a one- to three-year warranty, with the option of extending this with a maintenance contract from the OEM or an approved vendor.

Energy Storage Challenges

Warranties pose a number of challenges for developers trying to develop flexible and scalable systems able to perform a variety of usage profiles within the scope of the lending requirements. Concerning both the manufacturing and the performance warranties, there are challenges for project developers. The technical credibility of the warranty will determine the sufficiency of any guarantee(s) also offered with the project. The perceived risk in the project—and therefore its ability to be financed—is highly dependent on the warranties and guarantees that are offered.

Because there are multiple suppliers required to build and construct an energy storage project, separation of accountability remains an issue. The market has responded with engineering, procurement, and construction (EPC) contractors who step in as the primary single interface and point of contact for the owner. There is now a precedent and expectation that the EPC assumes liability risk in the form of guarantees that provide liquidated damages payments when violated.

During the 2009-2019 ramp-up of the energy storage market, many providers of energy storage products and services have been strategic and aggressive in establishing market share. To acquire this market share, many have taken on risk in the form of warranties and guarantees in order to achieve financing for projects. The technical soundness of the warranties and guarantees should be evaluated by a technical due diligence provider to determine whether the offeror is taking a reasonable and responsible risk in the offering.

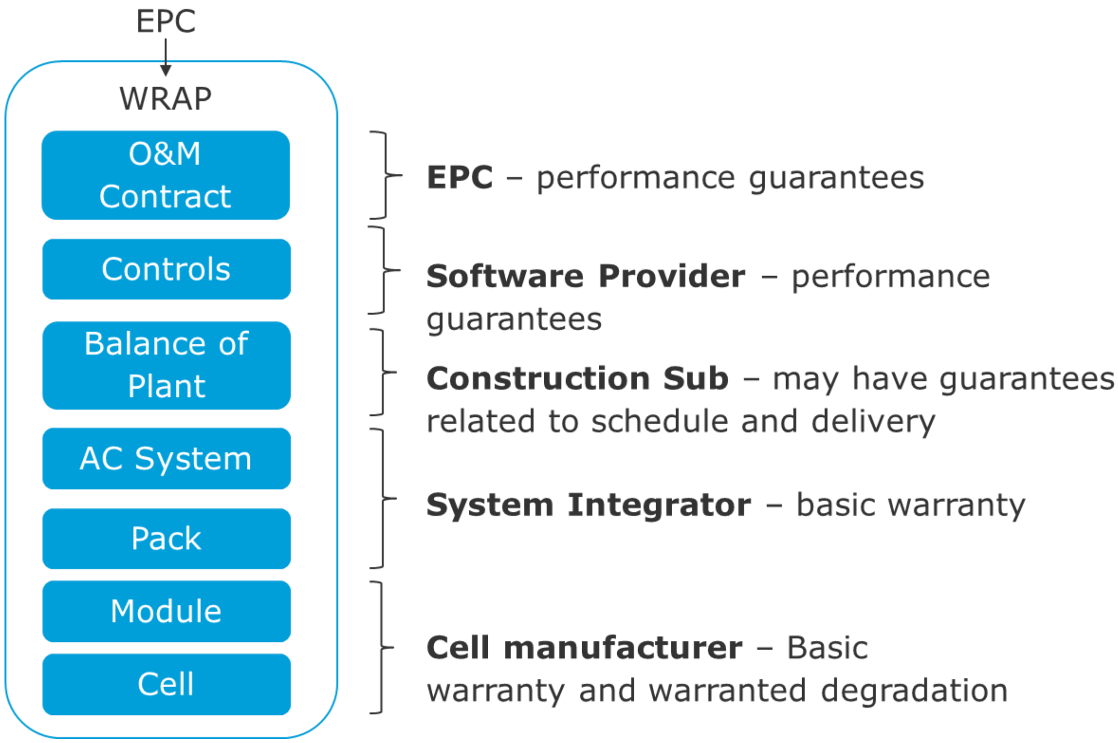


Figure 2.5.1
EPC wrap
Source: DNV GL, Davion Hill Ph.D.

Warranties versus Guarantees

There are differences between warranties and guarantees. Providers of services and products in an energy storage project are responsible for segmented portions of warranties and guarantees, but a “wrap” or “back to back” guarantee is typically provided by the senior EPC. These distinctions are provided in figure 2.5.1, along with the role and function of suppliers in an energy storage project supply chain.

Warranty

Limitations on manufacturing warranties are typically straightforward specifications to ensure that the energy storage equipment or system has been properly manufactured, handled, installed, and operated according to OEM specifications. These warranties are generally provided as part of the purchase of the product and can be valid for 15 years.

Specifically, OEM manufacturing warranties cover repair or replacement of equipment only. If the system is not repairable in the field (and battery modules seldom are) it must be returned to the manufacturer’s facility. The transportation and handling charges for returning the unit to the manufacturer are not typically covered in OEM warranties. This is an important aspect of warranty coverage for customers who are price conscious and concerned about purchasing extended warranties. This shortfall in OEM coverage can be covered in the O&M (Operations and Management) service agreement to include unit removal and replacement but must be specifically spelled out in the agreement.

Other items also typically excluded by an OEM's warranty include events beyond the reasonable control of the OEM, including acts of God, government regulatory changes, fire, natural disasters and other forms of severe weather, acts of terrorism, riot, blackout, war, and delays by a third party to provide services in support of the OEM or a designated service provider. These provisions are often defined in a force majeure clause.

An important prerequisite for service providers who handle, install, commission, provide field maintenance, or operate the energy storage system is that they must be authorized and approved by the OEM to perform these required services. These third-party service providers must also comply with the OEM manual, and applicable ordinances and safety regulations, when performing these services on the unit.

A warranty is foundational to the guarantees for a project. A warranty is provided by entities that are supplying the project with products such as batteries, battery modules, and battery systems. A basic warranty covers parts, defects, and faulty workmanship and usually has a limited duration for a time period that is less than the project life. However, most energy storage projects require a warranty on the battery to guarantee a minimum energy capacity, duration of discharge, efficiency, or all of the above. Such warranties may be tied to a reimbursement for economic loss.

Guarantees

A guarantee, often called a "performance guarantee," is a service to the project and will depend on one or more warranty terms. Two common guarantees are as follows:

- **Energy capacity** (kWh or MWh), distinguished either by a prescribed degradation curve or a minimum capacity to be maintained for the duration of the project.
- **Availability** (%), which specifies up-time and response time.

Less common, but important, guarantees are:

- **Duration** (min or h), which may be implied from a power rating and a capacity guarantee.
- **Power** (kW or MW), for situations where derating may occur.
- **Efficiency** (%), for projects where the project may be sensitive to charging costs.
- **Market-based guarantees** (e.g., performance score).

Both the warranties and the guarantees must be based on technical credibility. However, the financial credit worthiness of the offeror(s) of the warranties and guarantees is also considered during project evaluation because a violation of either warranties or guarantees may result in the payment of liquidated damages.

The guarantee may be provided for the entirety of the project life, or it may have a limited term that can be extended with optional payments by the owner. The guarantee period for a particular energy storage system is generally geared toward the market segment where it will be sold. For example, systems sold into the residential and smaller commercial markets have, many times, a 10-year warranty comprising both the manufacturing and performance warranty—which are based on expected unit lifespan and the system's usage profile. Often, warranties in these markets are included in the original price for the product, meaning that the OEM has simply capitalized the warranty cost into the purchase price for a full 10 years.

Guarantee and Warranty Limits

Guarantees and warranties have built in limitations or contingencies. These contingencies may be affected by suppliers to the project that are not the offeror(s) of the warranties or guarantees. In order for the warranty or guarantee to be upheld, the following limitations may apply:

- **Temperature:** Typically specified as an operational envelope between a minimum and maximum, averaged over a specified time period. The temperature measurement is often an average ambient measurement within a container. The software and dispatch controls will affect the temperature, but so will the sizing and design of the HVAC system. Temperature is often non-uniform across the battery cells.

- **State of Charge (SOC) Limits:** A battery will have "hardwired" SOC limits at upper and lower ranges for safety or longevity purposes, but the battery manufacturer may favor certain intermediate SOC ranges and limits, or adjust the warranty depending on the average SOC. The SOC is often averaged over a time period. The system SOC will directly affect the electrochemical SOC of the battery cells. The two numbers are usually different. SOC limits are primarily dependent on software and dispatch controls.

- **Power or C-rate:** The average power rating of the system during operation may have an effect on the battery warranty. The system power translates directly to the C-rate that the battery cells experience. C-rate is defined as charges or discharges per hour.

- **Throughput:** Throughput (See Figure 2.5.2) is often defined as MWh/MW per year. If a battery has higher throughput than expected, it has been cycled more aggressively. Therefore, its limitation in available lifetime will be reached sooner. Most warranties and guarantees have a throughput cap. A coarser measurement of throughput is cycles. The throughput at the battery cell must be determined first in order to determine how much throughput a system can sustain.

- **Lifetime**: A calendar limit of the project life is always offered. A common project life is 10 years. Lifetimes may be longer, but warranty guarantee adjustments may occur after year 10.

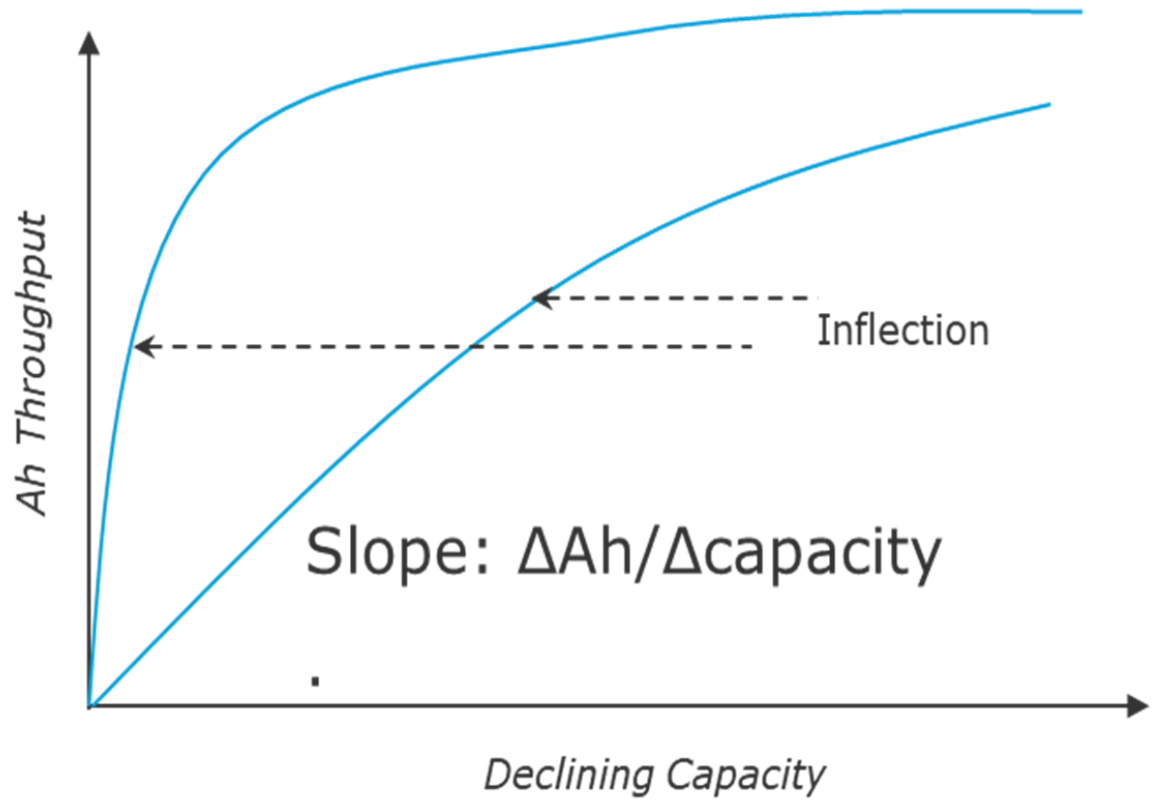


Fig. 2.5.2
Throughput varies depending on the c-rate, temperature, average SOC, and SOC swing of batteries.
Source: DVV GL, Davion Hill Ph.D.

Adjustments to a warranty or guarantee must consider the usage and environment of the battery's operation. Specifically, the baseline energy capacity target of the warranty will be reduced if usage patterns or environmental conditions exceed the limits of the OEM according to the schedule or operational conditions provided in the warranty. Since there are a number of these attributes, calculating the resulting warranty coverage under a variety of usage patterns and environmental conditions can be a complex calculation.

Because of this possibility of reduction in the warranty coverage due to operating outside of the originally stated ranges, lenders should specify a constrained operating profile in order to maintain full warranty coverage. These conservative usage patterns include temperature, charging/discharging rates, average state of charge, and state of charge swing.

Risk in Warranties and Guarantees

Warranties and guarantees are affected by all parties providing products and services to the project.

For example, if a degradation rate warranty is provided by the battery manufacturer, and a capacity guarantee is provided by the EPC, the EPC supports the guarantee with the warranted degradation rate. However, the dispatch and controls software can affect the degradation rate by operating the system in different SOC or power ranges that can also affect temperature. Therefore, a truly “back to back” guarantee and warranty package for the project will need additional guarantees or backstops from the controls provider that assure that the system will be operated in the SOC, temperature, and power ratings that are consistent with the expectations set by the battery warranty.

Liquidated Damages

Liquidated damages (LDs) are monetary payments made by the providers of guarantees to the project owner in the event of a failure to uphold a guarantee. The guarantee provider is often the senior EPC contractor, but may also be any individual party offering a guarantee.

The LDs may be calculated and designed to compensate for lost revenue, contract-related fines, system replacement, repair, augmentation, or all of these contingencies.

Because liquidated damages are tied to future financial risk, during the diligence phases of the project the owner and/or lender may evaluate the likelihood of the future ability of the offeror of the guarantee to pay liquidated damages in the event of a guarantee violation.

If the creditworthiness of a guarantee offeror, or the ability of the offeror to uphold the guarantee is in question, there may be insurance products that can pay out liquidated damages in place of the offeror. Such products transfer the liability of the liquidated damages payments from the balance sheet of the offeror to the cash flows of the project in the form of an additional operational project cost. In this instance, the insurance provider may require certain technical risk diligence on the project to assure that the warranties and guarantees are technically sound.

Enforcement of LDs and Disputes

In order for a liquidated damages claim to be enforced, the claimant needs reliable and tangible data to support a claim. That data must arise from a test—one which is often a pre-defined test procedure written into the EPC contract. Defining the test procedure contractually minimizes a dispute if and when a violation is found.

Disputes and LD claims are strongly dependent on the following factors:

- Whether the validation or measurement method was contractually defined.

- Accuracy of data collection.

- Steward(s) of the data.
- Ambiguity in the measurement method.
- Resolution of the data.

Identification of critical data that is needed to uphold, verify, support, or challenge guarantee disputes must occur before the project is energized. If and when a guarantee is violated, and there is no means to use data to verify or dispute the violation, the project owner will typically have no recourse but initiate legal action in order to seek compensation for the resulting project losses.

Once data is defined, its storage, quality, resolution, and security should be defined in the contract, and the owner should have access to it. It is usually the case that the system integrator will collect limited data, perhaps without long-term storage, on basic operational parameters such as voltage, temperature, and current. This data is usually not at the cell level. The dispatch and controls provider may provide longer-term data storage. If the dispatch and software controls provider is not the same entity as the system integrator, agreements will be required to assure that the stewardship of the data remains uncompromised.

Acceptance Tests, Validation Tests, and Monitoring

The simplest determination of whether LDs are going to be paid is when a contractually defined test demonstrates that a warranty or guarantee has been violated.

Testing to verify whether a warranty or guarantee condition has been met is critical to both project finance and the continued operation of the project. The owner should have contractual terms that entitle him to request any contractually defined test within a notice period.

All the adjustment limitations on the degradation rate or capacity of an energy storage project should be validated during the project design phases. Third-party databases are available. These include the data provided in the DNVGL Battery Performance Scorecard[2], which warehouses degradation data for commercial batteries. This data can be used to independently measure battery degradation behaviors. This data can also be used to validate degradation rates, warranty adjustments, and the sufficiency of the warranty in the context of the project and the integration of the battery into a specific project system.

Technical due diligence providers should be brought into the contracting phase of energy storage project development to aid in the writing of specifications for factory acceptance tests, field commissioning tests, tests to dispute or verify guarantees, and data warehousing and monitoring. Some diligence providers also provide independent monitoring and data storage.

Emerging Technologies

Bankability is a term commonly used often when discussing the quality of both the equipment and the equipment warranty. Essentially, market leading firms providing commercially proven storage technologies at scale have an advantage over firms with an emerging energy storage technology. From the quality perspective of a warranty contract, product warranties are viewed to be only as good as the OEM's balance sheet. This reality can hamper the market commercialization of energy storage technologies by smaller firms.

Best Practice

Warranty coverage is an important consideration for project developers. For many, any additional cost is subject to review or pairing in order to make the numbers work for the budget. Groups able to self-insure or self-fund projects may have the opportunity to consider limiting costs by reducing the duration or coverage of the warranty, or by taking on the risk of a less proven technology. For those needing outside financing, having the system under warranty is typically a requirement. As more systems are deployed, a larger amount of experiential data will be available upon which to base these decisions and provide a basis for choice.

An important development in warranty coverage emerging from the OEMs is the concept of flexibility. OEMs understand the complexity of the current warranties, and the explicit cut-offs based on usage or environmental conditions. If the battery is operated in an environment two degrees hotter than listed, is the entire warranty invalidated? Depending on the usage profile and product, there may be alterations to what is covered over the outer years of a warranty. Indeed, some equipment might require an increase in the cost of the warranty for those outer years.

Going forward, the growth in warranty coverage expansion is expected to improve with advancements in energy storage technology. As the different OEMs become more confident with the operational capabilities of their products, competitive pricing pressure is expected to drive enhancement to the warranty offerings.

For emerging technologies, a believable warranty is critical for success. However, emerging technologies are many times developed by small firms with little financial backing. Therefore, credit enhancements (found in the Risk Management BPG, Part 7) provide a financial backing for the viability of the firm, and bankability studies (found in the Engineering BPG, Part 3) provide a greater assurance of a technology's viability until it becomes commercially successful and the product warranty can be based on experience.

Resources

- David Conover ET AL., *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems*-(PNNL-22010_Rev._2/SAND2016-3078_R)_Pacific Northwest National Laboratory and Sandia National

Laboratories Apr. 2016, available at https://energystorage.pnnl.gov/pdf/PNNL-22010Rev2.pdf.

References

[1] A C-rate of 1 is 1 discharge an hour. A C-rate of 2 is two discharge or charge events in an hour, i.e., the battery can discharge or charge in 30 minutes. A C-rate of 0.5 is half a discharge or charge per hour, or a two-hour charge/discharge duration.
[2] Davion Hill & Michael Mills-Price, 2018 Battery Performance Scorecard can be downloaded at https://www.dnvgl.com/publications/2018-battery-performance-scorecard-132103. The 2019 report will be published later this year.

ENERGY STORAGE BEST PRACTICE GUIDE 3:

PROJECT ECONOMICS

Project Economics

Chapter One: Overview

Chapter Lead: Russ Weed, Cleantech Strategies

Background

When a project developer intends to develop an energy storage project, the project must be closely aligned with the requirements of the party providing project financing. These requirements can be financial and include return on investment, policy-driven (procurements), technical (storage as best resource), and programmatic (storage as part of a solution set).

In the early days of energy storage development, the project-specific requirements had often been "parochial," depending on the project's location, the array of interests there, and the policy approaches regarded as most effective within that location. This was not unusual, historically speaking.[1]

At some point, the market requirements on energy storage projects will likely be dominated by the financial return on investment (ROI). Anticipating that, increasing numbers of energy storage projects will be driven by ROI, so it is important that the project developers, project financiers, solution providers, and other market participants clearly understand the different applications for storage—including the cost savings, revenue streams, and resiliency from storage. To aid in this understanding, and benefit the industry, the energy storage industry needs to compile case studies of applications and projects employed in the market.

References

[1] Such "parochialism" is not unusual in the development of market categories such as energy storage. History has many examples. E.g. Fernand Braudel, *Civilization and Capitalism 15th to 18th Century*, 1967.

Project Economics

Chapter Two: Applications

Chapter Lead: Mike Jacobs, Union of Concerned Scientists

Background

Across the electric power system, storage can provide capabilities ranging from the customer site to the local distribution system to the bulk power and transmission system. The best practices for employing storage depend on matching the performance of the storage asset with the application(s) that avoid the greatest cost and/or provide the highest value.

A useful way to summarize applications is to categorize each as primarily an energy (kWh or MWh) or power (kW or MW) service, and then to give each application a descriptor. An IEEE (Institute of Electronics and Electrical Engineers) publication authored by a number of leading storage thinkers[1] identifies six energy applications and six power applications.

The California Public Utility Commission (CPUC) describes applications as "use cases,"[2] while investigating how to establish a procurement target for the state's investor-owned utilities (IOs)—as directed under the AB 2514 law passed in 2010. CPUC resolved the initial procurement target by setting requirements based on where the storage would be attached to the system: transmission, distribution, or customer sited.[3]

Defining applications by the segment of the power system provides categories more closely related to the value and potential for revenues from storage. The segments chosen for discussion here are Wholesale, Retail, and Reliability.

In addition, the ability to recognize value from an application will differ by the role and responsibilities of the energy storage asset owner or offtaker/customer. A clear understanding of the applications valued by each type of owner or offtaker requires determining their costs and needs.

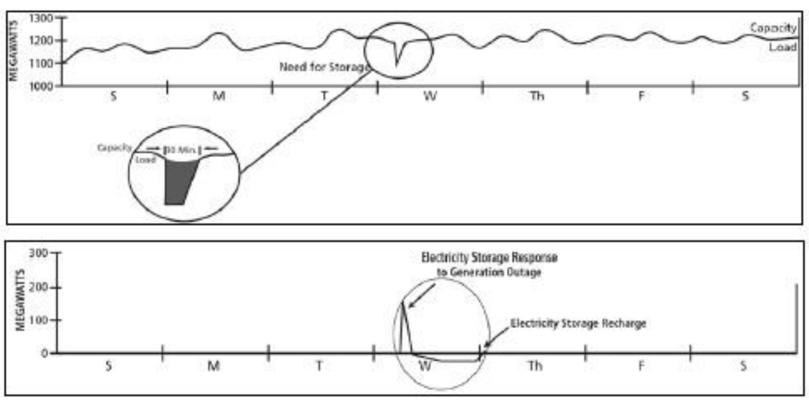
Table 3.2.1
Major energy storage applications.
Source: R. H. Byrne, T. Nguyen, D. Copp, B. Chalamala, and I. Gyuk, "Energy Management and Optimization Methods for Grid ESS," *IEEE Access*, Vol. 6, 2018, p. 13232.

Summary of Energy Storage Applications

Wholesale Applications	Retail Applications	Reliability Applications
Reserves	Customer Demand Charge Reduction	Grid Resilience
Resource Adequacy	Time-of-Use Charge Reduction	Voltage Support
Arbitrage; Renewable Energy Time Shift	Grid Resilience	T&D Upgrade Deferral
Transmission Congestion Reduction		Frequency Response
Frequency Regulation		Small Signal Stability

Wholesale Applications

Reserves



Storage for Reserve Capacity

Fig. 3.2.1
Wholesale applications: storage for reserve capacity.
Source: DOE/EPRI Electricity Storage Handbook, 2015 edition.

As explained in the DOE/EPRI Electricity Storage Handbook:

> Operation of an electric grid requires a reserve capacity that can be called upon when some portion of the normal electric supply resources becomes unavailable unexpectedly. Generally, reserves are at least as large as the single largest generation unit serving the system. Typically, total reserve capacity is equivalent to 15% to 20% of total electric supply.[4]

Reserves usually come from generation resources that are online and operational (i.e., at part load). The use of storage for reserve capacity has the advantage that it does not discharge the storage until needed, unlike generation that will be burning fuel.

Resource Adequacy

Resource adequacy, or firm capacity, are two names for the supplies counted on to meet the peak demand of an electric system. Every utility and grid operator must have some means to plan for peak demand and procure adequate supply. Resource adequacy procurement for utilities is often a competition between "all resources." Storage can be offered either as an alternative to a peaking unit, or in combination with renewable generation. The value derives from providing an alternative means to meeting peak demand and has an analogous application in those behind-the-meter deployments with customer demand charge reduction. Between these two analogous applications, the market potential for this application is 100% of peak demand on the grid, plus a margin.

Arbitrage Renewable Energy Time Shift

Daily variation in demand, as well as marginal energy production costs and prices, creates an opportunity for arbitrage. This can be achieved via storage resources by buying when the price is low and selling when the price is high. The existence of significant levels of renewable energy can also create an incentive or value for using storage to shift the time between energy production and consumption. An analogous application for retail customers is for those who have a varying price for energy such as a time-of-use rate. Retail customers that are unable to have net-metering treatment for on-site production are a market for storage behind the meter, such as presently occurs in Hawaii and Germany.

Transmission Congestion Reduction

Transmission congestion occurs when low-cost energy cannot be delivered to some loads because transmission is not adequate to deliver that energy. Transmission congestion leads to increased costs or locational marginal pricing (LMP) for wholesale electricity on the other side of the constraint.

To avoid the cost associated with congestion, electricity storage is a perfect mechanism. To optimize this advantage, the storage system would avoid the congested part of the transmission system by being located downstream from it. Energy would be stored when transmission congestion is not present and then returned to the system in the absence of congestion, thereby delivering energy at a lower cost than the electricity available from the congested transmission system.

Frequency Regulation

Making adjustments for brief electricity usage or supply that could impact a power system's stability, frequency regulation is an ancillary service provided by generators, loads, or storage. The need for frequency regulation is roughly one percent of the power system capacity. RTOs/ISOs provide market-based compensation to power sources that can readily and reliably adjust usage or output in response to an automated signal.

Retail Applications

Customer Demand Charge Reduction

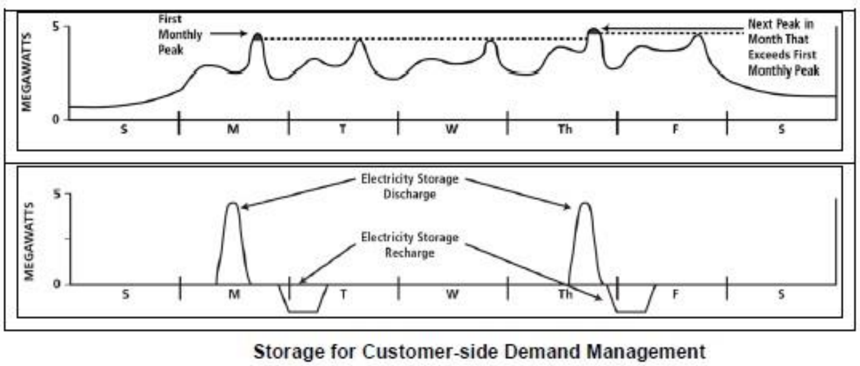


Fig. 3.2.2
Storage for customer-side demand management.
Source: DOE/EPRI Electricity Storage Handbook, 2015 edition.

Many utilities apply a demand charge in the rates paid by their customers—both industrial and commercial. The demand charge is based on the utility measurement of the highest demand during any 15-minute period in a month or year. Utilities also use demand charges in wholesale pricing of services or transmission, and the resulting units are $/MW. Energy storage located on the customer side of the meter can reduce the measured demand and be valued by the $/kW rate that applies to that customer. Distribution entities and/or small utilities which pay a transmission demand charge can also value this application.

Time-of-Use Charge Reduction

The application of storage to time-of-use (TOU) charge mimics arbitrage in most respects except for the very important difference that the announced price and timing of price differences established in the utility retail rates provide a certainty not available in the wholesale energy market.

Grid Resilience

As severe weather impacts on the power system become more common, retail customers can find value in a type of energy storage (sometimes called grid resilience) that provides continuous electric service. Grid resilience also helps mitigate problems caused when a variety of other factors impact the sensitivity of digital devices and data-management services, causing power supply and power quality interruptions.

Reliability Applications

Grid Resiliency

The severe weather causing more and more prolonged power outages in various places in the United States is stimulating conversations about resilience and micro-grids as a supplement to power system reliability now provided by poles and wires.

Voltage Support

Historically, conventional generation from investments in wires have provided voltage support to electric systems. Energy storage can provide voltage support by controlling the injection of energy and reactive power. This can be valuable to a utility on the transmission system or a local distribution line.

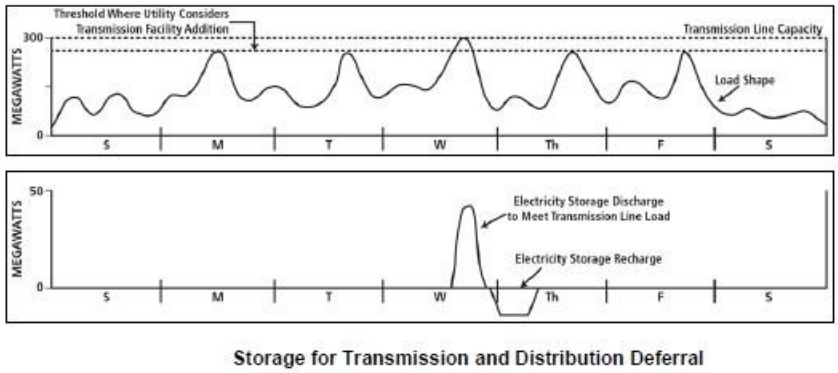


Fig. 3.2.3
Storage for transmission and distribution deferral.
Source: DOE/EPRI Electricity Storage Handbook, 2015 edition.

Transmission and Distribution Upgrade Deferral

A transmission and distribution (T&D) upgrade deferral can significantly benefit energy storage. Some T&D upgrades are needed for voltage support. Others are needed due to congestion or peak demand that exceeds the ability to supply adequate voltage from existing wires.

Frequency Response

Frequency droop refers to a critical generator response when a large generator is lost to use. Sometimes called inertia (or "synthetic inertia"), this feature of conventional generation can be defined as the replacement of power lost to the power system with an equal amount of power—which is measured as a change in frequency. Equipment across the power system has the potential to contribute to this frequency response.

Small Signal Stability

Measures of grid reliability and responses to disturbances take many forms. "Small signal stability" refers to the stability of the power system in response to small perturbations.[6] Based on frequency feedback, the injection of real power at various locations in the grid can be used to damp inter-area oscillations.

Wholesale Applications

Reserves

Several types of reserves are defined and priced in the organized markets (i.e. ISOs). Value for reserves can also be found in a utility's Integrated Resource Plans (IRPs) where the utility has addressed levels of reserves. Reserves are paid based on MW capacity, rather than on hours of operation or MWH.

Generation owners have added storage to conventional or renewable generation in order to improve their ability to provide reserves. When the generation is wind or solar, this is sometimes known as Renewable Capacity Firming.

Resource Adequacy

Resources for resource adequacy are planned in advance, and most commonly compensated for as a megawatt of peak or load-carrying capacity. This is done in a revenue stream separate from energy produced through operations. Battery-storage projects with a four-hour discharge duration were first recognized, and paid, for resource adequacy following California's implementation of its AB 25140 storage procurement mandate. In many markets, there is a routine mechanism for qualifying to sell "firm capacity." There are also auctions to establish prices. Combinations of solar-plus-storage or wind-plus-storage are encouraged in both utility and capacity market structures.

Energy Price Arbitrage

Because the prediction of wholesale prices is uncertain, energy price arbitrage in the wholesale market is not a secure and predictable revenue stream as of June 2019. However, versions of this application that either have a fixed price such as time-of-use rate, or offer a physical or environmental benefit, provide more certainty and possible value.

Transmission Congestion Reduction

This can be analogous to arbitrage but is also one way to view storage as providing an alternative to a transmission (or distribution) upgrade. The economic value of congestion reduction for the system depends in part on who is the sponsor of the storage installation.

Frequency Regulation

Initial reforms by FERC and RTOs/ISOs to make use of the speed and accuracy of storage came in 2012. Prior to storage industry advocacy, and subsequent review by FERC of the payments and performance of frequency regulation, the performance of conventional generators for this service was measured at five-minute intervals. For resources such as energy storage that are much quicker to respond than conventional generators, a special signal developed by RTOs/ISOs currently includes four-second intervals. Speed is likely to be ever faster as the grid further modernizes. The prices paid for this service have been subject to market conditions, and the performance requirements remain controversial as of this writing.

Retail Applications

Customer Demand Charge Reduction

The basic requirement for this application is to carry a portion of the customer load or demand. The shape and duration of the load may not be constant and will be affected by the prior installation of storage or other load-modifying resources such as solar. The theoretical size of this market is roughly 25% of the electricity system demand, but economic and practical limits are substantial as of this writing.

Time-of-Use (TOU) Charge Reduction

The benefit of a TOU to the retail customer can be readily calculated. TOU rates are also beneficial to society because of the changes to usage they produce, along with lower utility service costs in several categories over time. Utilities sometimes offer TOU rates as an option to customers. Utility commissions are gradually finding that it is beneficial to have policies for widespread and mandatory TOU rates.

Grid Resilience

Energy storage deployment for grid resilience can include other energy supplies and be delivered through a micro-grid approach. In a micro-grid, the energy storage duties can be thought to include many, if not all, of the applications defined for storage. Differing for every customer, the retail value for resilience is dependent on the intolerance of grid interruptions.

Reliability Applications

Grid Resilience

A utility can improve the reliability of a section of the grid with a "resilience" project. In the event of an outage, a relatively small number of customers can be served by any one micro-grid or battery supplement. If for a small number of customers, such projects owned by a utility can face regulatory hurdles in establishing the justification for this service improvement.

Voltage Support

A localized need, voltage support does not have a market price. Value from storage depends on alternatives available for a utility being less economic, or where a renewable generator faces system upgrade costs, or limits on energy production, due to voltage problems. Utilities have various capital equipment solutions for voltage support.

Transmission and Distribution (T&D) Upgrade Deferral

T&D upgrades are inherently specific to locations. Value from storage comes from a lower capital cost or other economic and/or environmental feasibilities unavailable from previous conventional solutions. There are cases where the utility need has been met by a "non-wires alternative." The most prominent of these is the Brooklyn/Queens Demand Management Program run by Con Ed in New York City.[7]

Frequency Response

To date, no generator or storage asset has been paid for services to address frequency droop/system inertia. And as of this writing the potential revenue is very small. However, island grids have illustrated the value of this form of energy storage deployment.

Small Signal Stability

A capability for small signal stability has been demonstrated and used in the utility procurement of storage hardware. Due to the increase in transmission capacity available after installation, the value of this service can be high. However, no market-based payments for storage in this application have occurred as of this writing.

Resources

- M. Jacobs, “How Battery Storage Displaces and Replaces Conventional Generation – Trajectory of Storage Providing Supplemental Services, to Essential Services, to Full Replacement of Generation,” available at https://www.sandia.gov/ess-ssl/wp-content/uploads/2018/08/2017_EESAT_Proceeding_Jacobs.pdf

- NRECA. Battery Energy Storage Technology Overview and Co-op Case Studies (2018)

- Sandia. DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA (2015), available at https://www.sandia.gov/ess-ssl/publications/SAND2015-1002.pdf

References

[1] Raymond H. Byrne, Tu A. Nguyen, David A. Copp, Babu R. Chalamala, Imre Gyuk. “Energy Management and Optimization Methods for Grid Energy Storage Systems,” IEEE Access, 2017
[2] California Public Utility Commission. materials at http://www.cpuc.ca.gov/General.aspx?id=6442452867.
[3] *Id.*
[4] DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA, Chapter 1, Electricity Storage Services and Benefits. 2014. *http://prod.sandia.gov/techlib/access-control.cgi/2015/151*
[5] *Id.*
[6] Small signal stability analysis. https://www.slideshare.net/magician00 - New York Public Service Commission. Order Establishing Brooklyn/Queens Demand Management Program http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B83594C1C-51E2-4A1A-9DBB-5F15BCA613A2%7D

Project Economics

Chapter Three: Rate Design

Chapter Lead: James Bride, Energy Tariff Experts, LLC

Background

What is Rate Design?

Utilities design rates to recover the cost of providing utility service. Rate designs should collect the cost of service from a wide variety of customer types, incentivize consumers to use services efficiently, and charge for activities that increase costs for the utility system (e.g., usage during peak periods). The Bonbright Principles have largely guided the construction of rate designs during the last 50 years. These principles are as follows: effectiveness in collecting the cost of service; stability and predictability in utility revenues and consumer costs; promotion of efficient use; fairness; incorporation of externalities; sufficient simplicity to be comprehensible to consumers; and public acceptability.

In some regions, utility rates may be divided by function if those functions have distinct cost of service and revenue requirements. Examples of utility functions that may have unique revenue requirements are generation, transmission, distribution, and public policy charges (e.g., utility efficiency programs).

Broadly speaking, electric utilities typically use three different types of charges: fixed, demand, and usage-based. Usage and demand charges may be differentiated by season. Subtypes of these charges are illustrated in Figure 3.3.1.

Common Utility Charge Types and Subtypes Definitions

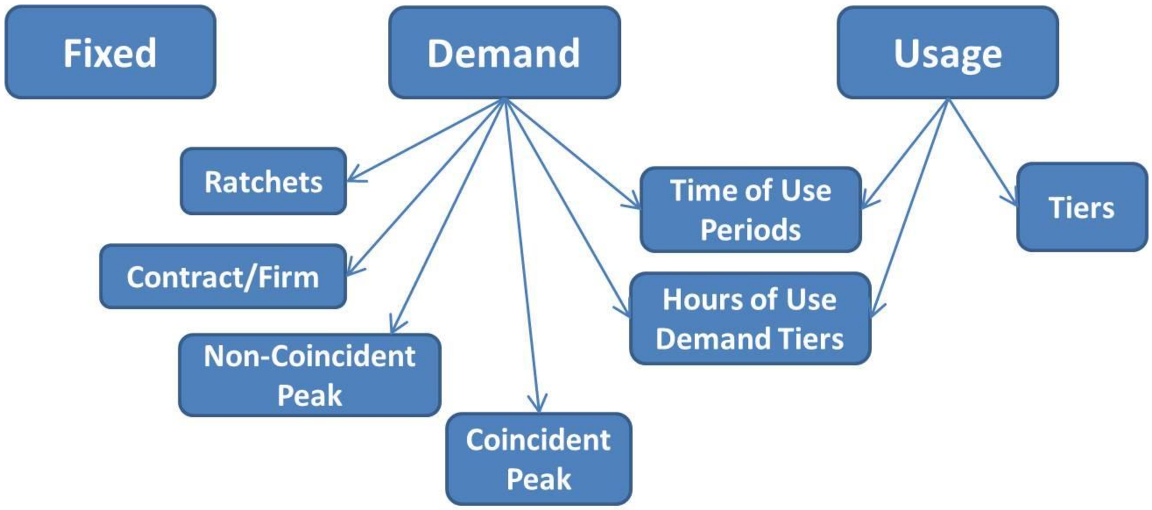


Fig. 3.3.1
Summary of utility charge types and subtypes.
Source: James Bride, Energy Tariff Experts, LLC.

- **Fixed Charge**: A pre-determined monthly charge to have a utility account.
- **Time of Use (TOU) Period**: A pre-determined set of hours used to differentiate utility rates by time. TOU periods may vary by season.
- **Demand Charge:** A charge based on the maximum rate of consumption over a 15, 30, or 60 min. period within a billing period or TOU period.
- **Coincident Peak (CP) Demand Charges**: A charge based on measured demand during the interval(s) where the peak load hour(s) occur in a utility system.
- **Non-Coincident Peak Demand (NCP) Charges**: Demand charges based on the measured peak load of the customer, irrespective of when the utility system experiences peak load.
- **Usage Charges**: Charges based on volumetric consumption of kWh—and billed in $/kWh.
- **Usage Tiers**: Price thresholds for usage charges where prices increase or decrease once a threshold is exceeded.
- **Hours of Use (HUD) Demand Rates**: A rate structure where usage pricing tiers are determined based on the ratio of peak kW demand to metered usage (kWh).

This type of rate structure results in customers with low load factors (low ratio of kWh to kW) having usage billed in higher priced usage tiers.

- **Contract Demand**: A minimum amount of demand that a customer is obligated to pay for monthly service.

- **Retail Rates**: The utility rates that apply to end use consumers approved by state level regulators.

- **Wholesale Rates**: Rates in the wholesale power markets for generation regulated by FERC. Based on location, wholesale rates are incorporated into retail rates.

- **Standby Rates**: Rates that can apply to customers with on-site generation for the utility to provide back-up service.

Illustrations of Rate Elements

Figure 3.3.2 shows an example of a TOU rate structure. In this example, there are three TOU periods during the day with different unit costs for usage (see left axis). The intent of a TOU rate structure like this is to charge more for usage when system loads are highest (e.g., late afternoon), and less during off-peak periods when loads are lower. Figure 3.3.2 also includes an example output curve from a solar PV array to show how the alignment of TOU periods can impact the economics of DERs.

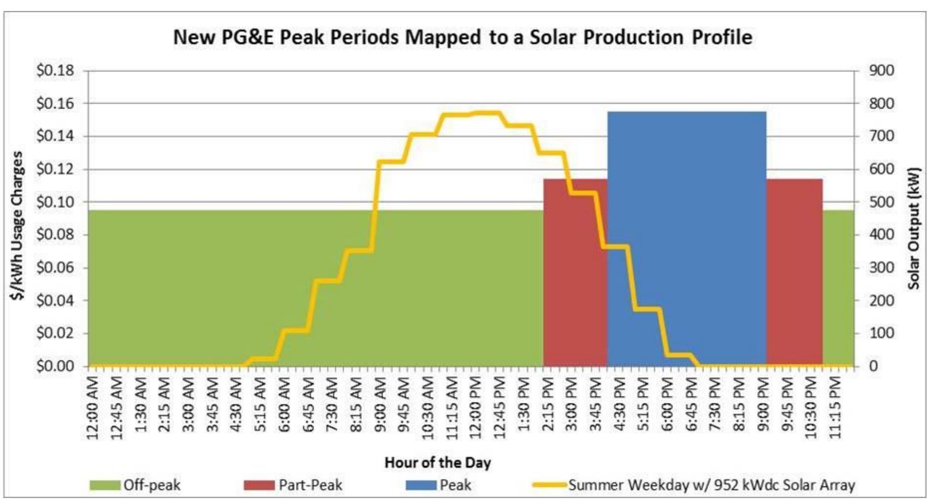


Fig. 3.3.2
Example of Time of Use Rates.
Source: James Bride, Energy Tariff Experts, LLC (Fig. incorporates data from PG&E rate tariffs and NREL's PVWatts system).

Figure 3.3.3 shows 15-min interval meter data for the electric load of an office building—before and after the addition of solar PV. As Figure 3.3.3. illustrates, solar PV pushes the peak load interval back, and also modestly reduces it. In most utilities, the peak demand billed to the customer will be the highest 15-minute interval recorded during the billing cycle. Many utilities impose demand charges by TOU period. If the TOU period is reasonably short, or the load is peaky, then storage may help reduce demand charges.

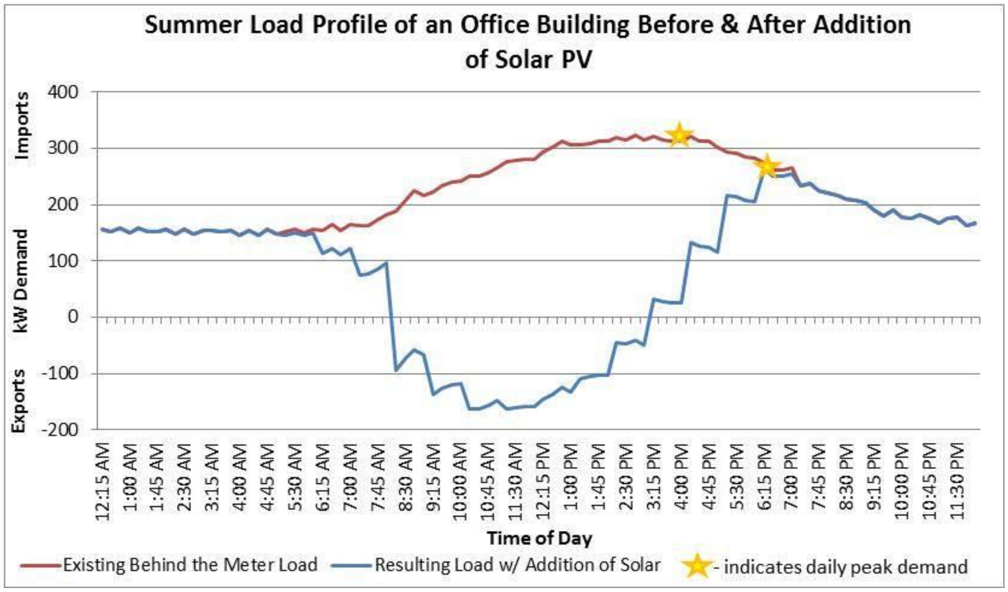


Fig. 3.3.3
15-min interval electric load meter data.
Source: James Bride, Energy Tariff Experts, LLC.

Figure 3.3.4 shows a typical calculation waterfall for a demand ratchet. In a ratchet type rate design, demand charges can be based on either the highest demand measured in the current month or some percentage of the highest demand in the last year. Demand ratchets tend to have a big cost impact on seasonal loads or poor load factors. This type of rate design poses a high risk for storage because a 15-min. load spike can drive costs for the next year.

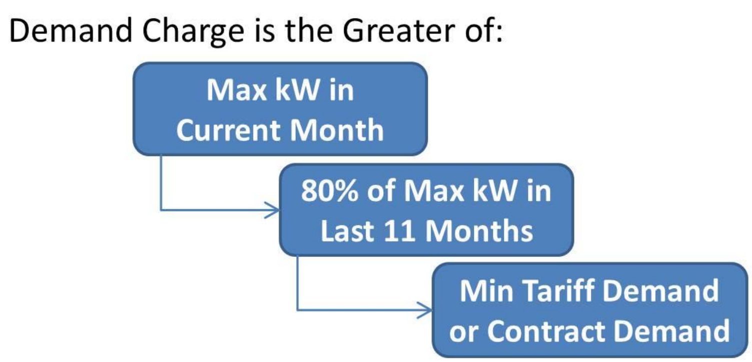


Fig. 3.3.4
Demand ratchet calculation waterfall example.
Source: James Bride, Energy Tariff Experts, LLC.

Table 3.3.1 shows the calculation logic for a HUD-type rate structure. In this type of rate structure, total charges are based on load factor (ratio of peak demand to average hourly usage in the billing cycle). kWhs are apportioned to billing tiers based on a calculation where the size of the tier is driven by the peak demand. Once kWhs are allocated to the first tier, the kWhs are then allocated to each successive tier until they have all been apportioned. Typically, each successive tier has a lower unit cost $/kWh for billing. If there are a high number of kWhs per kW of peak demand, more kWhs will be allocated to lower priced tiers and total unit costs to the customer will be lower. This type of rate structure has the effect of rewarding high load factor customers while charging more to those with poor load factors. HUD rates are difficult for storage economics because there is no discrete demand charge or opportunity for TOU arbitrage.

Table 3.3.1
Example hours of use demand charge.
Source: James Bride, Energy Tariff Experts, LLC.

Example Monthly Metered Usage & Demand Values

Usage (kWh)	Demand (kW)
170,000	400

Unit costs go down w/ each successive tier
This results in lower costs for customers w/ high load factors

Apportionment of kWh into Hours of Use Demand Tiers for Billing

Tier	Size of Tier Based on Max Demand	Calculation	kWh Apportioned to Billing Tier	Unit Cost for Tier ($/kWh)
1	1st 100 kWh per kW Demand	400 kW x 100 =	40,000	$0.10
2	Next 100 kWh per kW Demand	400 kW x 100 =	40,000	$0.08
3	Next 100 kWh per kW Demand	400 kW x 100 =	40,000	$0.06
4	All additional kWh	170,000 – (Tiers 1, 2, &3)	50,000	$0.04
		Total Billed kWh	170,000	

ISO-NE has a capacity market where customers are charged based on their contribution to the annual system peak load hour. Figure 3.3.5 shows the daily peak loads during the summer of 2017. The red column shows the day where the peak load hour occurred. The snapshot in the lower right-hand corner shows the load of an example customer during the peak load hour (which is shaded in orange). The average demand of the customer during this peak load hour is used in order to assign a “Capacity Tag,” which then determines demand charges for capacity that will apply during the next year. Depending on the utility and market, coincident peak demand charges can be applied on the distribution or supply portion of a customer’s invoice.

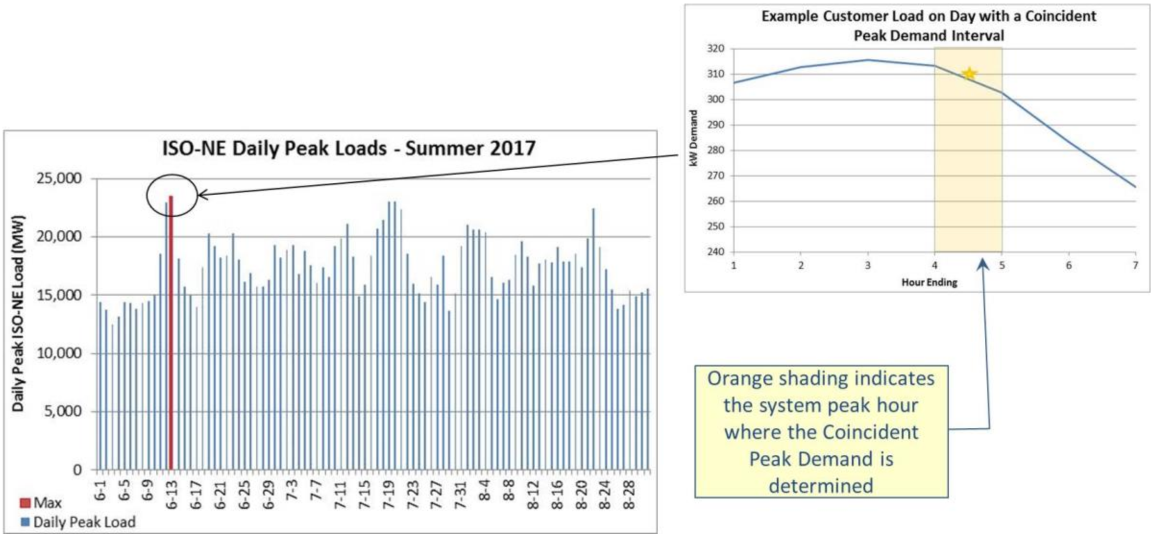


Fig. 3.3.5
Example of coincident peak demand.
Source: James Bride, Energy Tariff Experts, LLC (with data extrapolated from ISO New England Energy Load & Demand Reports).

Challenges in Energy Storage Related to Rate Design

Energy storage economics are dependent upon the ability to arbitrage energy from low to high value time periods. Rate design elements that accomplish this include high demand charges, coincident peak charges, and time of use rates.

Table 3.3.2
Summary of storage-friendly rate elements.
Source: James Bride, Energy Tariff Experts, LLC.

Rate Design Element	Characteristics Favorable to Storage
Demand Charges	High demand charges ($20+/kW-month) determined in a defined time period
TOU Usage charges	A high differential in volumetric energy charges between peak and off-peak time periods
Coincident Peak charges	Demand charges based on end user consumption during the grid's maximum load hour. These rate elements are favorable to storage when they can be reasonably predicted with data from the grid operator and charges for coincident peak demand exceed $10/kW-month

Unfavorable rate design elements include demand ratchets, low demand charges (< $10/kW-month), and flat rates for usage. Demand ratchets are particularly problematic because a 15-min. demand peak can result in an increase in monthly demand charges for the next eleven billing cycles. Demand ratchets leave no margin for error in battery performance risk. HUD structures also tend to be unfavorable because they lack discrete demand charges.

Standby rates can be particularly problematic for storage because they effectively function as additional monthly fixed charges. Some utilities have historically used standby charges to reduce the economic viability of cogeneration and, more recently, solar generation. Standby charges are typically billed monthly on a $/kW basis per unit of installed distributed generation. If standby rates are applied to customers with energy storage, they may reduce or eliminate the economic benefits of storage.

Eligibility for net metering is another rate design aspect that can significantly affect energy storage. Net metering is a rate design whereby renewable generation facilities send the grid any “extra” energy generated, and receive in return, over a monthly netting period, retail credit for net exports. Most net metering programs were designed 10+ years ago; their designers never contemplated the colocation of storage with renewable generation. As a result, this is a rapidly evolving issue in rate design. Over concerns related to “roundtripping” grid power instead of only exporting “green” power, some utilities have adopted prohibitions on net metering participation by customers that have both renewable generation and storage. Depending on the characteristics of the host load, a prohibition on net metering for sites with renewable generation and storage can present a significant constraint to system sizing.

Wholesale market and utility demand response programs were designed with the presumption that load curtailment or back-up generation would provide demand response capacity. Demand response is a potentially significant revenue source for storage in certain markets, but programs need to be designed in a way that allows for storage to augment curtailment at a participant customer site.

Implementation of FERC Order 841 opens wholesale markets to storage resources over 100 kW, but definitions of storage resources, rules for participation, and available markets vary widely. (See BPG 01: Project Development, Chapter 4 *Energy Regulatory* for a detailed discussion of FERC Order 841. Also see BPG 03: Project Economics, Chapter 2 *Applications* for a discussion of wholesale and reliability applications potentially available to storage through FERC Order 841.) Participation of storage resources in retail tariffs, incentive programs, and wholesale power markets is an emerging issue. For example, a storage resource that is optimized to flatten peak demand in a behind-the-meter application would be precluded from offering capabilities into the wholesale market (e.g., reserves, regulation, etc.) during any hour when the onsite load has the potential to incur a peak demand. This is one of many examples of mutual exclusivities that, in practice, limit the achievable “value stack” to a smaller number of revenue streams.

While retail and wholesale storage incentives and markets are unlikely to be fully harmonized, shortening the commitment durations for wholesale grid services such as reserves would allow batteries to increase their participation in wholesale markets outside of the hours related to mission critical tasks such as demand charge management. For example, many RTOs require reserves to be provided in full day increments, whereas in some RTOs regulation services can be scheduled on an hourly basis. Unsurprisingly, due to generally shorter commitment periods, regulation has been a more attractive market for storage relative to reserves.

Best Practice

Behind the Meter Systems

Although the concept of best practices in rate design for storage is still evolving, Table 3.3.3 includes selected best practices and the utilities or jurisdictions that have implemented them. (This is a non-exhaustive list.)

Table 3.3.3
Selected best practices in rate design for energy storage.
Source: James Bride, Energy Tariff Experts, LLC.

Best Practice	Description	Example Application
Short peak periods with high demand charges	Peak periods of six hours or less with strong incentives for load shaping	SDG&E Rate AL TOU
High Coincident Peak Demand Charges	Coincident Peak Demand charges that are high cost and based on energy usage during short, predictable intervals.	PSE&G Rate LPLS
Exposure to Wholesale power market prices	Customers are exposed to wholesale power markets with the potential for significant differences in hourly prices	Commercial rates in ERCOT
Defined Policy for Colocation of Storage and Renewable Generation	Clear provisions on interconnection and compensation for exports from hybrid energy systems	NY Hybrid Energy Storage System Tariff – 12/13/2018 NY PSC Case 15-E-751
Incorporation of Storage into Interruptible Rate Design	Large customers on interruptible rates are allowed to use storage to meet load drop requirements for interruption events	Ad hoc applications to date
Prohibition on Standby Rates for DERs	Utilities are precluded from imposing standby charges on DERs via regulation or legislation	MA Green Communities Act
As Used Standby Demand Charges	If a utility does impose a standby charge, that it be applied on a pro-rated "as used" basis to reward consistent resource uptime	ConEd Rider Q,
Storage participation in demand response programs	Customers participating in demand response are allowed to use storage to augment/firm their load shedding capabilities	
Retail Payment for Capacity Value of Exports	Payments for systems that can demonstrate capacity value during peak load intervals on the grid	NY VDER tariff Capacity payment Alternative 3

Front of the Meter Systems

Standalone renewable generators are often referred to as "Front of the Meter" (FOM) systems. Examples of these systems include community solar gardens or other solar arrays that monetize their production via virtual net metering, wheeling tariffs, feed-in tariffs, or hybrid tariff designs such as New York State's Value of Distributed Energy Resources (VDER) tariffs. Some of these tariffs contain elements of both retail and wholesale compensation structures. Other retail tariffs may compensate renewable generation exports via hourly Locational Marginal Pricing (LMP), which is set via a pricing point in the relevant wholesale power market. As a result, further integration of storage, and storage paired with renewables, is blurring the lines between retail and wholesale tariff structures.

Table 3.3.4
Retail compensation types for FOM storage.
Source: James Bride, Energy Tariff Experts, LLC.

Best Practice for FOM	Description and Implications for Storage Economics
Time Varying Energy Payment	Time varying payment rate for energy or application of wholesale hourly spot prices can reward energy arbitrage
Incentives for Discharge During Peak Periods	Adders or increased payments for discharge during defined peak periods can compensate storage for its dispatchability
Capacity Payments	Payment for demonstrated performance during peak load intervals during a defined period

Resources

- OpenEI - https://openei.org/wiki/Main_Page
- Regulatory Assistance Project (RAP) - https://www.raponline.org/
- "Principles of Public Utility Rates", James C. Bonbright, Columbia University Press 1961. "Understanding Today's Electricity Business"

Project Economics

Chapter Four: Project Proforma

Chapter Lead: Richard Baxter, Mustang Prairie Energy

Background

The proforma provides an integrated economic evaluation of the proposed energy storage project. The proforma generally takes the form of a project financial model covering all the years of operation and is structured to consider the forecast of all of the expected cash flows, expenses, and financial accounting such as taxes, depreciation, and other fees. Once agreed on, it will serve as the basis for structuring the project's financing agreement.

Project proformas are analytical tools developed by project developers to ascertain the financial viability of a proposed project. Developers use them to evaluate the sensitivity of a proposed project as it relates to a variety of assumptions and possible market conditions, while equity and debt providers use them to evaluate the soundness of a project's ability to provide the required return, and the project developer's assumption and approach. Through evaluating the sensitivity of the model to the potential range of input conditions, the equity and debt providers can gain a better understanding of the risk-adjusted return for the project.

The modeling framework of a project economic model is generally straightforward, even for energy storage projects with complicated operation usage profiles. The complication in the modeling arises from how closely the framework will track the actual economic operation of the facility. Because of the differing capital and operating characteristics of different energy storage technologies, a critical issue is to separate any technical biases from impacting the comparison of a particular project's economic analysis that is based on one technology versus another. Evaluating these differences in equipment costs and system capabilities comes into play when financiers and developers need to replicate their market models in order to optimize multiple project revenues.

Energy Storage Challenges

Project economic models themselves are relatively straightforward, so the critical challenge is providing visibility into their economic and operating assumptions, making sure to consider changes resulting from supporting multiple applications

The revenue from an energy storage facility will be expressed as a contracted revenue stream from a PPA (Power Purchase Agreement), derived from merchant activity by the facility, or some combination thereof. Depending on the services provided, the revenue will be based on the capacity (kW) or energy (kWh) provided. Besides revenue, some energy storage systems provide value from savings through such cost avoidance measures as peak shaving. This value stream will be recognized as a revenue stream in the modeling, but some care should be taken as savings are not treated the same for taxes or financing treatments.

System costs have become less of an unknown over time as familiarity with energy storage systems increases. The variable component remains with the operating costs. Greater familiarity with these operations is reducing the variability, but this understanding still lags that of the initial costs due to the time required to create a sufficient base of operating time and experience.

Electricity prices can influence, sometimes significantly, and have a significant impact on overall operating costs as they will express themselves in both the station power loads (HVAC, controls, etc.) and the efficiency losses that occur when charging and discharging. The rates for these costs may vary by jurisdiction, especially for behind-the-meter deployments. The relevant electricity prices will experience variability in both market segmentation and regional differences. This is another area of direct interest for developers as they typically have to contract separately for the station power needs of the facility.

The cost of capital—debt/equity ratio and equity and debt costs—is critical to the profitability of a project. These cost values are typically specific to the developer as elevated levels are proxies for the level of risk that the lender assigns for a specific developer or project. The debt to equity ratio can have a noticeable impact on the overall return for the project. Cost of capital is also strongly affected by the familiarity and comfort of the investor with the business model and the accompanying variables. As repetition of project formats increases, we can expect a corresponding decrease in capital cost similar to what has been experienced with solar projects.

Tax deductions for depreciation are generally available in respect of U.S. federal income and state income. These deductions are typically based on the amount paid for the storage facility, less half of any investment tax credit claimed in respect of the storage facility. U.S. federal income tax deductions are currently available at an accelerated rate for most, but not all, taxpayers in respect of storage projects. For taxpayers who can claim depreciation deductions in excess of income from a storage project (in general, corporations that own an interest in a storage project directly or indirectly through a partnership and, in some cases, individuals), these accelerated rates generally improve the financial viability of storage projects because the deductions are front-loaded and therefore more valuable under time value of money principles. State income tax deductions for depreciation often follow the federal law, but there is some variation at the state level. It also should be noted that in times of low income tax rates, depreciation deductions are less valuable in real terms.

Local property taxes also impact how energy storage facilities will be treated. To date, local governments have generally had little experience in this area, but some state incentives are currently available. For example, California currently has a valuable property tax incentive for taxpayers who place storage facilities in service.

Although economic and financial assumptions do not typically drive the profitability decision for a project, poor choices and usage may frequently accentuate volatility and needlessly increase the level of uncertainty. The choice of economic and financial assumptions for project modeling is the purview of the project developer. The source should be reputable, consistent, and provide a clear methodology for its assumptions so that the developer can answer questions from lenders regarding these key drivers. The U.S. Energy Information Administration publishes the widely used Annual Energy Outlook, a publication which provides long-term energy projections for the United States based on existing regulatory, economic, and technical assumptions and trends. For project developers, this modeling system provides comprehensive and detailed economic pricing drivers with ample supporting methodology for a project located in different parts of the United States. In addition to the central report, there is an appendix containing the output for the various components of the model. The value here is in the publication's consistency, as much or more so than its accuracy. Competing forecasts such as those from Bloomberg NEF's New Energy Outlook are also available, but they may not have the same depth and broad acceptance.

Best Practice

The Best Practice for energy storage proforma modeling are a patchwork, with some already established, and others still evolving. But the framework for developing a sound and robust project financial model covering energy storage projects is the same as any other energy project development. The components that are still evolving pertain to those parts of the analysis framework that are specific to the energy storage market. This would include any proprietary analysis framework to account for specific market understanding and assumptions, limitations of the energy storage module according to the required usage profile, and how the application of stacking interacts with the limitations of battery capabilities.

There are three key frameworks needed to understand the development of best practices for a project's proforma model, and thus to understand the level, or degree of development, of any best practices in the industry.

The first framework "how we are trying to use the proforma model" provides a transparent, analytical framework for the financial analysis of a proposed energy storage project.

The second framework, "what we are trying to show," goes to the strength of the argument that the project developer is trying to make about the proposed energy storage project. Since energy storage project economics are by no means easy, the strength of the argument for the soundness of the project's economics thus lies on the level of detail in the tools and the pertinent scenario analysis that the developer is able to bring to bear. In particular, the understanding of the impact of existing and possible market price drivers, and the ability to highlight where a project can be at an advantage vis-a-vis others, is important. As the number of applications grows, the requirements to support them become fundamental to any modeling framework. Both third-party models and models internal to a project development team are rapidly gaining in capability and fidelity.

The third framework, "who is the audience," concerns first determining the audience, and then understanding what they are looking for in the results of the model. Generally, the audience for the proforma models is investors—either equity or debt providers. In general, many in the investing community continue to be surprised by the variability in the modeling capability and quality upon which energy storage investment decisions are based. But this group is quick to add that they are seeing a marked improvement in 2019 and believe this trend will continue. They do, however insist they must still review the models for mistakes in coding and market assumptions. The latter review need is based on evaluating the developer's understanding of market data and assumptions, and then understanding the impact these assumptions have on the model. For this reason, having a scenario approach is useful as it gives greater credence to the strength of the analysis. What some investors believe they typically need is not necessarily the right answer (at least initially), but the right thought process. Many investors have worried that the models sometimes feel that they were worked in reverse—starting with a financially successful project, and then working back toward the beginning of the modeling analyses with some unrealistic initial assumptions tucked away. A developer's ability to robustly defend the whole spectrum of proforma assumptions will strengthen the case being made to his financiers.

One final point about models is that they are simply tools, and thus different approaches give different answers. For example, in evaluating the levelized cost of storage, different assumptions will provide different answers—even using the same initial cost data—because the questions the model is attempting to answer are different. As another example, one could develop a proforma of a project based on production costs, and that would be different from others such as the Lazard LCOS, which looks to understand what is the market revenue input price for the model in order to achieve a desired project return.

Resources

- Wilson Sonsini Project Finance Guide.
  - https://www.wsgr.com/PDFSearch/ctp_guide.pdf

- U.S. Energy Information Administration - Annual Energy Outlook.
  - https://www.eia.gov/outlooks/aeo/

- BloombergNEF New Energy Outlook.
  - https://about.bnef.com/new-energy-outlook/

Project Economics

Chapter Five: Case Study

Chapter Lead: Ray Byrne, Sandia National Laboratories

Background

Grid resilience is becoming a high priority for many stakeholders. Motivating factors include the widespread outages caused by Hurricane Katrina in New Orleans, Hurricane Maria in Puerto Rico, and Super Storm Sandy in the northeastern United States. This case study focuses on the resilience needs of a small municipal electric utility in Sterling, Massachusetts.

The Sterling Municipal Light Department (SMLD) is a progressive public power utility located 10 miles NNE of Worcester, Massachusetts in the town of Sterling. Serving the Town of Sterling for over 100 years, SMLD has more than 3,700 residential, commercial, municipal and industrial customers. Customers are fed power through approximately 160 miles of distribution lines.[1]

As stated in the *Proceedings of the 2017 IEEE Power and Energy Society (PES)*:

> A member of ISO New England (ISO-NE) and a wholesale aggregator of power with power purchases from generation throughout New England and New York, SMLD has a long history of investment in renewable generation. Approximately 35% of its power generation comes from renewable sources, primarily wind, hydro, and solar. Solar accounts for approximately 30% of the department's peak load. Two 1-megawatt solar installations went on-line in 2013, placing SMLD at the top of the Solar Electric Power Association's Top 10 utility rankings for the year for new solar watts per customer. The SMLD system currently has 3 MW of solar installed.[2]

The primary design goal was to provide reliable power to first responders in the event of an extended outage caused by a large storm. Outages caused by winter storms are common in New England. This definition of resilience assumes there will be several days warning in advance of the storm in order to have sufficient time to ensure that the energy storage system is fully charged. This is less challenging than other resilience applications where the time of the event/outage is unknown. Another design goal was to size the system for other potential benefits—also known as "blue sky" benefits—that might help pay for the investment. (See the Resources section for an additional case study, report and presentation.)

Energy Storage Challenges

The challenges associated with the Sterling project are common to many resilience- related applications: that the expected benefit using value of lost load (VoLL) calculations rarely results in a significant benefit, leaving project developers to find other applications to justify the capital investment. To meet these challenges, SMLD considered the following grid services:

- Energy arbitrage.
- Frequency regulation.
- Grid resilience.
- Reduction in the Forward Capacity Market (FCM) obligation.
- Reduction in the Regional Network Services (RNS) obligation.

The value of energy arbitrage was estimated by an analysis of historical market data from ISO-NE.[3] A Linear Program (LP) optimization algorithm was applied to estimate the maximum potential revenue, assuming perfect foresight (best case).[4] A similar analysis was also applied to estimate the maximum potential frequency regulation revenue. For grid resilience, value of lost load data from Lawrence Berkeley National Laboratory was employed.[5]

The category that best fit the Sterling application was public administration (small commercial and industrial). However, this category did not capture the benefits associated with maintaining power to critical loads that can prevent loss of life—such as communications with first responders. In this case, the forward capacity market obligation was calculated based on the load during the annual peak load hour as identified by ISO NE (see Table 3.5.1.), and the prices from the forward capacity market. (Forward capacity market prices are set at auction several years in advance. The RNS (Regional Network Services) payment is based on the load during the monthly peak hour defined by ISO-NE. The RNS rate for 2015 was $98.70147/kW-yr.[6]

Table 3.5.1
SMLD Capacity Clearing Price, ISO-NE. Period runs from June 1 to May 31.
Source: R. H. Byrne, S. Hamilton, D. R. Borneo, T. Olinsky-Paul and I. Gyuk, "The Value Proposition for Energy Storage at the Sterling Municipal Light Department," in Proceedings of the 2017 IEEE Power and Energy Society (PES) General Meeting, Chicago, IL, 2017.

Year	Price ($/kW-Month)
2010-2011	$4.254
2011-2012	$3.119
2012-2013	$2.535
2013-2014	$2.516
2014-2015	$2.855

Year	Price ($/kW-Month)
2015-2016	$3.129
2016-2017	$3.150
2017-2018	$7.025
2018-2019	$9.551
2019-2020	$7.030

The energy storage challenges with this project included:

- Estimating the resilience value: VoLL calculations didn't properly capture the value of maintaining power to critical loads that can save lives (e.g., first responders).
- Market uncertainty impacting the prices for energy, frequency regulation, and the forward capacity market.
- Uncertainty associated with future RNS prices.
- Uncertainty in the ability to estimate the times of the monthly and annual peak load hours.
- Regulatory risk: Changes in the definition of the capacity and RNS obligations would impact future potential revenue.

The risk of forecasting the peak hours was mitigated by increasing the size of the storage system so that the capacity was two hours. Increasing the discharge time increased the likelihood of capturing the peak load hour.

Best Practice

A best practice for any energy storage deployment is to quantify the potential benefits from each grid service that the system will provide. Consideration of the potential use cases and the associated charge/discharge profiles also feeds into the technology selection process. Depending on the applications, some technologies might perform better than others. In market areas, potential revenue can be estimated from historical market data.

Assessing the perfect foresight case is important because it provides an upper boundary on expected revenue. It is also important to evaluate realistic forecasting algorithms that do not rely on perfect foresight. In many cases, frequency regulation provides the maximum benefit. In these cases, the optimum policy is to provide frequency regulation—which does not require any forecasting—all the time. In cases of multiple grid benefits that provide a similar monetary benefit, it is important to evaluate the feasibility of providing these benefits simultaneously. For the energy storage system, this is accomplished by analyzing time series data with a state of charge model. Often this is formulated as a rolling horizon optimization problem.[7] A common mistake is analyzing each benefit independently and then adding up the benefits. This often results in double counting. By performing a time series analysis with an energy storage model, the charge/discharge constraints of the system are properly considered, along with the state of charge constraints.

In a vertically integrated utility, the analysis of energy storage benefits often involves quantifying cost savings from the energy storage deployment. In the Sterling example, these cost savings were associated with a market. With energy storage, production cost modeling is frequently required to quantify the potential savings from more efficient operation of the generation fleet.[8] For energy storage deployments related to technical performance (e.g., voltage support in a distribution network), the value of storage is the cost of the lowest price alternative that meets the technical need.

Often, the monetizable benefit from energy storage is tightly coupled with the regulatory framework. This introduces regulatory risk; a change in the regulations might impact future potential revenue. A thorough understanding of the regulatory framework and potential changes to the framework that might impact future potential revenue is highly recommended. Since energy storage is still a relatively new technology, there is the potential to influence the evolution of the regulatory framework in order to level the playing field for energy storage. Meeting with regulators prior to deciding on deployment is also highly recommended.

In many cases, there are non-monetizable benefits associated with the deployment. Examples include carbon reduction and resilient power to first responders. Sometimes the monetizable benefits justify the investment. If the non-monetizable benefits are the primary reason for investment, additional analysis is often required to both accurately estimate the societal benefits and make the argument for deployment.

Resources

- S. Galbraith, T. Olinsky-Paul, “Resilient Power Project Case Study,” Sterling Municipal Light Department, March 2018, available at: https://www.cleanegroup.org/wp-content/uploads/Sterling-case-study.pdf

- R. H. Byrne, S. Hamilton, D. R. Borneo, T. Olinsky-Paul and I. Gyuk. "The Value Proposition for Energy Storage at the Sterling Municipal Light Department," in *Proceedings of the 2017 IEEE Power and Energy Society (PES) General Meeting*, Chicago, IL, 2017, available at:

”https://www.cesa.org/assets/Uploads/SterlingMA-2017PES-SAND2017-1093.pdf

- Webinar: “The Value Proposition for Energy Storage at the Sterling Municipal Light Department,” available at https://www.cesa.org/webinars/the-value-proposition-for-energy-storage-at-the-sterling-municipal-light-department/

- https://www.cleanegroup.org/wp-content/uploads/Sterling-case-study.pdf

- https://cesa.org/assets/Uploads/SterlingMA-2017PES-SAND2017-1093.pdf

- https://cesa.org/webinars/the-value-proposition-for-energy-storage-at-the-sterling-municipal-light-department/

References

[1] “NEC Energy Solutions to Supply Sterling MA With the Largest Battery Grid Energy Storage Installation in New England,” 2016. https://www.neces.com/assets/STERLING_Press_Release.
[2] R. H. Byrne, S. Hamilton, D. R. Borneo, T. Olinsky-Paul and I. Gyuk. "The Value Proposition for Energy Storage at the Sterling Municipal Light Department," in *Proceedings of the 2017 IEEE Power and Energy Society (PES) General Meeting*, Chicago, IL, 2017.”
[3] Benjamin Whitney Griffiths. Reducing emisions from consumer energy storage using reltail rate design. Energy Policy. 2019;Vol. 129: 481-490.

[4] R. H. Byrne, S. Hamilton, D. R. Borneo, T. Olinsky-Paul and I. Gyuk. "The Value Proposition for Energy Storage at the Sterling Municipal Light Department," in *Proceedings of the 2017 IEEE Power and Energy Society (PES) General Meeting*, Chicago, IL, 2017.”
[5] Solar Electric Power Association (SEPA), "SEPA utility solar rankings," 2013. [Online]. Available: http://www.solarelectricpower.org.
[6] R. H. Byrne, S. Hamilton, D. R. Borneo, T. Olinsky-Paul and I. Gyuk, "The Value Proposition for Energy Storage at the Sterling Municipal Light Department," in *Proceedings of the 2017 IEEE Power and Energy Society (PES) General Meeting*, Chicago, IL, 2017.
[7] M. J. Sullivan, M. Mercuriov and J. Schellenberg, "Estimated value of Service Reliability for Electric Utility Customers in the United States," Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA, 2009.
[8] R. H. Byrne, T. A. Nguyen, D. A. Copp, B. R. Chalamala and I. Gyuk, "Energy Management and Optimization Methods for Grid Energy Storage Systems," *IEEE ACCESS,* vol. 6, pp. 13231-13260, 2018.

ENERGY STORAGE BEST PRACTICE GUIDE 4:

TECHNICAL PERFORMANCE

Technical Performance

Chapter One: Overview

Chapter Lead: Scott Daniels, Schneider Electric

Background

The technical performance of an energy storage system is central to the ability of the developer to design a profitable system for the project, and for the operator to ensure that the system will reliably perform per the requirements of the contracted services.

Many aspects of technical performance are critical for the overall success of the project. These include:

- Data Interoperability.
- Degradation / Augmentation.
- Performance Measurement.

Data Interoperability refers to the need to standardize the data elements in reporting so that key performance indicators on different projects can be shared widely without corruption of the descriptive data.

Degradation is the reduction in capacity (kWh) of the battery's energy storage capacity over its lifespan. Different energy storage technologies will experience degradation at different rates. Some technologies will show little or no degradation, while others will experience significantly more. Augmentation is the addition of extra energy storage capability over the life of the system to ensure sufficient usable energy for any contractual or desired operation.

Performance measurement is a critical requirement in order to define the technical performance of the energy storage system. The first step in this process is to clearly define the applications so that the performance of the unit can be measured in a systematic and comparable manner. Varied applications will require different application metrics to define the specific needs of each application.

Technical Performance

Chapter Two: Data Interoperability

Chapter Lead: Dixon Wright, USI Insurance

Background

The question as to how data is administered and leveraged both internally and externally for energy storage projects is critical to achieving increased efficiency, improving data analytics, reducing costs, and increasing profits. These goals have been the focus of countless data standards efforts, and the foundation for established standards bodies.

Data standards for energy storage are a specialized niche. For all standards, the value proposition is increased when specific data elements are incorporated into federally recognized machine-readable multi-industry data standards such as Key Performance Indicators (KPI). With KPI, data elements can be utilized and leveraged for other up-stream purposes in various supply chain market segments. The potential is maximized when the upstream use of aggregated KPIs enables better administration and improves risk management, which in turn can attract capital and financial market support for energy storage.

Improved data interoperability will, with data analytics for underwriting and predictive analytics for risk management and loss control, support innovations at emerging ConstrucTech, InsurTech, and FinTech companies to drive down costs and improve access to capital. The resulting products and services from capital markets will be more competitively priced, and insurance and surety financial markets will leverage data to better define terms and conditions, as well as coverages and claims response. Data with secure, reliable data interoperability that’s based on industry-adopted data standards and standardized model contracts is the requirement necessary to promote and accelerate ConstrucTech, InsurTech and FinTech company development of innovative products and services.

Appendix 1 in the Appendices section (see end of chapter for Appendices) provides a chronological history of data standards, with links that provide background information on the various efforts that culminate in a multi-stakeholder data exchange open standard model.

Appendix 2 is an alphabetical list of the leaders involved in crafting the data platform for the Smart Grid—with each leader contributing individually and in collaboration within the stakeholder network.

Appendix 3 is a presentation from the Global Climate Action Summit Impact Event, with a call to action that outlines recommended data standard structures and objectives.

To offer positions and provide the foundation for implementation during the drafting of this guide, the chapter's final section outlines these recommendations to further expand data interoperability and enable electronic commerce.

- Identify and engage with all trade associations and various standards efforts that intersect with energy storage in order to compare and compile all the data elements already defined in some format.

- Expand the XBRL[1] Orange Button taxonomy to include as many of the common data elements for energy storage as possible that break the data silos between the capital and financial markets and the regulators, utilities, corporate offtakers and the construction community.

- Identify and implement multi-stakeholder pilot projects with trade associations to accelerate the development of data interoperability that is based on federally recognized machine-readable data standards.

- Explore the public benefit for how storage stakeholders might leverage the work already completed under the US DOE-funded Orange Button.

- Align with the UN Sustainable Development Goals.

Energy Storage Challenges

The most essential components of best practices are efficiency, effectiveness, and cost/benefit—each of which is directly impacted by the underlying foundation of how data is managed, administrated and, most importantly, exchanged between stakeholders. This reality has resulted in numerous efforts to streamline data exchange through the establishment of multiple industry-specific data standards, with each having its own unique data terms and definitions.

The legacy data standards efforts identified in Appendices 1 and 2 have created a vast wealth of resources and a network of industry collaborators—all striving to achieve the same objective: support data driven decisions via a secure and reliable data exchange across the supply chain and throughout the ecosystem.

These legacy data standards efforts have also created a highly fractured ecosystem with thousands of disparate systems, a large number of data standards, and an incalculable number of data exchanges—all of which impose inefficiency and constrain effectiveness. The potential cost of implementing the wrong "single" data standard frequently overrides the potential benefit and advancement toward true data interoperability.

The federal policy of establishing data sets and standards such as the Green and Orange Buttons enables free, secure, and reliable data interoperability between stakeholders. It also provides the fundamental structure for innovation in planning, procurement, construction, and improved risk management. However, adoption and implementation require consensus.

Consensus is the result of individuals and trade associations collaborating with public and private entities on ways to make a positive impact. This encompasses attracting capital through impact investing, developing new financial products and services as part of impact underwriting, driving business processing improvements though impact programing, developing STEM programs that leverage universities for impact campuses and, most importantly, impacting policy that provides direction and clarity.

The Green Button, the established data set for energy consumption, has generated several innovative apps that target ways to reduce energy demand via applying data analytics to identify where improvements in consumption can be made.

The Orange Button, the data set for energy production, expands the XBRL taxonomy—a federally recognized, machine-readable data standard—by over 5,000 data elements to enable data interoperability and data analytics for the construction and operations of solar facilities across multi-industry segments.

The Orange Button and XBRL taxonomy allow the creation of standardized forms, contracts, policies and procedures, including monthly operating reports for solar construction with standardized electronic surety bonds. Model forms and contracts can streamline the entire process from original concept to permitting through construction, as well as provide ongoing monitoring for improved and efficient risk management—all so projects are more bankable and bondable.

Storage bankability will be impacted by how challenging situations between project stakeholders are resolved. An orderly process with predictability and reliability for loss mitigation will serve to enhance storage bankability—regardless of whether the financial security posted is a letter of credit or a surety bond.

To help remove confusion caused by unsynchronized data standards, the United Nations, along with many federal, state and local initiatives, has been actively engaged in promoting data interoperability between industry silos. Synergizing multiple data standards for top level Key Performance Information (KPI) data interoperability, while maintaining the independence and value of each individual data standard for its constituency's specific needs, requires collaboration and neutral platforms and solutions.

The DOE's Orange Button collaboration with XBRL is one effort that will have a direct impact on energy storage. It is a resource for developing best practices—not only because it is neutral, but also because it supports multi-industry segments. The Orange Button XBRL taxonomy is designed to attract capital, finance, insurance, and surety products for the construction of clean energy and infrastructure projects.

Best Practice

The best way to facilitate financing and surety credit support for energy storage is not to create a separate or siloed approach to storage, but to consider a holistic approach for the entire system, with storage as a synergized component of that system—not a stand-alone asset.

To synergize components of an energy system there must be an established data interoperability capability with industry-adopted data element terms and definitions. This not only allows a “plug and play” type of structure for procurement and construction, but a way to quantify, monitor, and measure performance so that obligations can also be quantified in contracts, and clearly understood by the capital and financial markets.

Under the leadership of SunSpec Alliance and eXtended Business Reporting Language (XBRL)[2], the DOE-funded Orange Button removed the technological barrier for data interoperability. It did so by expanding the XBRL taxonomy for the construction and operation of solar facilities on the Smart Grid. The Orange Button collaboration with the capital and financial markets to establish data interoperability also expanded the federally recognized XBRL, which public companies, including many utilities, use to report financial data to the Securities and Exchange Commission. This comprises many of the data elements used in the construction and operation of solar facilities for reporting to the capital and financial markets.

The objectives of the Orange Button were to reduce soft costs by streamlining the administration and processing of financing, and for securing insurance and surety on projects. The objective of many of the Orange Button collaborators is to leverage the DOE Orange Button XBRL data for implementing improved risk management. This occurs by enabling portfolio administration where the data originates at multiple disparate systems operating under multiple vendor and O&M systems. With data standards, the data received will be in a consistent format that can be measured and monitored for predictive analytics and improved risk management.

While the data elements themselves are valuable for maximum impact from the capital and financial markets, these elements need to be consistently applied within the contracts themselves. This is so standardized and/or model contracts, and related contract forms including surety bonds, letters of credit and insurance policies, will prove beneficial.

The DOE Orange Button and the expanded XBRL taxonomy provide secure, reliable data interoperability based on industry-adopted data standards, and can be used for standardized model contracts. Standardized contracts that utilize industry-adopted data standards that enable improvements in risk management and predictive analytics will improve the ability to secure financing, insurance, and surety. On the other hand, contracts and related forms with non-standard terms need to be manually reviewed and underwritten. In addition to the underlying contract risk, the need for ongoing contract monitoring (which requires individual attention and processing) will not make it easy for a party to secure competitive financing, surety, and insurance.

Recommended Areas of Focus

Data Interoperability

- Promote the use of XBRL Financial Industry Business Ontology (FIBO)[3] and other federally recognized, machine-readable data standards to stimulate innovation and competition.

- Prohibit the use of proprietary data standards for a data exchange that constrains innovation and stifles competition for compliance with public laws.

- Promote the use of industry trade group-published data sets to be synergized with federally recognized, machine-readable data standards like XBRL and FIBO, and have the respective trade associations maintain and update their data sets as warranted—and have those data sets remain under their control for the benefit of their constituency.

- Prohibit any industry trade group from imposing any constraints, licensing requirements, or fees of any kind on the use of the trade association data set if that data set has contributed to, and has been incorporated into, machine open data standards like XBRL and FIBO.

Digital Commerce

- Promote the use of secure electronic bonds. There are a number of competitive companies that already provide this service.

- Prohibit the continued use of expensive and burdensome paper bonds that are subject to fraud.

- Promote the use of competitive industry standardized surety bond delivery and administration systems on all public works.

- Prohibit public agencies from imposing proprietary bond delivery and administration systems. Examples are PennDOT and Nationwide Multistate Licensing System and Registry (NMLS)[4].

Multi-agency Data Interoperability

- Require all federal, state and local agencies to adopt federally recognized, machine-readable data standards such as XBRL and FIBO as part of any funding provided by the government under MGT Act 4, the Federal Information Technology Acquisition Reform Act, and other standards or legislation that provide funding for system upgrades.

- Prohibit all federal, state and local agencies that (1) receive funding from adopting or implementing a data standard or reporting requirement that does not utilize federally recognized, machine-readable data standards like XBRL and FIBO or (2) adhere to any requirement that is a "silo approach" to a single industry, trade association, or government entity.

Cyber

- Promote the engagement of stakeholders in best practices for cyber risk mitigation via the federal government by providing, as part of the Cybersecurity Information Sharing Act, clear policies and procedures which, when followed, provide legal liability cover for all entities and stakeholders.

- Provide a national defense posture for providing private entities and stakeholders with a national cyber protection resource that includes real time monitoring and threat detection to establish an offensive approach to mitigating cyber risk.

- Engage with USI working group members as part of the National Cybersecurity Public-Private Partnership.

Appendices

- ACES Working Group - Technical Performance - Data Standards - Appendix 1 - Chronology and Resources
    - http://nebula.wsimg.com/a61f1859e95716740ffc3c5344ceb1b2?AccessKeyId=0F2A1D2434293D46EBEC&disposition=0&alloworigin=1

- ACES Working Group - Technical Performance - Data Standards - Appendix 2 - Leadership and Resources
    - http://nebula.wsimg.com/a952e596b93e58e0ee8d02a8ee0f929a?AccessKeyId=0F2A1D2434293D46EBEC&disposition=0&alloworigin=1

- ACES Working Group - Technical Performance - Data Standards - Appendix 3 – Global Climate Action Summit Impact Event
    - http://nebula.wsimg.com/eced4dd3cfb5cf38cf127cc5ade2c847?AccessKeyId=0F2A1D2434293D46EBEC&disposition=0&alloworigin=1

Resources

- https://xbrl.us/home/industries/surety/
  XBRL is the financial reporting data standard all public companies use to report to the federal government as a public resource and free to use, so it is not industry specific and synergizes terms and definitions for key data elements to assure consistent terms and definitions for every data element regardless of data source, or industry specific data standard.

- https://www.nibs.org/page/bsa
  The National Institute of Building Sciences NBIMS-US Project Committee (National BIM Standard-United States Project Committee) is a leading standards

body for the construction industry and will have significant impact in building the Smart Grid.

- https://www.constructionprogress.org/
  The Construction Progression Coalition (CPC) is a non-profit organization uniting Architecture, Engineering, and Construction (AEC) Professionals, Technology Solution Providers (TSPs), and their governing organizations (GOs) around a shared language to define project interoperability standards. CPC is transforming the future of digital project delivery through a Common Data Exchange (CDX) that includes building the smart grid, with its component parts, including energy storage.

- http://www.missiondata.io/
  MissionData is a national coalition of technology companies that empower consumers with access to their own energy usage and cost data.

References

[1] XBRL, And Introduction to XBRL, https://www.xbrl.org/the-standard/what/
[2] Resource Page, EDM Council, About FIBO: The Open Semantic Standard for the Financial Industry, https://edmcouncil.org/page/aboutfiboreview#
[3] Nationwide Mortgage Licensing System, https://nationwidelicensingsystem.org/Pages/default.aspx; Pennsylvania Department of Transportation. https://www.penndot.gov/ProjectAndPrograms/RoadDesignEnvironment/Posted%20and%20Bonded%20Road%20Program/Pages/default.aspx
[4] Modernizing Government Technology Act 12DEC2017, Pub. L. No. 115-91, National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, § 1076 through 1078, 131 Stat. 1283 (2017).

Technical Performance

Chapter Three: Degradation/Augmentation

Chapter Lead: Richard Baxter, Mustang Prairie Energy

Background

An energy storage project's performance over its lifetime is greatly affected by the factors of degradation and augmentation. Understanding these two items is critical to meeting the project's contractual requirements.

Degradation

Degradation is the reduction in capacity (kWh) of the battery's energy storage capacity over its lifespan. Different energy storage technologies will experience degradation at different rates, with some technologies showing little or no degradation while others experience significantly more.

Degradation is driven by the process of how the energy is transformed into the storage medium; technologies relying on electrostatic, mechanical or purely reversible chemical reaction will experience little or no degradation during the transformation of the electrical energy. Chemical energy systems—batteries—do undergo physical change, and thus degradation during the charging and discharging process, thereby losing some portion of initial battery capacity over their operating life. However, this is not true of all chemical storage systems; flow batteries are generally designed for limited to no degradation of energy storage capacity during operation.

Degradation comes through two pathways: calendar aging and cycle life. Calendar aging accounts for the eventual capacity loss resulting from slow chemical changes to the batteries. The cycle life aging of the battery is driven by factors that can reduce the cycle life. They include operating temperature, operating range for the state of charge, charging rate, and discharging rate. Therefore, over the life of the system, how much energy can be cycled through will decline. Depending on how the energy is used, this decline will be faster or slower.

Augmentation

Augmentation represents the additional energy storage equipment needed for the system over its lifespan in order to maintain the capability agreed to under the performance guarantee. This is often described as usable energy (kWh) capacity, which is the amount of energy targeted or required to be cycled through the system daily throughout the system's lifespan. However, if the energy storage system is slated for providing capacity (kW) instead of energy (kWh), then a different (and lower requirement) augmentation schedule would be required to ensure the cycling capability for the energy needed.

Augmentation requirements are based strongly on the performance capabilities of the energy storage technology in question, and the usage profile of the energy storage system during operation.

Energy Storage Challenges

A variety of challenges exist for energy storage systems to be able to manage the usable capacity of their energy storage systems with respect to an intended application requirement.

Degradation

Degradation schedules are found in the warranties from the different battery OEMs. As with many chemical cell technologies, degradation of the primary type of energy storage system used today—lithium-ion—depends upon a variety of usage factors to determine the degradation the system will experience. In addition, each OEM within a storage technology family has a slightly different chemistry and manufacturing process, which requires different capabilities from one vendor to the next. A further challenge for project developers is the constantly evolving—and improving—quality and capability of these systems, especially with respect to a potential variable usage profile. This leaves the developer with the need for a very clear and detailed understanding of the degradation of the system and the limitations this will imply for various usage profiles.

Augmentation

Augmentation schedules aim to find the least-cost approach to obtain the required capability of the system over its lifespan. The challenge is to map the declining cost of batteries (and improving capabilities) with the expected usage profile over time—leaving sufficient capacity in the battery to provision the needed usage requirements (and avoid penalties), but not have excessive amounts of spare capacity.

To easily ensure sufficient capability over the life of the system, the project developer could simply overbuild the energy storage system, but that strategy can be needlessly expensive as batteries today cost more than they will in the future. Due to the declining cost of the equipment, the typical cost minimization strategy is to push off into the future as much of the augmentation as possible as future batteries are expected to cost less.

Determining the least-cost augmentation schedule will continue to vex many project developers who desire to use the energy storage facility for a number of applications. Thus, the result is typically some mixture of initial oversizing—with augmentation occurring a few years into the future, but as infrequently as possible in order to minimize the labor component.

The requirement for the initial oversizing of the battery system arises from the need to match the cycle life of a battery with the intended usage profile of the energy storage system. This is especially true for chemical batteries. The cycle life of a battery depends on a number of factors; two important ones are the Depth of Discharge (DOD), and the cycling range of charging and discharging in each cycle. For instance, a battery will have a cycle life of X cycles when cycled at 100% DOD for each cycle. If the cycle life—X—of the battery at 100% DOD is less than the desired lifespan, the cycle lifespan of the battery can be extended by reducing the range of the DOD for each cycle. Therefore, by adjusting the DOD from 0% to a 100% state of charge (SOC) on each cycle to then cycle between 10% SOC and 90% SOC (80% DOD for each cycle), the cycle life of the battery is extended.

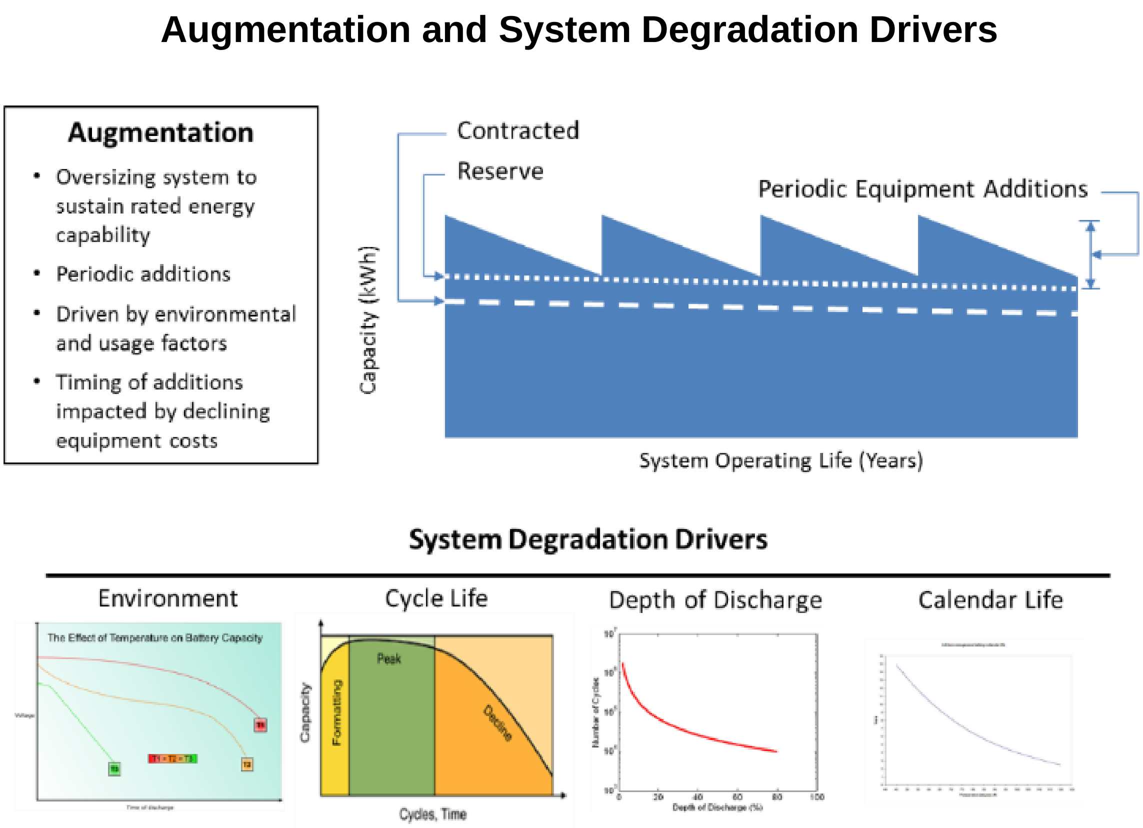


Fig. 4.3.1
Augmentation and system degradation drivers.
Source: Richard Baxter, Mustang Prairie Energy.

This impact on the battery's cycle life varies by technology. Technologies such as flow batteries and flywheels are designed to cycle their entire energy range without degradation. Chemical batteries such as lithium-ion or lead will experience an increase in their cycle life as the range of charging and discharging of energy per cycle is reduced. (Changes also vary by cathode chemistry in lithium-ion cells.) Additional attributes that will impact the life of the battery include operating temperature and the rate of charging/discharging.

Augmenting the energy storage capacity of a facility often means adding more than just additional batteries. Specifically, for lithium-ion batteries this question manifests as to whether the project is only required to added DC battery modules, or complete AC level systems. The issue is based on the ability to add new battery modules in line with existing, older battery modules tied to a common inverter—which has been the practice for many cost-conscious developers. As the modules will have different electrical properties (due to age), balancing them becomes more difficult. However, if the modules are instead added to the overall system with a new inverter (at the AC level), or with a DC-DC converter, then the new modules can be electrically isolated from the older ones and run with more reliable performance over time, albeit at a slightly higher capital cost.

Best Practice

Managing the degradation, and finding the least-cost augmentation schedule, is high on the list for project developers looking to craft a cost-effective capital budget for their energy storage facility.

Degradation

Successfully managing degradation of the energy storage module over the project term relies on system integrators who are able to balance the designed capability of the technology with the hoped-for application profile requirements. This typically starts with a detailed understanding of the degradation profile of the cells, including the environmental and usage impacts under different usage profiles. For instance, running the system at an elevated temperature saves on both the cooling and parasitic load requirement, but shortens the lifespan of the cells and, if allowed to operate at too high a temperature, would violate the warranty. Knowledge of the different equipment OEMs is also critical as one vendor's equipment capabilities will differ from another.

By integrating the capabilities of storage technologies and least-cost strategy, OEMs and integrators can provide solutions for specific usage profiles that deliver stable, usable energy capacity over the life of the system or, alternatively, a declining assured capacity over time.

Typically, projects needing assured energy capability such as asset deferral or renewable time shift will need to ensure full usable energy over the system's lifespan. Projects that can manage with a declining usable energy capacity will be more focused on power availability and ramping capabilities.

Augmentation

A variety of augmentation strategies exist, each with their own benefits and costs. Oversizing of the system pushes the costs up front but saves on future installation costs. Periodic augmentation allows for a lower-cost approach to match the capacity needs, but it requires additional balance of system cost to absorb additional modules and labor costs. Finally, the replacement of individual modules has been suggested as a middle ground approach to reducing capital outlays while benefitting from reduced battery costs. However, to date, this approach has not worked well because of the technical needs involved in balancing the varying voltage of the different modules on a particular battery string (below the inverter).

Resources

- David Conover Et Al., Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems (PNNL-22010Rev.2/SAND2016 3078R) (Pacific Northwest National Laboratory and Sandia National Laboratories Apr. 2016), https://energystorage.pnnl.gov/pdf/PNNL-22010Rev2.pdf.
- Raymond H. Byrne, Matthew K. Donnelly, Verne. W. Loose, and Daniel J. Trudnowski, Methodology to Determine the Technical Performance and Value Proposition for Grid-Scale Energy Storage Systems, (Sandia National Laboratories 2012), http://www.energy.gov/sites/prod/files/2017/01/f34/SNL_ARRA_report_final_SAND2012_10639.pdf
- Davion Hill &Michael Mills-Price, 2018 Battery Performance Scorecard, https://www.dnvgl.com/BatteryScorecard.

References

[1] Pennsylvania Department of Transportation, https://www.penndot.gov/ProjectAndPrograms/RoadDesignEnvironment/Posted%20and%20Bonded%20Road%20Program/Pages/default.aspx

Technical Performance

Chapter Four: Performance Measurement

Chapter Lead: Scott Daniels, Schneider Electric

Background

Measuring energy storage performance presents a variety of challenges. The first is to clearly understand the problem before delving into the various types of energy storage solutions. This process starts by borrowing best practices from product design and development, with the goal of forming a list of requirements. These requirements will then eventually lead to detailed specifications.

It is also important to understand the general problems that energy storage is trying to solve—renewables integration and peak shaving among them. But for many industry players, there is no clear understanding of the metrics that are directly impacted by these general problems. A key first step is defining the application metrics for all energy storage applications. Doing this allows for a ranking of these application metrics so that technical performance can be assessed and measured. What follows is a list of application metrics that can be used for all energy storage applications. Note that these metrics can be applied to other forms of battery applications, ranging from uninterruptable power supplies (UPS) and EV batteries to portable power batteries including cell phones, tablets and wearables.

Table 4.4.1
Key energy storage metrics.
Source: Scott Daniels, Schneider Electric.

Key Energy Storage Performance Metrics

Metric	Units	Definition	Notes
Energy Density	Wh/L	Energy for a given volume	When volume is a concern
Specific Energy	Wh/kg	Energy for a given mass	When mass is a concern
Power Density	W/L	Power for a given volume	When volume is a concern
Specific Power	W/kg	Power for a given mass	When mass is a concern
Self Discharge	% / Yr	Self discharge over time	Discharge when not connected
“Cost” - Power	$/W	Cost of each Watt delivered from a battery system	Power applications
“Cost” - Energy	$/Wh	Cost of each Wh delivered from a battery system	Energy applications
Elevated Temp	°C	Service/operational temperature	Elevated temperature applications
Cold Temp	°C	Service/operational temperature	Cold temperature applcations
Cycle Life	Cycles	Cycles before EOL* is reached	Temp, Rate, DOD etc..?
Shelf Life	Years	How long can the cell sit on a shelf before EOL*	Temperature Influence
Calendar Life	Years	How long can the cell be connected/on before EOL*	Temperature Influence
Safety	0-7	Per SAE Standards: 0=Safe, 7=BOOM	Refer to UL, SAEJ2464 & EUCAR
Roundtrip Efficiency	%	The total efficiency of both charging and discharging	Important for Renewables Integration & Similar
Disposal	$	The cost to reuse, recycle and/or dispose	Important to account and prepare / plan for
Manufacturability		How easy is it to manufacture	Cell focused
Supply Robustness		Are materials readily available	Cell focused: Cobalt etc. also # of cell suppliers

When examining these metrics, keep in mind that battery storage end of life (EOL) is typically 80% for automotive and roughly 65% for stationary or initial capacity batteries.

These metrics provide a clear and universal way of communicating what is important about energy storage applications and how the various energy storage key metrics rank in level of importance for a given application. One straightforward way to rank these metrics is with a simple scale: High, Medium and Low. To do this, it's helpful to borrow a concept from Agile software development called "Story Pointing." In story pointing, software developers rank tasks associated to user stories that are based on qualitative, not quantitative efforts. Just like story pointing, ranking application metrics is a qualitative process.

This process begins with a flexible template that can be applied to all energy storage applications. The focus is on a typical "Time of Use" application. Note that this is an example, and each application may likely have nuances that differ from application to application. While these may seem nearly identical, they are not. (For example, consider indoor versus outdoor energy storage time-of-use applications.)

The following figure focuses on a time-of-use application that targets Peak Load Shift and Demand Response. Please note that this time of use application assesses and ranks a multi-use energy storage solution. This example can easily be separated into separate Demand Response and Peak Load Shift applications.

Time of Use (TOU)

Peak Load Shift & Demand Response : Target Med to Large Format Mid-Rate / Energy Cells

Voice of Application
Outdoor solution with HVAC
Near Room temperature operation – Slightly elevated due to self heating
Space is very limited
Concrete pad will be used when installed – Weight is not a concern
Safety is very important
Power Reduction for a given time
Cycling is frequent

Multi Use Battery

Energy Storage System

2 to 6 hour run-times: C/2 to C/6

Metric	Units	Importance	Notes	Metric	Units	Importance	Notes
Energy Density	*Wh/L*	High		**Elevated Temperature**	°C	Med	
Specific Energy	*Wh/kg*	Med		**Cold Temperature**	°C	Low	
Power Density	*W/L*	Med		**Cycle Life**	*Cycles*	High	
Specific Power	*W/kg*	Low		**Shelf Life**	*Years*	Med	
Self Discharge	*% / Yr*	Low		**Calendar Life**	*Years*	Med	
"Cost" – Energy	*$/Wh or Wh/$*	High		**Safety**	*0-7 (UL, SAE, EUCAR)*	High	
"Cost" – Power	*$/W or W/$*	Med		**Round Trip Efficiency**	*% (>90%)*	Med	
Manufacturability		Low	*Supply Chain*	**Disposal**	*$*	Med	
				Supply Robustness		Med	*Supply Chain*

Explanations

Metric	Importance	Why
Energy Density	High	This is an Energy Application
Specific Energy	Med	Mass is not as important as volume
Power Density	Med	This is an Energy Application
Specific Power	Low	This is an Energy Application and mass is not important – Concrete pad
Self Discharge	Low	The battery will always be connected and used frequently
"Cost" – Energy	High	This is very important – Energy Application
"Cost" – Power	Med	This is an Energy Application
Manufacturability	Low	Can limit the number of suppliers – China is now adopting NMC
Elevated Temperature	Med	Can increase system efficiency running at elevated temperatures
Cold Temperature	Low	Not important since the battery will self heat when in use and container has HVAC & insulation
Cycle Life	High	The battery will cycle frequently – Greater than one cycle per day
Shelf Life	Med	Not that important since the batteries will not sit in inventory
Calendar Life	Med	Cycling dominates the aging of the battery, but calendar life impacts expected life
Safety	High	Always important – Safety cannot be compramized
Round Trip Efficiency	Med	Financial perforamce is based on Power Reduction Over Time
Disposal	Med	Disposal has no standard yet, but will.
Supply Robustness	Med	This can influence future pricing and availabilty

Fig. 4.4.1
Time-of-Use analysis.
Source: Scott Daniels, Schneider Electric.

Application Performance Metrics: Recognizing, Understanding and Ranking

This example focuses on a multi-use battery system and covers just one example. There are instances when energy storage integrators are developing battery systems for several different types of applications. They can, and often do, use this exercise to look for similarities in various applications in order to develop energy storage systems where a single battery system can be used for multiple applications. The goal of this approach is to build scale to reduce costs, establish product consistency to eliminate variability, create platforms that use like parts for better servicing, etc. Note that integrators need to form a cohesive product strategy that leverages platforms to drive value.

Step One

The first step is to conduct a "voice of application." This is very similar to a "voice of customer" exercise, but the application does not fill out surveys nor conduct interviews. This exercise is best approached by assessing the smaller nuances of the application—including indoor versus outdoor installations, space constraints, and roundtrip efficiency requirements. In this example, the energy storage system will be installed outdoors in a moderate temperature environment with HVAC equipment. In other cases, the application may not call for HVAC equipment.

Step Two

The second step is to rank all the application metrics in level of importance on a scale of High, Medium and Low. Remember that these rankings are relative to each other. Once this step is completed, the Time of Use data should be consulted for a deeper understanding of why a metric was ranked "important" versus "not important." Please note that solutions are not being addressed at this stage.

Step Three

The third step is to translate the highly ranked metrics into drivers and clearly identify these important drivers as the ones to be solved before the other drivers are considered. This time-of-use example has four metrics ranked as "High" in importance. These metrics—Energy Density, Cost of Energy, Cycle Life and Safety—are the primary drivers that need to be solved first. (They include safety, because if it were not a metric that was ranked, stakeholders would ask "Why isn't *safety* not important! Another note regarding the safety metric is that larger vertical cities often have risk adversity towards advanced batteries such as lithium-ion. This risk adversity stems from the legacy negative stigma of oxide-based lithium-ion battery cathode chemistries and their volatility. It's not always "What if the lithium-ion battery catches fire?" but rather "What happens if the lithium-ion battery is *in* a fire?")

Now that it's known what characteristics to look for in a battery system in order to satisfy the four primary drivers, the goal is to identify the battery systems that most importantly satisfy these four primary requirements and then satisfy the remaining secondary requirements. To do this requires progressing to the technical assessment of battery systems.

Energy Storage Challenges

Technical assessment of advanced battery systems is not a simple task. For example, lithium-ion advanced battery systems have many different components, starting with the cell leading to sub-modules, modules, racks, etc. The general key to driving up value with an advanced battery system is to incorporate the most active material possible into a given space. The active material within a battery system is what performs the chemical-electrical work. The remaining balance of the system material serves to support this chemical-electrical work.

To drive the most value in a battery system, one must start by assessing the root building block of the energy storage battery system. Which brings us to the battery cell and the many variables which drive battery cell design. (Again, remember that the overall active material percentage within a battery system is what drives battery system value.)

Today's advanced batteries have numerous cathode and anode chemistries, along with many different designs and sourced materials—all leading to a vast array of performance capabilities. The most common form of energy storage today is based on lithium-ion. The three most common cathode chemistries used in stationary energy storage are Lithium Nickel Manganese Cobalt Oxide (NMC), Lithium Iron Phosphate (LFP) and Lithium Manganese Oxide (LMO). Another cathode chemistry worth mentioning is Nickel Cobalt Aluminum Oxide (NCA), which, once its technical performance is improved, has the potential for use in stationary energy storage. All except LFP are oxide chemistries.

The most common forms of anodes are carbon based, resulting in oxide chemistries that have a nominal voltage ranging from 3.6 to 3.8 volts per cell. (LFP has a nominal voltage of around 3.2 volts per cell.) The oxide cathode chemistries have much greater energy densities when compared to LFP. Indeed, the trends for energy storage have been shifting from LFP to NMC, with the Chinese market now beginning to experience this transition.

LFP is often referred to as a safer cathode chemistry when compared to oxide-based cathode chemistries. That is because the oxygen in LFP chemistry will not evolve at elevated temperatures. The NMC cathode chemistry has seen vast improvements in safety and life over the last several years thanks to added ceramic safety layers, improved manufacturing quality, and new plant safety improvements. These NMC safety improvements have closed the safety gap between these two popular chemistries. Because of NMC's increased energy density over LFP, which, for NMC, has led to lower system prices and increased safety performance, NMC is now the preferred choice in lithium-ion cathode chemistry for energy storage applications (and electric vehicles).

To help better understand what else impacts battery system technical performance (omitting the common cathode and anode chemistries, along with their binders and plasticizers), what follows is a brief introduction into other variables that impact the technical performance of the root building block of an advanced lithium-ion battery system—otherwise, known as the battery cell. Starting at the cell level, this includes the design and sourced materials of the battery's many various components, illustrated here by a graphic that lists some of the cell design influencers on technical performance.

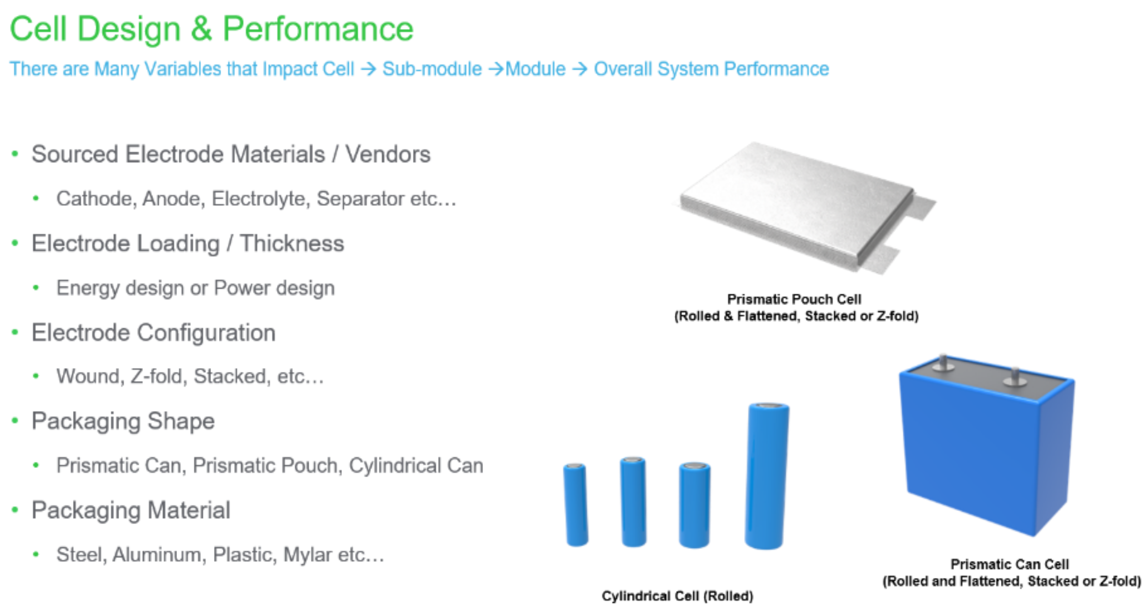


Fig. 4.4.2
Cell design and performance.
Source: Scott Daniels, Schneider Electric.

These variables are critical to the overall battery system design and resulting technical performance. Note that a bad cell design or cell selection will lead to greater inefficiencies downstream in the system design. An example of a poor choice in cell design or selection would be to use a small format cylindrical pure energy cell in a battery system that is targeted for a high cycle, mid-rate application such as renewables integration. The limiting characteristics of a cylindrical energy cell are the lower roundtrip efficiencies, resulting in greater cooling requirements, decreased cell packing efficiencies that result in less active material per given unit volume, increased numbers of small format cells leading to a more complex cell management system, and increased modes of failure from the numerous electrical connections. This example is not to single out small format cylindrical cells, but only to provide an example of cell choice and the resulting impacts on technical performance. Small format cells are ideal for applications that require a small format energy solution for laptop computers, tablets and cell phones.

The following is a list of common key attributes of a power cell versus an energy cell.

- Lower internal resistance.
- Better roundtrip efficiency @ similar rates.
- Requires less cooling @ similar rates.
- Greater cycle life.
- Less active material (thin electrodes).

- More complex to manufacture.
- Greater costs to manufacture.
- Lower energy densities.
- Lower specific energy.
- Higher power densities.
- Higher Specific Power[1].

Stationary applications are not the main drivers of battery system consumption and the technical evolution of advanced battery systems such as lithium-ion. The main drivers come, by orders of magnitude, from the automotive industry. (Automotive cell technology is stationary cell technology.) The following is a graphic that shows the relationships of the EV industry to stationary energy storage applications in terms of battery pack performance. Note that electric vehicles typically use large format cells, and that these cells are designed to provide greater power due to limited cooling options in an EV—which has resulted in the need for better roundtrip efficiencies. Also note that electric vehicles are constrained in both size and weight, which has led to the use of large format prismatic cells that have greater packing efficiencies.

Automotive Industry Drives the Energy Storage Industry (for now)

EV > PHEV > HEV for Total Energy = Battery Pack Size and Weight

Electric Vehicle (EV) = "Low-Rate or Energy Pack"
- Key Metric: Energy Density, Specific Energy, Temperature
- Shallow DOD Low-Rate Cycles (Rarely 100% DOD): Moderate Cycle Life
- Decent Charge Acceptance
- Good Low-Rate Roundtrip Efficiency

Energy = 1 to 4 hours
1C to C/4

Plug-in Hybrid Electric Vehicle (PHEV) = "Mid-Rate Pack"
- Key Metric: Energy & Power Density, Specific Energy & Power, Cycle Life, Temperature
- Varying DOD Mid-Rate Cycles (often 100% DOD): High Cycle Life
- Very Good Charge Acceptance
- Excellent Mid-Rate Roundtrip Efficiency

Mid-Rate ~ 30 min to 1 hour
2C to 1C

Hybrid Electric Vehicle (HEV) = "High-Rate or Power Pack"
- Key Metric: Power Density, Specific Power, Cycle Life, Temperature
- Many Varying DOD High Rate Cycles (Often 100% DOD): Very High Cycle Life
- Excellent Charge Acceptance
- Excellent High-Rate Roundtrip Efficiency

Power = 15 to 30 min
4C to 2C

12V Start Stop or idle Reduction

Micro-Hybrid Electric Vehicle (MHEV) = "Very High-Rate or High Power Pack"
- Key Metric: Power Density, Specific Power, Cycle Life, Temperature
- Many Varying DOD High Rate Cycles (Often 100% DOD): Very High Cycle Life
- Excellent Charge Acceptance
- Excellent Very High-Rate Roundtrip Efficiency

High Power = 5 to 15 min
12C to 4C

48V Start Stop or idle Reduction

Micro-Hybrid Electric Truck (MHET) = "Extreme Rate or Very High Power Pack"
- Key Metric: Power Density, Specific Power, Cycle Life, Temperature
- Many Varying DOD High Rate Cycles (Often 100% DOD): Very High Cycle Life
- Excellent Charge Acceptance
- Excellent Extreme High-Rate Roundtrip Efficiency

Very High Power < 5 min
>12C

Fig. 4.4.3
Automotive industry as it relates to energy storage.
Source: Scott Daniels, Schneider Electric.

Next comes an expanded discussion on lithium-ion battery chemistries, which includes a power chemistry Lithium Titanate (LTO), plus a comparison of battery chemistries. Because it covers most of the stationary energy storage applications—and in order to keep things simple—this approach will differentiate only between energy and power batteries.

What follows is a table that compares seven different cell and chemistry types of Tier 1 battery manufacturers, ranking each cell performance metric. The rankings are poor (P), good (G), very good (VG), and excellent (E).

Table 4.4.2
Tier One cell technology comparison.
Source: Scott Daniels, Schneider Electric.

Cell Tech Comparison: Tier ONE Suppliers

Metric	Power (LFP)	Power (LTO)	Power (LMO)	Power (NMC)	Energy (LFP)	Energy (NMC)	Energy (NCA)
Energy Density	P	P	P	G	G	E	E
Specific Energy	P	P	P	G	P	E	E
Power Density	E	E	VG	G	G	G	P
Specific Power	E	E	E	VG	G	G	P
Self Discharge	E	VG	E	E	E	E	VG
"Cost" – Energy	P	P	P	G	G	E	E
"Cost" – Power	E	VG	E	E	VG	VG	P
Elevated Temperature	VG	P	G	VG	VG	VG	VG
Cold Temperature	VG	E	VG	P	VG	P	P
Cycle Life	E	E	VG	VG	E	VG	G
Shelf Life	E	VG	E	E	E	E	VG
Calendar Life	E	G	VG	E	E	E	VG
Safety	E	E	VG	VG	E	VG	G
Round Trip Efficiency	E	E	E	VG	E	E	G
Disposal	P	P	P	P	P	P	P
Manufacturability	E	VG	VG	VG	E	VG	G
Supply Robustness	E	P	E	VG	E	VG	VG

This table matches up well to the previous "Time of Use (TOU)" Voice of Application and performance metric ranking.

The next step is to assign values to the rankings and calculate them in order to generate a heat map. The following is a simple heat map that steers the ranked application to a Tier 1 cell technology.

Table 4.4.3
TOU application heat map.
Source: Scott Daniels, Schneider Electric.

TOU Application Cell Technology Heat Map

	Power (LFP)	Power (LTO)	Power (LMO)	Power (NMC)	Energy (LFP)	Energy (NMC)	Energy (NCA)
Time of Use (TOU)	30	30	24	30	36	42	36

Table 4.4.4
Multi-application heat map.
Source: Scott Daniels, Schneider Electric.

Multiple Application Cell Technology Heat Map

	Power (LFP)	Power (LTO)	Power (LMO)	Power (NMC)	Energy (LFP)	Energy (NMC)	Energy (NCA)
Grid Stabilization	48	45	39	36	39	33	18
Time of Use (TOU)	30	30	24	30	36	42	36
Renewables Integration	50	49	43	45	53	59	44
Time of Use (TOU) EV	38	37	31	36	41	47	38
Stable Grid 3-Phase UPS	36	33	30	27	27	24	12

The heat map generated is steering the application to use an Energy (NMC) cell. The next step is to run this exercise through other applications and their ranked performance metrics such as grid stabilization and renewables integration.

Not meant to be used to make decisions, this information should be regarded as a technology guide—something that steers applicable parties towards the correct decision. Note also that there may be instances where compromises should be made—including building scale, multi-use battery systems, and risk adversity factors.

Best Practice

Multiple Dependencies That Impact Performance

The performance metrics stated earlier are not independent from each other for a given application. If we were to just ask how long a battery system will last, we need to be careful to understand that performance metrics work together and will impact the life of a battery system and its overall performance. To elaborate, cycle life is not independent of calendar life. If you have a 10-year calendar battery system that is capable of 10,000 cycles, these must be taken simultaneously. This means the maximum life is 10 years if you never cycle the battery.

To keep things simple, let's assume that each cycle is controlled—and equal. Cycling will happen 500 times each year. After five years the battery has expended 50% of its usable life in standby mode and 25% of its life cycling. Now the battery only has 25% remaining life after only 5 years. Note that this is not remaining capacity, but rather design life. We can clearly see that this battery will only last 7.5 years under this simplified use. Remember that this is a very simplified model, and once variability in depth of discharge, rate, and temperature are added in, things get complicated very fast.

Therefore, performance modeling and simulation are critical to both the success of the battery system and the financial performance of the project.

What Happens as Battery Systems Age?

As battery systems age, the operating characteristics change. When we evaluate battery systems, one of the first questions that should be asked is, "Is this battery system designed for end-of-life operation?" The reason for this is because as batteries age, they not only loose capacity, they also have increasing internal resistance—which leads to decreased rate capabilities. The decreased rate capabilities will have a negative impact on roundtrip efficiencies and require more cooling as more heat is generated during operation. If these design challenges are not taken into consideration, there can be a compounding aging effect since the temperatures of the cells will increase as they age and result in a shorter life, lower operational performance, and produce a negative financial performance.

Resources

- Institute of Electrical and Electronics Engineers, *IEEE Std 1547.1a™-2015 (Amendment to IEEE Std 1547.1-2005) Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems; Amendment 1*, 2015, available at: https://standard.ieee.org/standards/1547_1a-2015.html (Content available for purchase – free for subscribers).

- Working Group Meeting, Institute of Electrical and Electronics Engineers, New York, NY: 2015.*IEEE P1547.1 Draft Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces* (Oct. 27, 2016), available at: http://grouper.ieee.org/groups/scc21/1547.1_revision/mtgMinutes/P1547%201-20160601-conbined%20slide%20for%20minutes.pdf.

- Electric Power Research Institute, *ESIC Energy Storage Test Manual 2016*, EPRI, 3002009313, available at: https://www.epri.com/#/pages/product/3002009313/?lang=en-US

- DNV GL – 2018 Battery Performance Scorecard, available at:

  https://www.dnvgl.com/publications/2018-battery-performance-scorecard-132103.

References

[1] Presentation, Scott L. Daniels, "Introduction to Energy Storage Application Metrics, Mar 9, 2016, http://nesa.org/file/11474/download?token=ouyye6Qa.

ENERGY STORAGE BEST PRACTICE GUIDE 5:

CONSTRUCTION

Construction

Chapter One: Overview

Chapter Lead: Richard Baxter, Mustang Prairie Energy

Background

The construction process has a number of important attributes. These include:

- Engineering, Procurement, and Construction (EPC) Contracts.
- Commissioning.
- Recommended Practice for Installing Energy Storage Systems.

EPC contracts govern the installation design and construction process for an energy storage facility. For this reason, the experience of the firm providing these services is critical. Designed to clearly state the requirements for all parties to an energy storage project, these contracts support the successful execution of deployment, lay the foundation for profitable operation, and are a key component in attracting lenders through clearly stating and dealing with the primary areas of project risk.

Commissioning is an important function that should not be overlooked. Commissioning an energy storage system ensures that all components and the integrated system itself are installed, tested, and ready for operation according to the OEM's and system integrator's checklists. This process does not simply start when the construction is completed but reaches back into the design phase where the commissioning team became familiar and comfortable with the equipment vendors' commissioning procedures. They do this by reviewing the equipment specifications and applicable codes and standards that the system is required to meet, and review (if provided by the integrator) or develop an integrated Sequence of Operations (SOO) for the commissioning process.

Finally, the National Electrical Contractors Association (NECA) published an ANSI-approved standard NECA 416-2016. This standard is titled *Recommended Practice for Installing Energy Storage Systems* (ESS). NECA 416 describes:

> the methods, procedures, and best practices that should be used for installing multiple types of energy storage systems. It also includes information about controlling and managing energy storage systems, as well as commissioning and maintaining energy storage systems. The standard's focus is specifically on installations of battery systems, flywheels, ultra-capacitors, and electric vehicle (EV) smart charger vehicle-to-grid (V2G) technologies that are used for storing electrical energy in on-site wiring systems.[1]

Two additional, and important, resources found in the NECA 416 document are installer and inspector checklists.

References

[1] Paul Dvorak. “Recommend Practice for Installing Energy Storage Systems.” June 23, 2017. https://www.windpowerengineering.com/projects/policy/recommended-practice-installing-energy-storage-systems-now-available/.

Construction

Chapter Two: EPC Contract

Chapter Lead: Richard Baxter, Mustang Prairie Energy

Background

For the majority of developers, the construction and delivery of their individual energy storage facility is coordinated via a contract with an EPC firm. The EPC firm must be capable of providing highly specialized engineering, procurement, installation, construction and commissioning services via a number of subcontractors and suppliers who will undertake specific aspects of the scope of work. These contracts are designed to clearly allocate the division of responsibilities between the developer of the energy storage projects and the firm responsible for the energy storage systems installation. A key component in attracting lenders by clearly allocating the primary areas of project risk, the EPC contract lays the foundation for a profitable operation.

EPC contracts are typically "turnkey"—requiring the EPC firm to deliver a facility ready for commercial operation by a specified date and within a specified budget, subject to customary change order provisions for unknown conditions, force majeure, developer-caused delays, and other factors. Through detailing the different parties' responsibilities with regard to the project, the EPC contract aims to both deliver the project according to the schedule while also limiting opportunities for the different parties to claim cost overruns.

Besides expertise and experience, developers are increasingly turning to EPC firms to provide another critical project component: a complete energy storage equipment warranty wrap that ensures system-wide protection in the form of a defect warranty and performance warranty. These instruments may also include warranties of availability and energy capacity degradation.

The willingness of a particular EPC firm to provide this coverage will be based on the familiarity and confidence of the EPC firm with the various components (battery modules, BMS, controls, PCS, HVAC etc.), and with its own engineered, designed, and integrated energy storage system.

For these reasons, an experienced EPC firm is quickly becoming an indispensable partner for lenders, project developers and utility customers. Indeed, the EPC firm is the group responsible to the developer for knitting together all of the technical details of the equipment and the project. As is quickly becoming apparent, the multifunctional operational capabilities of an energy storage system are a central area of concern, posing the question: *Will all the components of the energy storage system still be able to perform to their fully stated operational range when coupled together*? [1]

For many multi-component systems both in and out of the energy storage industry, the answer is a guarded, though oft times, emphatic *no*. The solution is for the developer to work closely with the EPC firm—which will be the management source, and a single source at that—for the technical challenges faced during the deployment of the energy storage system. Since the industry is rapidly expanding with multiple vendors of different components, EPC firms are facing a potentially large performance risk acceptance in order to win contracts. In response, it is natural for EPC firms to then look for ways to reduce the risks they are requested to cover—ways including down-selecting vendors to a smaller pool so there is a greater working relationship with OEMs of key components.

Payment terms for EPC contracts are typically a fixed amount, essential for the project developer to have in order to craft a reliable budget for the project. A critical issue raised by many interviewees in a recent DOE study[2] concerns who is responsible for cost over-runs when the inevitable changes happen to the original plan. On the surface, cost over-runs, as well as benefits from any potential cost savings, would typically be covered by the EPC firm—as agreed to in the contract. However, since the market is still relatively young, most EPC firms interviewed for the study believe that the typical movement would be towards cost over-runs. In reality, significant negotiations usually take place to cover as may contingencies as possible, with the EPC firm building into their bid sufficient space for some cost over-runs. When significant changes to the contract occur, change order agreements dealing with these scope changes are negotiated separately.

Energy Storage Challenges

In the aforementioned study[3] involving project developers, EPC firms, and other storage parties revealed that there are five areas of EPC contract coverage which can provide significant challenges in developing an energy storage project.

Table 5.2.1
Contract coverage key areas.
Source: ACES Working Group.

Key Areas of EPC Contract Coverage	
1	Project Development
2	Project Management
3	Engineering
4	Procurement
5	Construction

Project Development

Developers typically undertake project development activities such as site selection, zoning and land use permitting, local AHJ approvals, and site development prior to the issuance of an RFP for selection of an EPC firm. However, it will be the responsibility of the EPC firm to perform its duties within this framework.

Project Management

The EPC firm provides a single point of contact and is responsible for staying on budget and following the project timetable. The EPC firm is also responsible for adhering to local ordinances and regulations in the permitting process. Project developers interviewed highlighted the need for the EPC firm to have a good working relationship, and regular communication, with the developer during the process to highlight any concerns for impending issues so they can be dealt with in a timely manner. EPC firms with significant project development experience, especially in similarly sized energy storage projects, are thus highly valued.

Engineering

The system integrator firm provides the system engineering design and documentation for the facility for use during construction. It is the EPC firm's responsibility to incorporate this design and documentation into the project's site layout, engineering and integration studies, and required permitting.

The system integrator firm performs system design and component integration as they match up the required usage profile of the system with the technical capability of the equipment—all while managing the overall cost. This work includes understanding the differences between the stated capabilities of separate components, and their successful integration into the system.

Site design and construction are performed by the EPC firm. Project developers interviewed for the ACES study highlighted site-specific engineering costs as a major concern for project budget overruns. Although many of the experienced industry players continue to focus on leveraging those lessons learned from previous deployments, site specific requirements continue to drive up NRE (Non-Recurring Engineering) costs. Because of this, most project developers are trying hard to not pay for the EPC experience curve. In advance of quoting, this risk can be mitigated by completion of such site investigations as geo-tech, environmental site assessment, and storm water drainage planning.

Procurement

The EPC firm is responsible for procuring (with purchases either flowing through the firm or simply in coordination with it) all the components of the energy storage system according to the product specifications listed in the system design. As more vendors and system integrators enter the field, the EPC firm must base the selection of different components against vendor evaluations for quality and responsiveness—not simply price. The EPC firm is also responsible for contracting the shipping and transportation of equipment to the construction site.

As the market grows rapidly in the next few years, nearly all developers interviewed stated that they believe there will continue to be a number of periods where supply issues will directly impact their ability to deliver a project on time.

Construction

The EPC firm is responsible for coordinating the construction of the facility. One of the critical risks for construction overruns is in the site engineering, so experience with site assessment and development, environmental management, and foundation construction is imperative in order to maintain cost containment. The EPC firm's responsibilities include selecting subsidiary electrical contractors to assist with the installation and commissioning.

Project developers interviewed for the study stated that there remains a wide range of experience when it comes to EPC firms, and that many of the projects continue to be impacted by the site preparation and construction. EPC firms interviewed also agreed that the construction component can be far more expensive than originally thought, but that cost-overruns were driven by earlier changes in design that necessitated alternations in the construction and installation segment. Both parties agreed that specially built enclosures or containerized systems allow for ease of construction and installation.

Best Practice

EPC costs have proven to be one of the most fluctuating components of project costs. These costs vary significantly by market segment, with engineering and construction areas showing the greatest variability.

Variability in engineering costs is driven by non-repeatable engineering work, generally described as NRE costs. These can be significant due to the variability in locations, customer class of facility, and whether the facility is a retrofit or a green-field location. These NRE costs have so far been generally non-translatable from one deployment to another. Leaders at EPC firms also cite the lack in continuity in partners, both on the OEM and customer sides, for driving up the costs. EPC firms feel that having the opportunity to perform a number of jobs with a particular project developer would allow the two firms the chance to lower costs through a gained familiarity with work processes.

Procurement costs are derived from the purchasing and delivery of needed construction equipment. Procurement cost overruns can be driven by multiple factors, but those most unique to the energy storage industry relate to OEM supplier reliability on delivery timeliness. While a slippage in schedule can incur penalties for missing schedule milestones, this risk is of heightened importance for energy storage projects intended for summer peak capacity, since they typically need to be in service (COD) by June 1st—or run the risk of losing out on participating as a resource for that summer. These risks can be somewhat mitigated by utilizing liquidated damages clauses in the OEM equipment supply contracts.

Because there are a number of fixed costs that favor larger facilities, construction costs generally decline as a percentage of capital costs as the system size increases. As with engineering costs, there are also large site-specific factors that can drive up costs, especially for smaller systems where the energy storage unit is being installed into an existing structure with limited space and pre-existing electrical systems.

Finally, EPC firm costs are also impacted by exposure to the equipment warranty and any possible liquidated damages for delay or performance caused by facility construction issues. Project owners and lenders increasingly require a "fully wrapped" warranty from the EPC firm, thus making it responsible for all defects in design, equipment, and performance in the event the system fails performance tests. Lenders want to know that the project can perform to expected performance metrics (availability, round-trip efficiency, capacity) backed by liquidated damages (agreed upon compensation for a specific breach of a contract). For these issues, there will continue to be an evolution in the limits for EPC firm responsibility and liability as, over time, the full extent of system operations and reliability continue to emerge.

Resources

- Electric Power Research Institute, *ESIC Energy Storage Implementation Guide* 3002010896, 2017 available with membership at: https://www.epri.com/#/pages/product/3002010896/?lang=en-US

- DLA Piper, *EPC Contracts in the Power Sector*, 201l, available at: https://www.dlapiper.com/en/us/insights/publications/2012/02/epc-contracts-in-the-power-sector/

References

[1] Richard Baxter, Imre Gyuk, Raymond H. Byrne, Babu R. Chalamala, *Engineering Energy-Storage Projects: Applications and Financial Aspects*, IEEE Electrification Magazine (Volume: 6, Issue: 3, Sept. 2018). (Access requires subscription.)
[2] Sandia Report, Energy Storage Financing: *Performance Impacts on Project Financing*, SAND2018-10110, Sept. 2018.
[3] Id.

Construction

Chapter Three: Commissioning

Chapter Lead: Richard Baxter, Mustang Prairie Energy

Background

Commissioning an energy storage system ensures that all components of the integrated system itself are installed, tested, and ready for operation according to the OEM's and system integrator's checklists. This process does not simply start when the construction is completed; it reaches back into the design phase when the commissioning team becomes familiar with the equipment vendors' commissioning procedures. They do this by reviewing the equipment specifications and applicable codes and standards that the system is required to meet, and review (if provided by the integrator) or develop an integrated Sequence of Operations (SOO) for the commissioning process.

As part of the commissioning plan, safety is critical, and as such is incorporated into the commissioning process through first identifying the safety systems—fire suppression and sub-module containment (or physical separation)—that need to be installed, and then drawing up the site incident prevention plan.

Table 5.3.1
Tests and procedures needed to ensure the facility has been commissioned properly.
Source: ACES Working Group.

Key Commissioning Tests for Energy Storage Projects	
1	Factory Acceptance Tests
2	Operational Acceptance Tests
3	Functional Acceptance Tests

Factory Acceptance Tests

During the construction phase, the commissioning team tracks vendor Factory Acceptance Tests prior to equipment shipment to the site. It then reviews the installation procedures and inspections. The commissioning team also uses this time to ensure that site training and emergency response procedures are adequate, together with the on-site testing and startup procedures for the unit.

Operational Acceptance Test (OAT)

The Operational Acceptance Test will demonstrate the ability—or inability—of a system to operate safely. After each system component passes the test, that subsystem will be checked off and deemed ready for operation. Key components include mechanical, electrical, controls, electrical protection, safety, and communication subsystems. To ensure validation of the procedures, third-party testing is emerging to provide developers and lenders a second critical look at the system so that they have confidence in its successful operation.

Functional Acceptance Tests

The Functional Acceptance Test will ensure that the equipment and controls are operating successfully, and that the system is ready for its design operation according to the planned usage profile. The FAT can be performed multiple times via standardized testing plans and procedures designed to ensure that the system is able to perform the specific functions and applications for which it was designed, and that all sub-systems are able to work in concert. Increasingly, FATs have a special focus on the software, controls, data collection, and communications that are rapidly expanding a system's operational capabilities.

Training programs for operators have gained in significance as the complexity of the systems increase. The thoroughness of these programs is increasing due to an operator's need to be updated as equipment and control systems are modified by different vendors. Prior to signing off on the FAT, operation and maintenance procedures and warranties must be reviewed to ensure that the equipment's capability matches the intended operational requirements for the intended market role of the unit. This last step is critical as varying market roles may unintentionally force the system out of compliance with the warranty, thus violating clear tenants of the lender's requirements.

Energy Storage Challenges

The commissioning process for an energy storage facility is a critical juncture in the project development process. It is here that all components are checked and verified to show that they adhere to the integrator's design and standards, as well as local ordinances. Parties involved in the commissioning process face five specific challenge areas.

Inter-Party Coordination

Coordinating the actions of all parties involved in the commissioning process is essential for having an efficient and effective commissioning process. For this reason, it is imperative that all parties agree—and adhere to—a well-defined division of responsibilities for all components of the commissioning process.

An important component of coordination is the alignment of timelines for the various steps involved. For instance, different, but related, components such as the BESS (Battery Energy Storage System) and the PCS (Power Conversion Systems) systems are commissioned simultaneously, so coordination between different providers is required. One benefit as systems grow in size is that they can be commissioned on a sequential basis, allowing the most efficient access to the site for the different providers involved.

Scale

Energy storage systems have grown quickly in both size and complexity, leading to a more challenging commissioning process. Care is required as physical interconnection, controls and environmental conditions can all have different impacts on a larger system.

Pre-integration

To speed up and simplify the on-site integration process, components and systems are increasingly arriving at the site already integrated. This is especially true of controls and software, which means many PCS and BMS systems can be integrated early in the project in order to later prevent costly and time-consuming field integration work.

Interconnection

Many energy storage systems are designed to be grid-interactive with other parts of the electrical system. The interconnection of the energy storage asset requires that the hardware at the point of interconnection, the communication system, and the internal controls are all designed to ensure reliable and safe operation of the facility. As business models stress a need for new and innovative applications, the commissioning plan must ensure that all these attributes for the proposed interconnection are sufficient.

Operation

All parties involved in developing an energy storage project want the unit to be able to operate successfully; therefore, they need the commissioning process to prepare the unit for a transfer in routine operations—that transfer being the change in staffing from the installation crew to the day-to-day operations team. If not properly documented, this change can lead to a loss of system knowledge. In addition, the Commercial Operation Date (COD)—a key contractual milestone—must be properly documented for financial payments and risk transfers to occur.

Best Practice

Proper organization is critical for a smooth commissioning process. Organizational elements should include:

Test Plan

- A detailed test plan and schedule that ensures all mechanical, electrical, plumbing and structural systems are tested and verified to be acceptable.

- Documentation that shows all equipment passed the requisite tests and inspection.

Turn-Over

- A formal turn-over process which includes all system testing documentation and drawings.

- Complete documentation to manage control of assets during the turn-over process.

Training

- Planning for the qualified and experienced staff needed, including a commissioning manager, skilled construction crafts and labor support, and any engineering support required.

- Operator training conducted by trainers who are experienced in all aspects of the equipment's operational and maintenance components.

- Complete training manuals for all systems to support operating the unit under all expected conditions.

Start-up

- All pertinent documentation needed for the start-up of each subsystem and the complete unit.

Resources

- Institute of Electrical and Electronic Engineers, *IEEE Std 1547.1a™-2015 (Amendment to IEEE Std 1547.1-2005) Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems; Amendment 1* (2015), available at: https://standards.ieee.org/standard/1547_1a-2015.html (Content available for purchase)

- Institute of Electrical and Electronic Engineers, *IEEE P1547.1 Draft Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems and Associated Interfaces* (2015), available at: https://standards.ieee.org/project/1547_1.html (Content available for purchase)

- Electric Power Research Institute, *ESIC Energy Storage Test Manual 2016*, 3002009313 (2016), available at: https://www.epri.com/#/pages/product/3002009313/?lang=en-US

- Pacific Northwest National Laboratory Richland, Washington and Sandia National Laboratories *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems*, 22010 (Apr. 2016), available at: https://energystorage.pnnl.gov/pdf/PNNL-22010Rev2.pdf

- National Fire Protection Association, *NFPA 855 Standard for the Installation of Stationary Energy Storage Systems* (2017), available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70

- National Fire Protection Association, *NFPA 855 Standard for the Installation of Stationary Energy Storage Systems* (forthcoming in 2020), available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=855

Construction

Chapter Four: Electrical Contractors

Chapter Lead: Richard Baxter, Mustang Prairie Energy

Background

The installation of energy storage systems (ESS) is a critical milestone in a project's development, safety, and long-term optimum performance. Because of the nature and evolution of ESS technologies and systems, it is particularly important to select the right electrical contractor. A well-chosen electrical contractor will help ensure that numerous components are installed, commissioned, and maintained properly—even when physically incorporating new components and systems of the different OEMs.

Issues can arise, however, when developers, integrators and EPCs are not completely familiar with best practices for electrical contractor selection. This chapter addresses those concerns to make sure that an experienced and well qualified electrical contractor is retained, and that this contractor can work as a critical ally with the project developer. The following best practices detailed will also help to ensure that unforeseen problems with new equipment or installation environments are solved prior to the Commercial Operation Date (COD).

The National Electrical Contractors Association (NECA) published an ANSI-approved standard NECA 416-2016. This standard is titled *Recommended Practice for Installing Energy Storage Systems* (ESS). It describes the methods, procedures and best practices that should be used for installing multiple types of energy storage systems. In addition to commissioning and maintaining energy storage systems, it also includes information about controlling and managing energy storage systems. The focus is specifically on installations of battery systems, flywheels, ultra-capacitors, and the electric vehicle (EV) smart charger and vehicle-to-grid (V2G) technologies that are used for storing electrical energy in on-premises wiring systems. Valuable installer and inspector checklists are included as a resource within this chapter.[1]

Energy Storage Challenges

NECA 416 provides valuable insights and important provisions for those involved in installing and providing energy storage system services for their customers. Energy storage systems are essential to renewable sources such as PV (photovoltaic) and wind systems and provide demand response and load leveling operating characteristics in large-scale applications.[2] This quality performance standard not only addresses the essentials of good workmanship and best practices that are common to energy storage system installations, but also provides important guidelines for addressing the commissioning and maintenance of such systems. This new standard from NECA provides a consistent foundation to build on when determining and implementing energy storage system use in new installations and existing systems, stand-alone systems, micro-grids, and other systems where back-up power and continuity of electric service are essential. The content of NECA 416 is also aligned directly with the minimum requirements in new Article 706 of the 2017 *National Electrical Code®* (*NEC®*).[3]

For the contractor who has had infrequent—or no—exposure to ESS technologies and operations, the essential challenge for the project developer is ensuring that the electrical contractor is up to date and trained in the latest ESS codes. Additionally, since these codes are still rapidly evolving, the contractor needs to be aware of impending updates that may occur during the course of the project. The contractor also needs to be aware of which codes the local Authorities Having Jurisdiction (AHJs) are enforcing, as these may not all automatically update in sync with one another.

Best Practice

The following are a series of best practices (non-inclusive) that are derived from the National Electrical Installation Standards (NEIS). These best practices are intended to provide essential guidance in evaluating and documenting energy storage system components and installations for safety and efficient operation.

Best practices for determining which electrical, building, mechanical, and structural codes and standards apply to an energy storage system installation must take into consideration the fact that codes, standards, and regulations are applied differently. This depends upon whether an ESS is:

- A product of a single manufacturer that supplies a unitary, prepackaged and self-contained ESS that is installed in the field.
- Field-assembled from matched components from a single manufacturer.
- Field-assembled from mixed components of different manufacturers that are selected and designed to function as a system.

Because of emerging technologies, the codes, standards, and regulations that provide safety and installation criteria for specific ESSs may not be available, or have not yet been adopted by the AHJ. In this case, ESS components and their installation should be evaluated based on their performance equivalent to similar technologies covered by specific codes, standards and regulations that demonstrate that the ESS, when compared to similar systems components and technologies, does not exhibit less safety or more hazards.

The burden of demonstrating that an ESS complies with codes, standards and regulations ultimately lies with the ESS owner/installer who, in turn, relies on the documentation of the firm or firms that produce the ESS products, materials, systems, and equipment to demonstrate full compliance with adopted codes, standards and regulations.

Working With ESS Manufacturers and AHJs

The advantage of installing an ESS that originates with a single manufacturer is that this one manufacturer has sole responsibility for the entire assembly or system. The manufacturer generally will document the compliance of the component parts—and ultimately the entire system—with one or more sets of codes, standards, and regulations. Additionally, the ESS manufacturer can detail how the ESS should be field-assembled, and how that assembly would likely be covered, as the product of one manufacturer, by one or more product standards. In short, an ESS that is a standardized component or product of one manufacturer is easier to evaluate for compliance with applicable codes, standards and regulations.

When an ESS is assembled from components of several different manufacturers, no single manufacturer is responsible for the entire assembly or system. Individual components are likely to have their own compliance standard. Multiple compliance standards may or may not be compatible with the assembly of the ESS as whole. The difficulty is verifying that components of different manufacturers, when installed as an assembly or system, comply with applicable or adopted codes, standards and regulations. In this case, for the system as a whole, the compliance of the individual components may or may not be acceptable to one or more AHJs.

Best practices related to coordination with AHJs should consider the following while (1) in the process of scheduling periodic inspections during construction of the system and (2) attaining final approvals.

Generally, one or more AHJs have the responsibility for verifying compliance with adopted codes, standards, regulations or the equivalent testing and evaluation procedures that demonstrate such compliance. According to Sandia's 2016 "Energy Storage System Guide for Compliance with Safety Codes and Standards," AHJs may include interconnecting utilities, the fire service (fire chief or fire marshal), code officials (building, fire, mechanical, and electrical inspectors), and third-party entities (testing and certification entities, insurance carriers, and registered design professionals).[4]

As further covered in the Sandia report, it is important for both the project developer and the electrical contractor to identify the relevant AHJs, the scope of their authority, and what codes, standards and regulations have been adopted to cover the installation of an ESS. (NOTE: AHJs will generally have adopted a library of the codes, standards and regulations which would be applicable to an ESS installation. Where more than one code, standard or regulation applies, review them with the AHJs in relation to the ESS technology being considered, and the intended installation of the ESS, in order to identify the specific provisions (generally the most restrictive provisions) that will apply. Then resolve any conflicting requirements prior to the start of the work). [5]

Knowing that the AHJ generally uses listing or product certification as a basis for issuing approvals, it is essential that all electrical equipment and components of the complete energy storage system are certified by a qualified electrical testing laboratory such as Underwriters Laboratories (UL) or Factory Mutual (FM). These qualified evaluation laboratories understand all applicable product safety standards that relate specifically to energy storage systems and equipment.

Documentation of Project Details

- Project Name.
- Project Address.
- Facility Owner (Name, Contact Person, and Telephone Number(s)).
- ESS Owner (if different from the Facility Owner) (Name, Contact Person, and Telephone Number(s)).
- System Developer (Name, Contact Person, and Telephone Number(s)).
- System Operator (if different from System Developer).
- (Name, Contact Person, and Telephone Number(s)).
- Serving Electrical Utility Provider and Contact Information (Utility Name, Contact Person, and Telephone Number(s)).
- ESS Name, Location on-site.
- AHJ(s) Organization Name(s), Contact Person(s) and Telephone Number(s), Scope of Authority, List of Adopted Codes and Standards, and Regulations.

Providing ESS Project Technical Documentation

- ESS Type.
- Technology.
- Services provided.
- Chemistry (if electrochemical).
- Enclosure:
    - Type.
    - Overall Dimensions (feet).
    - Footprint Area (square feet).
    - Height (feet).
    - Weight (pounds).

Technical Operating Documentation

- Minimum Charge Time (minutes).
- Maximum Charge Time (minutes).
- Minimum Discharge Time (minutes).
- Maximum Discharge Time (minutes).
- Self-Discharge Rate (% energy loss/day).
- Output Voltage Range (Min to Max, VAC).
- Designed (Site Rated) Stored Energy Capacity (kWh), Measured (Actual) Stored.
- Energy Capacity (kWh).
- Maximum Rated Continuous Discharge Power (kW).
- Operating Temperature Range (Min to Max, degrees Fahrenheit).
- Operating Humidity Range (Min to Max, percent).
- Operating Efficiency Range (Min to Max, percent).

ESS equipment and component safety

- Unitary or prepackaged ESS Equipment ID and testing and listing information.
- Pre-Engineered ESS with Factory-Matched Modular Components ID and testing and listing information.
- Individual ESS Component ID and testing and listing information.
- Engineered and Field-Assembled ESS ID and NFPA 791 or other safety documentation (Failure Mode Effects Analysis (FMEA) or similar)[6].

Site assessment and installation criteria

- ESS proximity to any buildings or structures.
- Clearances between any ESS fresh air intakes or exhausts and any fresh air intakes or exhausts of other close proximity buildings, structures, or systems.
- ESS elevation above flood plain.

- ESS foundation type and structural calculations, including seismic calculations if applicable.
- Seismic anchoring details, if applicable.
- Potential sources of physical damage—and means of protection.
- Details on ESS protection from external elements (wind, rain, snow, and wildfire) as applicable.
- Multiple ESSs are protected from each other, if applicable.
- Required access and egress provided.
- Methods to protect against unauthorized access (access control and physical security measures).
- Description of means of access to, and egress from, the ESS location.
- Description of means of access to the ESS location for fire department or first responder.
- Description of means of access for service and maintenance of systems and equipment.
- Systems and equipment listed for hazardous atmospheres, if applicable.
- Distance from stored combustible materials and similar hazards.
- List of chemicals (and volumes) associated with the ESS, as well as their acceptability as a function of type of construction, building use, height above grade, and/or distance from other buildings and facilities.
- Indoor ESS installation distances not more than 30 ft. below the finished floor of the lowest level of exit discharge, and not over 75 ft. above the lowest level of fire department access.
- Required fire and smoke separations provided between rooms housing ESSs and other spaces.
- ESS is suitable for installation outdoors, if applicable, and interconnected with required central control or monitoring systems.
- Roof construction is not combustible, and location is not over 75 ft. above grade, if roof-mounted.

- Rooftop access provided for emergency access, if applicable.
- Rooftop service walkways provided, if applicable.
- Sufficient clearances are maintained to edges of the roof or other rooftop construction[7].

Best Practices related to commissioning and startup of energy storage systems should meet the applicable provisions contained in NECA 90, which is titled "Commissioning Building Electrical Systems."

Qualified Persons

An important best practice is to rely on qualified professional designers, engineers, electricians, and installers. The NEC and NFPA 70E both define what constitutes qualified persons. Licensing and personnel certification, training, and experience are examples of credentials or documentation that demonstrate minimum competencies in a specific field.

"NECA's *National Electrical Installation Standards* (*NEIS*) are the only quality and performance standards for electrical construction. The NEIS collection has grown, and as new technologies emerge, the *NEIS* evolve and keep pace," said Michael Johnston, NECA's executive director of standards and safety. Johnston also emphasizes that "the standards are constantly evolving and providing significant value to those in the electrical designing and engineering communities. The *NEIS* significantly assist professionals in developing design specifications in that they reduce and often eliminate specification writing time." [8]

The *NEIS* are often used by electrical contractors, designers, consulting engineers, facility managers, and other professionals who design and specify for electrical construction projects and want quality and dependability that is integral to such designs. With their installation detail, illustrations and thorough explanations, the *NEIS* are also a valuable training tool for the electrical industry. NECA 416 is also a valuable reference included in the Energy Storage and Micro-grid Training and Certification (ESAMTAC).[9]

(Refer to NECA 416 *Recommended Practice for Installing Energy Storage Systems (ESS)* for complete information and Best Practices that should be applied when installing energy storage systems—whether they are small, medium, or large scale.)

Selecting Capable and Responsible Contractors

(*Note: Electrical contractors and electricians will serve as stand-in examples for this "best practices" section.)*

Safety, risk reduction, and performance are all important aspects of the contractor selection process. This list of best practices incorporates all three priorities with safety of persons and property being first and foremost. This integrative approach is a best practice because work that is done to codes and standards with the highest regard for safety also reduces risk and liability, while ensuring that the ESS optimizes performance and durability.

Best practices for selecting capable and responsible contractors for the installation, commissioning, maintenance, repair, and decommissioning of energy storage equipment and systems should include assessment of the following:

Contractor's License and Specialty

The electrical contractor must have a current state license to perform electrical work in the state in which the project will be constructed. The license must be in good standing. Be sure to check for violations, citations, and complaints. Ask the contractor if the company has more than one category of contracting license (such as plumbing, HVAC, carpentry, etc.). Energy storage requires highly specialized electrical work, which is best performed by a specialized electrical contractor, not a jack of all trades.

Note: An electrical contractor's license and an electrician's license are two separate and different documents that should not be confused or considered to be interchangeable. The contractor is the employer; the electrician is the employee who does the work in the field. Both are needed to produce safe and effective work. (See below regarding electricians.)

Insurance and Bonding

Be sure that the electrical contractor has fully adequate insurance and bonding to perform all the energy storage and other electrical work on the project. The bonding must cover both the dollar amount and full scope of the project. At the very least, insurance should include workers compensation, property insurance, and general liability.

Experience and Safety

Energy storage work is specialized electrical construction work and can be hazardous if not performed by a qualified, experienced contractor with a qualified, experienced staff. The prospective dangers of battery energy storage—such as arc blasts, toxic chemical releases, thermal runaway fires, and explosions—are significantly diminished by having qualified workers on the job. Request that all prospective electrical contractors document their experience and accompanying safety record pertaining to ESS work with:

- Types of installations and chemistries.
- Number of ESS projects.
- Sizes of installations.
- Locations of projects and dates.
- Total years in business doing electrical contracting work.

It should also be requested that all prospective electrical contractors provide documentation for the following:

- All workers performing electrical work will be current state licensed or state certified electricians, or electrical apprentices.

- In states which do not have state or local licensing, all electricians must be graduates of a state or federally approved electrical apprenticeship program.

- The electrical contractor will have electricians on the job who have successfully passed OSHA 30 and NFPA 70E.

- Contractor safety record from the previous seven years.

Note: In the electrical construction trade, “technicians,” solar installers, lighting maintenance techs, integrators, building automation specialists, etc. are not electricians. The overall electrical contracting work experience of the electricians on the energy storage project crew is one of the best predictors of project safety and quality.

Electrical equipment installation manuals often indicate that qualified electricians are required to install the equipment and systems. In cases of equipment and/or system failure where installation and or maintenance has not been verifiably performed by a qualified electrician, warranty coverage may be at risk.

Electrical apprentices are in training to become electricians. While certain apprentices are permitted to assist electricians, ensure that they are:

- Registered participants in a state or federally approved electrical apprenticeship program that graduates at least 60% of the participants.

- Fully supervised by an electrician who meets the previously mentioned electrician requirements.

- Working in a ratio to electricians that is in accordance with state laws.

Ask prospective contractors to document the skill and experience levels of their electricians.

Training Levels

Contractor training is generally focused on business operation, management, estimating, scheduling, finance, and sales and marketing. Because electricians are the skilled craftspeople who actually perform the hands-on electrical work, electrician training is the key factor affecting the safety and performance of electrical construction. Request that all prospective contractors provide evidence of basic electrician training such as electrical apprenticeship graduation, and documentation of any advanced training.

- Basic training: 8,000 hours of training and experience is required in most states to complete a state or federally approved apprenticeship program.

- Advanced training: For energy storage work, electricians who hold a certificate for the completion of the Energy Storage and Microgrid Training and Certification (ESAMTAC) course are highly qualified and should be recognized as such.

Utility Interconnection of ESS

Best practices for the selection of contractors and field electricians to perform ESS work should also include the requirements, needs, and safety hazards encompassed by utility interconnection. Here are some of the concerns[10] that have been expressed by individual U.S. utilities in reference to the critical importance of proper ESS installation:

"Utilizing energy storage systems helps with grid optimization, the integration of distributed generation resources, and the reduction of greenhouse gas emissions. However, these systems pose unique and particularly hazardous safety, fire, and electrocution risks. (Our utility) has a responsibility to ensure that integrated customer-side energy storage systems do not pose safety risks to customers or our employees, and do not threaten the integrity and performance of the electrical distribution system."

"Installing energy storage systems in residential and commercial settings will require special care."

"Energy storage systems can pose unique and potentially hazardous safety risks if not properly installed or operated." "... installations of these systems in residential and commercial settings should require a skilled, highly-trained workforce to ensure the long-term safety of customers, workers, and the public."

Electrical contractor selection and performance has a significant impact on project completion, risks, costs, and operation. It affects not just internal project dynamics but interactions with surrounding stakeholders including the local utility, AHJs, OEM warranty providers, and site hosts.

Resources

- National Electrical Contractors Association, Recommended Practice for Installing Energy Storage Systems, NECA 416 – 2016, available at: https://www.necanet.org/store/product/neca-416-2016-recommended-practice-for-installing-energy-storage-systems-416-16 (Content available for purchase)

- National Fire Protection Association, NFPA 855 Standard for the Installation of Stationary Energy Storage Systems, (forthcoming 2020), available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=855

- National Fire Protection Association, NFPA 70 National Electrical Code, Article 706, available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70

- ESAMTAC, Energy Storage and Microgrid Training and Certification, https://www.esamtac.com/

- National Electrical Contractors Association, Standard for Commissioning Building Electrical Systems, NECA 90-2015 (2015) available at: https://www.necanet.org/store/product/neca-90-215--standard-for-commissioning-building-electrical-systems (Content available for purchase)

References

[1] The National Electrical Contractors Association (NECA). 2017.
[2] Id.
[3] Id.
[4] Pacific Northwest National Laboratory, Sandia National Laboratories, Energy Storage System Guide for Compliance with Safety Codes and Standards, p 2-2 (June 2016), available at: https://www.sandia.gov/ess-ssl/publications/SAND2016-5977R.pdf
[5] Id.
[6] Id.
[7] Id.
[8] Paul Dvorak, *Recommended practice for installing energy storage systems now available*. Wind Power Engineering & Development, available at: https://www.windpowerengineering.com/projects/policy/recommended-practic-for-installing-energy-storage-systems-now-available/ June 23, 2017)
[9] Id.
[10] Sandia Report, Energy Storage Financing: *Performance Impacts on Project Financing*, SAND2018-10110 (Sept. 2018).

ENERGY STORAGE BEST PRACTICE GUIDE 6:

OPERATION

Operation

Chapter One: Overview

Chapter Lead: Matt Koenig, DNVGL

Background

Energy storage systems (ESS), like all capital equipment, see their most important consideration in the arena of their operations. All elements of the project, from the financial analysis to the COD date, are rendered irrelevant if the operational guidelines and best practices do not function to maintain performance and availability. If this is not the paradigm, then clients will be consistently racing to an unseen and/or unpredictable red light.

This best practice guide for ESS operations focuses on the lessons learned and operational paradigms developed over the course of nearly a decade of energy storage deployment in the United States. This Guide will discuss these points in an omnibus fashion as they are, at their root, applicable to all battery-based energy storage systems—both In Front of the Meter (FOM) and Behind The Meter (BTM)—with peculiarities of the systems' operational considerations and best practices folded in on top.

Energy storage systems can be controversial with authorities and financiers, primarily due to the possibility of catastrophic thermal runaway. To counteract these and other fears, concise communication of operational structure and procedures must be available from the project developer and/or operator. This includes a clear, delineated scope of responsibility (SOR), and best practices for the following:

- Operation and Maintenance: Chapter 2.
- Performance/Availability Guarantees: Chapter 3.
- End of Life: Chapter 4.
- Thermal Management: Chapter 5.

While other types of capital assets have similar considerations, energy storage is much more akin to a living organism—owing to the chemical reaction nature of the technology. Thus, simple best operational practices cannot be limited to cut and pasting from other, less dynamic, energy technology projects.

BPG 6: Operation
Ch. 1: Overview

Operation

Chapter Two: Operation and Maintenance

Chapter Leads: Joe Krawczel, Strata Solar; Matt Koenig, DNVGL

Background

Operation and maintenance procedures are a critical component of a successful energy storage facility. (When the solar PV industry was young, O&M execution risks ranked among the top three concerns of equipment manufacturers, rating agencies, and investors.) O&M procedures in the energy storage market will be affected by different geographical and market operation variations. Some variation will also exist by chemistry—flow batteries versus lithium ion—but other parts, such as inverters and HVAC systems, are more similar across the industry.

Lowering O&M costs will require a focus on shared best practices by the energy storage industry—which needs to incorporate better field data, performance measurement, failure analysis, and reliability scoring in order to understand the impact of usage patterns on equipment. Indeed, this type of effort was what lowered the financing costs associated with solar installations.

O&M cost models provide estimates for the costs of delivering an O&M program that considers both system characteristics and the additional conditions that determine optimal inspection and repair schedules. More robust O&M cost models will enable financial firms to easily categorize, predict, and support energy storage projects—resulting in lower financing costs. Better cost models would also increase the effectiveness of O&M procedures, preventative maintenance, and a reduction in the cost of maintaining energy storage systems. This will require standardized maintenance protocols.

As the energy storage market expands, the O&M component is expected to follow the evolutionary patterns of the solar industry. Some key issues:

O&M Price Pressure

Revenue stress puts pressure on all aspects of a project, especially projects that deal with actual cash outlays. For this reason, there will always be a constant balancing of what cost-effective balance is needed between different levels of O&M services, and what people will pay for.

Fleet Managers

Even though the market is relatively nascent, those groups with a plan to become system operators are developing their operational plans, including the O&M component. This can either entail bringing those roles in-house or lining up vendors for the services. In turn, this could affect the purchase choice of new units as operators down-select to a fewer set of providers for commonalty of operation.

Solar / Storage

One of the largest areas for growth in the storage market is through coupling with solar assets. As these systems already have extensive operational experience, operators for the solar field (many of whom see storage as simply an extension of the electrical balance of the plant) need to plan on the O&M for the battery system to be incorporated into the O&M part of the solar field overall.

Grid Services

The degree to which the energy storage system operates (rate of charging and discharging, amount of energy cycled) in order to perform specified grid services will have a direct bearing on the system's O&M requirements. Systems requiring more operation will require greater O&M services over their lifespan than those that play more of a reserve capacity role.

O&M Innovation

The energy storage industry is just beginning its commercial market expansion, so we can be confident that a number of existing methods of providing O&M services will change and adapt as the market expands. As operators manage systems in different areas, remote monitoring will be utilized to reduce required staffing levels and improve preventive maintenance practices. Other adaptation and changes to the equipment will occur, including modifying components that have a specified operational life to a design where just the core of that component can be easily replaced at a minimum cost—with the result being less field maintenance required.

Energy Storage Challenges

Some of the challenges for contracting O&M services include:

Qualified and Creditworthy O&M Providers

Given the relative nascence of the storage O&M industry, project owners and investors should be diligent in selecting providers that: (1) have requisite experience, or in the absence thereof, training and expertise to provide the services set forth in an O&M contract; and (2) have the financial wherewithal to support the liabilities incurred by executing the O&M contract, including payment of any liquidated damages for failure of the O&M provider to meet key performance metrics.

Scope of Responsibility

Parties involved in an energy storage project include the project owner, the equipment manufacturer, the system integrator, the customer, and the O&M provider. A well contracted project matches the equipment supply agreement to the use case agreed to in the offtake revenue contract. This includes: warranty and performance guarantee provisions that ensure that the requirements of the offtake revenue contract will be met for the life of the contract. The O&M contract is necessary and integral for ensuring that the supply agreement warranty, performance guarantee provisions, and conditions are not only met but enforced, and that the requirements of the offtake revenue contract are satisfied. Allocation of O&M responsibilities among the manufacturer, system integrator, O&M provider, and project owner need to be clearly defined to ensure that there are no gaps that would render the warranties or performance guarantees unenforceable or result in a breach of any offtake revenue contract.

Key Performance Metrics

Once the O&M provider's scope of responsibility is defined, and assuming that the O&M provider is responsible for more than scheduled maintenance to the system, key performance metrics should be reviewed and agreed upon. These may include uptime/availability and adherence to the offtake revenue contract requirements—each to the extent within the O&M provider's control. The parties should be careful to delineate between key performance metrics for which the O&M provider should bear responsibility, and those of the equipment manufacturer, integrator and owner.

Data Interoperability

Access to usable data by various parties is important to ensure the success of a project. Without established standards, it is important that data requirements are stated in the equipment supply, EPC and O&M contracts. In addition, the O&M provider needs to ensure that data is accessible.

Cybersecurity

s energy storage assets become more widespread and integrated into the electrical grid, cybersecurity will need to extend to all aspects of the control systems, especially the O&M monitoring systems that touch on all aspects of the system. This will be of even more importance at those smaller, more remote facilities that do not have a maintenance staff on-site.

Insurance

Project owners should review the O&M provider's insurance policies to confirm that there is sufficient coverage in the event of a loss or casualty event caused by the O&M provider's fault or negligence.

First Responder

The contract with the O&M provider should define each party's role in providing, testing and maintaining an alert system and fire suppression system. Additionally, the contract should assign responsibility for interacting with first responders in the event of a system casualty or a site incident that imperils equipment, health or safety.

Best Practice

Energy storage O&M best practices, while often intertwined with unidirectional renewable generation, do not follow in lockstep. There are, however, some common practices which translate well.

What Translates from Solar / Wind Markets

Key to any distributed energy installation operation is the existence of a robust and sufficient SCADA/DERMS software and operating environment. These systems are governed by warranties which are founded on strict operating envelope constraints: temperature, profile, etc.

The operating and data acquisition (DA) systems provide the necessary information to maintain the system in order to meet the warranty envelope, as well as safety and incident management. Thus, insofar as PV, wind, storage, etc. are distributed resources, they share a common backbone in the operation and systems which control them.

As with all engineered systems, maintenance—both scheduled and incidental—is key to operation and safety. Shared best practices include:

- Select low or no-maintenance alternatives when available.
- Make use of network-connected devices and components for remote testing, software configurations and/or updates, and remote resets.
- Provide required access to, and clearance around, equipment for maintenance.
- Enable third-party inspection and commissioning of original EPC installations in order to spot operational problems before acceptance.
- Set more than a KPI-mandated schedule minimum for needed inspection and maintenance.

Minimum maintenance includes the following four types of maintenance procedures:

- **Administration of Maintenance:** This overlaps with "Administration of Operations" and ensures effective implementation, control, and documentation of maintenance services and results. Administration includes: establishing budgets and securing funds for preventive maintenance, establishing reserves or lines of credit for corrective maintenance, planning services to avoid conflict with system operation or operations at the customer site, correspondence with customers, selection and contracting with service suppliers and equipment manufacturers, record keeping, enforcement of warranties, providing feedback to designers of new systems, and reporting on both system performance and the efficacy of the O&M program.
- **Preventive Maintenance:** Scheduling and frequency of preventive maintenance is set by the operations function and is influenced by a number of factors, such as equipment type, environmental conditions at the site (e.g., marine, snow, pollen,

humidity, dust and wildlife), and warranty terms. Scheduled maintenance is often carried out at intervals to conform to the manufacturer's recommendations as required by the equipment warranties.

- **Corrective Maintenance:** Required to repair damage or replace failed components. It is possible to remotely perform corrective maintenance such as inverter resets or communications resets remotely. Also, less urgent corrective maintenance tasks can be combined with scheduled, preventive maintenance tasks.

- **Condition-Based Maintenance:** Condition-based maintenance is the practice of using real-time information from data loggers to schedule preventive measures such as cleaning to head off corrective maintenance problems by either anticipating failures or catching them early. Because the measures triggered by conditions are the same as preventive and corrective measures, they are not listed separately. Rather, condition-based maintenance influences when these measures occur, with the promise of lowering the frequency of preventive measures and reducing the impacts and costs of corrective measures.

An example of an O&M plan checklist includes:

- List of responsible-party contact information, including site owner, offtaker of power, utility, local jurisdiction, local landowner, and emergency numbers.

- System documentation including as-built drawings, specifications, site plans, photo records, special safety considerations, electrical single-line diagrams, schematics, drawings, installed component “cut sheets” and warranties (including warranties from system installers), performance estimates, operation manuals associated with any of the equipment (including emergency shut-down and normal operating procedures), and contracts for preventive maintenance, service, and other operations documents—including contact response times and availability.

- Uphold manufacturers’ preventative-maintenance measures to preserve warranties and optimize system energy delivery, along with the schedule for each. Include details such as cost and the current supplier of each preventive-maintenance measure, and special instructions such as hours that work is to be performed, access to site, and locations where vehicles may be parked, and equipment staged.

- Descriptions of operational indicators, meters, and error messages; description of any physical monitoring setup and procedures by which performance data is to be archived and reported; and procedures by which data is regularly examined for system diagnostics and analytics.

- Keep an inventory of spare parts onsite or easily accessed by the maintenance crew; and implement a process for determining when other spare parts need to be ordered, based on component failure history.

- Clearly define the availability and performance metrics and events outside of management's control.

- Implement a focused training program for all O&M staff on processes relevant to each worker and the equipment they may be working on.

- Implement a chronological O&M log, with work order and task tracking to include initial commission report, inspection reports, and ongoing O&M history.

- Establish procedures for responding to alerts from monitoring diagnostics, error messages, or complaints from the building owner. Provider should also compile a troubleshooting guide for common problems.

- List of all equipment with make, model, serial numbers, and a system placement map (to spot trends in manufacturing defects). A supplier of replacement parts (vendor) should be listed for each piece of equipment.

- Criteria to decide whether to repair or replace a component—or to "cannibalize" other components to source replacement items or to order new parts.

- Establish procedures for re-acceptance testing following a repair.

- O&M program budget that includes costs for monitoring and diagnostics, preventive maintenance, corrective maintenance, and minimum exposure (line of credit) if replacement of an inverter or more expensive corrective maintenance is needed. [2]

What Does Not Translate from Solar / Wind Markets

By its very nature, energy storage is more complex and unpredictable than passive, unidirectional solar and wind. It is an active, controlled chemical reaction which produces bi-directional energy flows. As the energy densities of available storage technologies increase, they inch closer to what they are: a slow release of stored energy over time.

The raison d'être of storage is, "…*extracting maximum economic value from a battery against the limits of what the system can achieve in terms of charge and discharge cycles before degradation of the battery affects its performance and operational lifetime.*"[2] As a result, energy storage systems demand sub systems—which are not called for in the proper operation and maintenance of its distributed cousins.

Operational needs include

- Robust, vetted, and certified thermal runaway suppression systems (which will vary based on chemistry used).

- Electrical and fault isolation design and device specifications beyond that required for solar or wind.

- Establishing a network of storage operation and maintenance personnel and providers trained in the nuances and exigencies of energy storage systems.

- The emerging nature of energy storage technology mandates a much higher level of due diligence beyond the well-established and common elements of PV and wind O&M.

Energy Storage Technologies

Battery Type	Optimal Application	General Maintenance	Best Practices for Safety	Cycling Ability	Costs
Flooded Lead Acid	Off-grid, medium to high capacity	Electrolyte refreshing required by automatic or manual watering systems Equalization cycle can be periodically required	Hazardous Installed vertically only with basic racking solution Must be in well-ventilated space	High cycle life	Low initial cost of ownership Higher maintenance and accessory costs
VRLA Lead Acid	Grid-interactive, off-grid, UPS and backup power, emergency vehicles,	Maintenance-Free Superior shelf life Electrolyte does not need to be replaced Does not require equalization	Usually rated non-spillable for transportation. Sealed VRLA requires very minor ventilation with 99% recombination efficiency	High to moderate cycle life	Low initial cost of ownership with reduced maintenance and accessory costs
Lithium-ion	Hybrid EV's or high ambient temperature with high cycle required	Maintenance-Free	Must be used with an onboard battery management system to prevent over-charge / over-discharge / thermal runaway	Superior cycling ability	Very high initial cost of ownership. Dependent on application

Figure 6.2.2
Operational needs per Energy Storage Technology.
Source: Kathie Zipp, *Tips for Designing Solar Systems With Batteries*, SOLAR POWER WORLD, https://www.solarpowerworldonline.com/2015/12/tips-for-designing-solar-systems-with-batteries/

Resources

- H.A. Walker, Best Practices for Operation and Maintenance of Photovoltaic and Energy Storage Systems, (2nd ed. 2018), https://www.osti..gov/biblio/1489002-best-practices-operation-maintenance-photovolaic-energy-storage-systems-edition.

- Kathie Zipp, *Tips for Designing Solar Systems With Batteries*, SOLAR POWER WORLD, https://www.solarpowerworldonline.com/2015/12/tips-for-designing-solar-systems-with-batteries/

- Cass Whaley, Best Practices in Photovoltaic System Operations and Maintenance (2nd ed. 2016), https://www.nrel.gov/docs/fy17osti/67553.pdf.

- Slide Deck, Solar Power Plant - O&M Issues, (October 24, 2015), https://www.slideshare.net/NageswarRao7/2-solar-power-plant-om-issues

References

[1] Cass Whaley, Best Practices in Photovoltaic System Operations and Maintenance (2nd ed. 2016), https:222.nrel.com.gov/fy17osti/67553.pdf.
[2] Id.
[3] David Pratt, *Energy Storage O&M market needs 'higher levels of diligence', RES Says,* Energy Storage News, October 9, 2017, https://www.energy-storage.news/news/energy-storage-om-market-needs-higher-levels-of-diligence-res-says

Operation

Chapter Three: Performance/Availability Guarantee

Chapter Lead: Matt Koenig, DNVGL

Background

A term long applied to other energy storage markets, performance guarantees are a means to ensure that projects meet the performance requirements found within offtake agreements. Performance guarantees have, however, primarily been centered on energy production. Solar and wind-based solutions have some meaningful differences that render them initially more bankable and less problematic financially than energy storage.

Performance guarantees are an increasingly common requirement by customers to fulfill offtake agreement requirements. Lenders use them to ensure payment for the energy storage project in order to maintain specific technical performance parameters over the life of the system. These agreements require the developer to be responsible for developing the least-cost strategy to maintain the facility's specified performance envelope over the life of the agreed upon and defined "life" of the system application. This focus on system level performance during operation is different than the component warranty level, or the EPC level warranty "wrap" which ensures that the facility as a whole will operate according to the warrantied level.

Although often overlapping, the system performance guarantee is designed to be more comprehensive than the OEM in defined terms. As the market continues to evolve and people look to do more and varied operations with ES systems, these guarantees will necessarily blend into a hybrid formulation.

The performance guarantee is only intended to deliver a guarantee of system-defined functional fidelity to the application in question. Availability guarantees relate specifically to the uptime performance of the system. This guarantee will often, and logically so, relate to the integrator or its contracted sub-contractor for operations, service, and maintenance. It is intended to only deliver a guarantee of uptime.

In no way does performance and availability cover the financial performance and success of the system. These factors only apply to the need for the system to perform a specific set of operations, and to be ready to do so when needed. The timing and the success of the underlying financial outcome from the use of and the timing therefore falls solely to the offtaker. If this end user is seeking to shave demand peaks, or participate in.

Arbitrage (and for some reason does not time the use of the system correctly, or has a flaw in their analysis of the market), as long as the system performs when asked to do so, the performance and availability warranty terms have been met.

Energy Storage Challenges

As they once did for solar and wind markets, both customers and lenders want to know that energy storage systems will prove reliable in the long and short terms.

Wind and solar resources are, operationally, fundamentally similar, and thus fundamentally similar with regard to bankability and projected use. Both are pure generational assets, and unidirectional. They are predictable, with solar based on the daylight cycle, and wind based on wind studies—although less so than solar. These wind and solar resource assessments are independent of outside impact and do not degrade from usage. However, PV and wind technologies do degrade; solar degrading with age, with wind technology degradation typically based on maintenance lapses and shortcomings.

Energy storage, in comparison to these two technologies, can be likened to a gas tank for electrons—with attendant challenges. The technology is bidirectional, which can complicate grid interoperability. The most prevalent technology class—batteries—degrades due to a number of usage attributes and environmental conditions. The gas tank model loses fidelity at one key point; your gas tank does not get smaller every time you deplete it.

That being said, energy storage systems are highly engineered systems with the innate ability to be the most flexible and valuable asset on the power grid. Their great ability to undertake so many market roles comes with the challenge of understanding what the best applications are (for a particular energy storage technology) to craft a profitable system. The key to unlocking their value is understanding their performance and peculiarities. The answer to that lies in understanding why performance matters to energy storage systems, understanding what performance metrics mean, and knowing how these metrics can be leveraged to obtain lower cost lending in order to drive more project development.

Best Practice

The specifics of the performance guarantee will depend on the application required of the system in operation. However, from the perspective of coverage, you can describe performance guarantees along the lines of technical, system, or operational metrics.

- **Technical Guarantees:** These are typically focused on equipment capabilities such as capacity guarantees—which guarantee an annual available energy capacity over the life of the system. This will generally follow the warrantied capacity from the OEM and will consider constraints from issues such as cycle limits or energy throughput restrictions. Energy capacity requirements are typically set annually, but depending on the application, more frequent checks because of terms of cycle life constraints have been noted in existing contracts.

- **Availability Guarantee:** Typically focused on achieving a guarantee to operate a minimum percentage of time in the market, an availability guarantee is generally requested to be at 98% or greater. When reviewing this guarantee, care should be made to understand the impact or inclusion of scheduled downtime for maintenance or other plant needs.

In order to provide these performance guarantees, the project manager or, more realistically, the EPC or other groups with engineering capabilities, will have to determine the least cost method of matching its technical system modeling to its market modeling efforts. The post COD attainment of performance objectives relies squarely on monitoring, maintenance, and upkeep of the system—generally via the IPP or its agent.

For energy storage technologies that suffer degradation from usage, this means understanding the operational performance of the technology and the augmentation schedule required—including initial oversizing, augmentation, and the possible replacement of the storage module.

What Translates from Solar/Wind Markets

Historically speaking, in the early project stages for solar and wind lenders required cash reserves if they were not confident in the technology's performance capability and longevity, or if operational history was inadequate. In response, some solar panel manufacturers began providing a performance guarantee covering the efficiency of the solar panels throughout the life of the system. This allowed for the provision of different products—better equipment and maintenance would be qualified for an improved performance level—at different cost levels based on the added value that could be guaranteed.[1]

It should be remembered, though, that this was a much simpler construct, with the only performance focus being energy (kWh) production. As the technological and commercial risks of energy storage systems continue their downward trajectory, energy storage will map ever more closely to the settled financial science of wind and solar.

What Does Not Translate from Solar / Wind Markets

Operationally, energy storage, unlike wind and solar technologies, has many more degradation factors. This give added importance to not only clearly understanding a single application, but how the degradation factors of that application might interact with those of other applications found in the same project.

For instance, the Sandia National Laboratories report states that "…some derived metrics (efficiency, cycle-life, etc.) greatly depend on how the system is operated (depth of discharge, charge/discharge rate, etc.), and under what conditions it is operated (temperature, etc.). In order to respond to variable market conditions, this leaves the performance guarantee difficult to define for a range of a customer's multiple market role needs.[2]

Scope of Responsibility

Either by caveat or by practical evolution, there is a generally agreed upon hierarchy of responsibility regarding performance and availability.

- **OEM Equipment Responsibility**: Typically covered under the OEM warranty, it covers the storage module, and mandates the unit to be free from defects. It also provides some outline as to capabilities related to usage patterns and environmental conditions. The balance of the system is typically covered by the warranties from these sets of equipment providers.

- **System Level Responsibility**: Typically taken on by the system integrators who manage the component parts warranties that generally flow through to this level. As the industry has evolved, the EPCs are increasingly taking on the task of system integrator, and thus warranties. The leverage of who has this responsibility is generally governed by the ownership of the system maintenance contract.

- **Channel Delivered Systems Responsibility**: Equipment distributors generally flow-through any warranty coverage, but generally do not synthesize or integrate the coverage into a system-level coverage as integrators or EPCs do.

It is critical to clearly delineate the scope of responsibility. The warranty of performance and availability as defined in this document is the foundation of the financial success of the system. The framework and contracting of scope for service and maintenance, as well as controls and monitoring, depth and breadth, are significant in determining the ultimate success of the project.

Failure Mitigation

The mechanism for the resolution of a warrantable event at the financial performance interface is generally via liquidated damages, which should necessarily follow in lockstep with contracting performance and availability guarantees. Damages will vary by application and ownership model. Allowance for downtime due to the long lead times of present energy storage modules must be integrated into these damages.

Conclusion

Referring again to the Sandia National Laboratories report:

> The inclusion of performance and availability guarantees will benefit all involved by increasing transparency on this critical issue. Lenders will be able to lower their risk exposure to energy storage projects by obtaining some coverage for both technology and operation risk—two areas with which they have limited experience, and for which there is limited historical operating data.
>
> Project developers will also benefit by ensuring access to lower cost capital for the project via obtaining deeper technical analysis backing from the EPC and OEMs. Those OEMs able to either absorb the credit risk on their balance sheet or purchase third-party

insurance will benefit and be able to utilize this capability to their advantage for marketing purposes.[3]

Before any energy storage project contract can be considered complete, the monitoring, service, and maintenance of the system must be clearly defined and agreed upon to establish a clear scope of responsibility. Finally, to prove their market strategy of the systems, EPCs will also benefit from an increase in the need for a market performance analysis of the units.

Resources

- Institute of Electrical and Electronics Engineers, *IEEE Std 1547*.1a *2015 (Amendment to IEEE Std 1547.1-2005) Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems; Amendment 1* 2015, available at: https://standardsieee.org/standard/1547_1a-2015.html (Content available free for purchase – free for subscribers.)

- Working Group Meets, Institute of Electrical and Electronics Engineers, *IEEE P1547.1 Draft Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces*, (Oct. 27, 2016), available at: http://grouper.ieee.org/groups/scc21/1547.1_revision/mtgMinutes/P1547%201-20161027_into_and_concluding_slides.pdf.

- Electric Power Research Institute, *ESIC Energy Storage Test Manual 2016,* 3002009313 (2016), available at: https://www.epri.com/#/pages/product/3002009313/?land=en-US

- David Conover, et al, *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems* (PNNL−22010 Rev 2/SAND2016-3078R) Pacific Northwest National Laboratory and Sandia National Laboratories: Apr. 2016, available at: https://energystorage.pnnl.gov/pdf/PNNL-22010Rev2.pdf

References

[1] Richard Baxter, Energy Storage Financing: A Roadmap for Accelerating Market Growth (prepared by Sandia National Laboratories 2016), available at: https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2016/168109.pdf.
[2] Id.
[3] Id.

Operation

Chapter Four: End of Life

Chapter Lead: Richard Baxter, Mustang Prairie Energy

Background

To date, end of life responsibilities have not been a significant issue for commercial energy storage facilities since a large number of these facilities have not ended their operating life. But as the scale of these installations grows, and as they exit their operating lifespans, responsibilities for a responsible and scalable end of life process will grow in importance. While most energy storage facilities will be powered by lithium-ion facilities, it is critical to be aware that there exist a variety of additional energy storage technologies—all of which will all need to have a comprehensive end of life set of procedures as well.

Overall, end of life operations entails three requisite activity stages:

Decommissioning

Decommissioning of the site facility refers to the act of removing the energy storage equipment and returning the site/location back to a brownfield state. This can roughly be described as the construction/commissioning process in reverse, including the removal of the battery systems and then the housing and balance of systems. In this stage, systems comprised of containerized system components would have some advantages over specially built housing solutions.

Transportation

Transporting the energy storage system from the project site to a disposal location would, again, simply be a reverse of the initial deployment of the unit for those systems comprised of most energy storage technologies. If some components were constructed onsite, these could be removed in larger segments rather than broken down like the components originally shipped to the site.

Disposal

Disposal of the system's equipment is the final end-of-life decision for energy storage systems. There are essentially three areas of focus here: second life (re-use) issues, recycling, and the disposal of waste to an appropriate final location.

Second life is an increasingly popular idea for trying to take advantage of the remaining usefulness of a battery by transitioning it from one application into another. Typically, this has referred to transferring lithium-ion cells from vehicles into stationary applications that do not require a demanding usage profile.

Recycling has been part of the battery industry for many decades. The lead acid battery industry currently recycles 98% of all lead batteries, which represents a significant resource stream for newly manufactured lead acid batteries. Recycling for lithium-ion batteries is an emerging opportunity driven both by the expected growing volume of “spent” lithium-ion batteries, and the opportunity to reclaim some of the valuable metals found in those batteries. Recapturing the most valuable components of an energy storage system can impact the longevity of other energy storage technologies dramatically, such as the vanadium in the vanadium flow battery.

Waste disposal represents an important component that must be addressed for the expanding battery industry — especially the lithium-ion segment. Although much of the material in a lithium-ion battery can technically be re-used, there may or may not be the economic justification for reuse outside of a regulatory requirement. In addition, some parts of a lithium-ion battery may not be recyclable. Thus, some way to address these parts must be determined. Other types of energy storage technologies have their own waste disposal issues, and these too must be addressed.

Energy Storage Challenges

There are a variety of end of life issues challenges for energy storage technologies.

Decommissioning

Overall system designs vary between different energy storage technologies—leading to different requirements for the decommissioning of a facility.

For liquid-based systems such as flow batteries, the electrolytes must be removed from the system in order to control weight issues and the reaction of the material. Once removed, many of the modern flow battery systems are designed around modular, containerized solutions which can be removed from the pilings and hauled away. For mechanical systems such as flywheels, the system is typically removed in the same manner that it was brought on-site and constructed.

For cell-based chemical systems, the individual cells/modules are removed from the racking systems and transported separately. This is similar to the commissioning approach where the racking and system envelope/container is shipped to the site separately and then the modules are placed into the racks onsite.

After the energy storage equipment and related housing have been removed from the site, the site itself must be returned to the agreed-upon status, as stated in the contract. The requirements here will be driven in large part by how the system was installed and housed. A purpose-built building can, in many instances, outlast the energy storage system, and so poses an opportunity for repowering, or re-using, for another purpose. For systems installed on pylons or concrete slabs, deconstruction teams have the choice of either removing these footings or leaving them for other uses.

Transportation

After decommissioning the site, the components of the energy storage system will be transported to a facility for disposal. The transportation of the various components will need to be done in accordance with the controls and regulations of these systems, and with the understanding that regulations in the future will probably be more stringent for the transportation of caustic chemicals, along with partially energetic chemical devices.

Disposal

A number of challenges exist for the disposal of energy storage equipment.

For example, second life projects hold out the promise of transferring battery cells from one application into another one, thereby extending their usefulness and significantly increasing the cell's life cycle value. But challenges exist, stemming from a variety of requirements. Chemical cells age differently, so if the priority is to reuse, the cells must be tested, sorted, and re-packaged into modules of like-capability. Next, the second life application usage profile must match the capability of the remaining life in the cells. Finally, the cost of all of this handling, testing, and refurbishment must be made cost-effective.

Recycling, especially of lithium-ion cells, has garnered a significant level of interest by the industry as it looks toward a vast future array of "used" cells from both vehicles and stationary systems. Depending on the chemistry of the cell, different types of metals are the primary target of the recycling efforts. Since much of the different materials must undergo significant chemical transformation and processing prior to going into the cell, not all of the material is easily retrievable. Outside of the materials in a cell, however, the equipment that was part of the balance of a plant—housing, inverters, etc.—and is targeted for recycling, is much easier to process—especially where the focus is on metal recycling.

Disposal of materials remaining after the initial recycling effort must be done with proper handling methods, based on the type of material remaining. For some of the material, it may require disposal into a landfill capable of handling hazardous waste from chemical and industrial facilities. Some of the material could possibly be sent to municipal landfills. But only if it falls within the safety guidelines of that particular disposal site.

Best Practice

Much of the removal, handling, and disposal of batteries and energy storage systems must follow existing regulations for dealing with hazardous chemical and electrical equipment. As the scale of the energy storage industry grows, we expect the procedures to become more commonly understood and followed by those electrical and construction firms responsible for the construction and commissioning of these facilities.

Decommissioning

Although there have not been a large number of commercial energy storage facilities that have gone through an end-of-life process, there have been a few demonstration systems that have undergone the process. These have not only provided the industry with valuable decommissioning experience but have been helpful primarily in driving the development of those decommissioning guidelines that are acceptable to utilities and state public utility/service commissions (PUCs).

More importantly, there have been, for many decades, uninterruptible power supply (UPS) deployments at a variety of locations. These deployments have required the removal of battery banks from a variety of commercial and industrial establishments. This activity has laid the groundwork for the proper procedures required to decommission a previously active facility that contains both electrical and chemical components.

Transportation

The transportation of energy storage system components will generally conform to a reversal of the original equipment's initial transportation to the site.

There are a number of regulations currently governing the safe transportation of batteries. An important resource for understanding these regulations for transportation, both to and from the site, is the Rechargeable Battery Association (PRBA). The PRBA was formed in 1991 and has remained at the forefront of helping organizations craft safe regulations for the handling and transportation of batteries.

In 2004, the PRBA was granted official observer status by the United Nations Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Chemical Classification and Labeling,[1] making the organization an important global resource for firms dealing with energy storage system transportation issues.

Within the United States, a number of federal regulations apply for the transportation of batteries. According to PRBA they include:

- 49 CFR Subchapter C – U.S. Hazardous Materials Regulations.
- 49 CFR 173.185 – U.S. Lithium Battery Regulations.
- 49 CFR 172.102 – Special Provisions 130 and 340 applicable to dry cell batteries and nickel metal hydride batteries.
- 49 CFR 173.159, 173.159a – U.S. Lead Acid Battery Regulations [2].

Disposal

The process of handling and processing cells from vehicles and stationary facilities is rapidly maturing and is expected to continue to evolve as the scale of potential resources grows. Cells from the automotive industry are expected to be the largest component of the supply chain. This is due to the industry being a far larger market and having a product (motor vehicles) with a shorter lifespan than that of a stationary energy storage facility.

Recycling efforts, especially for lithium-ion cells, are also expected to be dominated by the focus on the automotive market. This means that cells and modules in the stationary energy storage industry are expected to be included in the resource stream derived from vehicles.

Final disposal of remainder materials is currently governed by the handling and disposal regulations for chemically active and/or hazardous materials. As the scale of the vehicle battery market drives far higher levels of disposal needs, and as landfill space continues to be at a premium, these added costs for final disposal are expected to drive the effort towards greater recycling—or the transformation of remainder material into an inert form and composition that's suitable for regular landfill disposal.

Resources

- Electric Power Research Institute, *Review of Environmental Life-Cycle Assessments of Lithium Ion Batteries for Grid-Scale Storage*, 3002009392 2017, available at: https://www.epri.com/#/pages/product/3002009392/?lang=en-US (Content available for purchase - free for members.)

- *Battery Recyclers*, PRBA.org, https://www.pbra..org/battery-safety-market-info/battery-recyclers/

- *State Recycling Laws*, batterycouncil.org, https://batterycouncil.org/page/State_Recycling_Laws

References

[1] Batteries in Transport—Applicable U.S. Hazardous Materials Regulations and International Dangerous Good Regulations, PBRA.ORG (Mar. 2017), https://www.pbra..org/wp-content/uploads/Overview-of-Battery-Transport-Regulations.pdf
[2] Id.

Operation

Chapter Five: Thermal Management

Chapter Lead: James Hunt, Hotstart

Background

The Importance of Thermal Management

No matter what the battery type or chemistry, thermal management is a necessity. As power density is increased and application environments become more extreme, a well-designed thermal management system becomes critical to a system's safe, robust, and reliable function.

Scope

This chapter deals with chemical energy storage devices only. The heating and cooling management needs of spinning, pressure, and gravity in energy storage systems are not addressed. The content of this section, however, can generally be applied across a wide range of battery types. Indeed, heating and cooling needs of the battery systems remain the same no matter how the power is used, thus the content of this chapter will apply to transmission, distribution, and behind the meter applications.

Benefits of Thermal Management

The benefits of thermal management range from the obvious to the obscure. Issues can arise due to thermal condition during charge, discharge, and even storage. Typical lithium batteries have an ideal temperature of about 25 °C (77 °F). This can vary with different chemistries, of course. Significant deviation from this temperature, both warmer and cooler, may have severe consequences.

It has been shown that charging at low temperatures accelerates dendrite growth, which has been linked to thermal runaway, a reaction that takes place at the point when the rate at which heat can be expelled from the system is exceeded by the rate that internal heat is generated. Once thermal runaway is started in one battery cell, it can spread to neighboring cells within the battery pack. It is best to employ an automated system of detection and action to immediately eliminate thermal runaway before it gets out of control and poses a risk to lives, environment, and property.

Overall performance of the system is also closely tied to the thermal condition of the battery cells. Both charging and discharging add heat to the battery and must be regulated in relation to the thermal state. Charge and discharge must also be limited at both high and low battery temperatures. In addition, one must be careful to avoid discharge rates as the battery temperature approaches a level that could cause a reduction of life. Also related to performance is the overall capacity of the battery; sufficiently low temperatures potentially lead to reductions in usable battery capacity.

Beyond mitigating the risk of battery degradation, the performance benefits of thermal management can be significant since battery storage systems can now be used in a wider range of climates. (Without some means of maintaining the core battery temperature within a usable range, much of the northern hemisphere would be off-limits to energy storage.) While regions closer to the equator offer the promise of pairing energy storage with abundant solar energy, the higher ambient daytime temperatures inherent to these climates, however, must be managed to capitalize on this advantage.

Lastly, energy storage system warranties must not be placed at risk for high value installations. Battery manufacturers are very capable of knowing, by multiple means, if their systems have been operated outside of design parameters. Temperature is no exception.

Energy Storage Challenges

With respect to the challenges of thermally managing battery-based energy storage, two related questions immediately come to mind:

- How effective is the thermal management scheme that has been employed?
- How much power, including the necessary electronics, controls, etc., is acceptable to be dedicated to maintaining the proper temperature of the battery unit?

This power overhead becomes a necessity for the operation of the battery and must be accounted for in both the initial power capacity calculation as well as the overall system round-trip efficiency quote.

Considering this requirement before a system is implemented may also provide the opportunity to take steps to reduce the overall cost. For example, in a hybrid system that includes an internal combustion power generator, an opportunity to exchange heat may exist. Also, in applications wherein a battery unit serves as a backup power system, a grid power connection (which is likely available) can be employed to furnish the wattage needed to maintain the temperature readiness of the batteries.

A third question that should be considered early in the development cycle is: *Are the battery packs and racks themselves designed to effectively transfer away from and into the core battery cells?* Highly tooled and cost-effective casing systems for battery cells potentially represent effective thermal insulation systems.

Best Practice

An effective thermal management system must be designed with appropriate capacity for both the system size and the environmental conditions encountered during service. The battery manufacturer will be able to provide information concerning the heat generation properties and environmental requirements.

The two primary methods of thermal management employed are air movement-based and liquid circulation-based. Both have their advantages and disadvantages; the most important thing is that they function adequately to keep batteries in an acceptable temperature range.

From a purely physical perspective, a liquid-based system has the highest capability for heat transfer. However, the battery packs must be designed for fluid circulation. In stationary applications, most packs rely on air cooling.

Third-Party Certifications

A detail that must not be overlooked is the incorporation of a Nationally Recognized Testing Laboratory (NRTL). The inclusion of a NRTL mark on the storage battery assembly will go a very long way toward gaining acceptance by the Authority Having Jurisdiction (AHJ). The reader may already be familiar with how North American certification marks work, but more information can be found at several key websites (see Reference 8 for details.) Sub-component requirements apply as well and, depending on the jurisdiction, additional requirements not indicated by the certification body also may apply.

It is recommended that the NRTL certification body be brought into a project as early as possible. That's because the interpretation of requirements by the certification engineer can often be significantly different than that of the engineer designing the system. The return on investment from catching issues early can be exponential as compared to having an unexpected delay during deployment.

Design

In many ways, large-scale battery storage systems are very similar to an engine-based power generator. Both convert chemical energy into electrical energy. The key difference (and advantage) is that the process is reversible in batteries. There are other similarities as well. Both require removal of heat in proportion to their efficiency. Both also require that care be taken to avoid damage at low temperatures.

Air Cooling and Heating

As just indicated, the most common method of transferring thermal energy both away and into batteries is via air movement. This method has the advantage of ease of configuration, and the HVAC units typically employed can be supported by locally available technicians. Also, minimal to no direct interface between the battery packs and temperature control system is required.

The battery packs are simply designed to shed heat to the outer case. From there, it is assumed that the provided air movement removes the heat. But unless care and forethought are exercised to ensure the even distribution of air flow is achieved, this action introduces a great potential for variability into the thermal behavior of groups of battery modules and racks. Similar problems are encountered in the area of data center management.

Liquid Cooling and Heating

Just as with engines, the use of a liquid heat transfer medium is a very practical way to move heat away from its source. The reverse is also true: a liquid circulation system works very well to bring heat to where it is needed. Water has the highest specific heat of any common substance, making it uniquely suitable as a coolant. This property gives water the ability to absorb a significant amount of energy before changing states, thereby contributing to the thermal stability of the battery during times of temperature extremes.

The future of high-power density energy storage will be enabled by water-based heating and cooling circulation. Furthermore, localized liquid heating and cooling of batteries is more energy efficient than the application of air movement to facilitate the heat transfer needed to control and balance temperatures. And (bringing up the question of warranty again) the capability of maintaining an even temperature across multiple battery modules and racks is much higher when a high energy capacity liquid is used versus air circulation. This can be a great advantage when evaluated against the narrow service temperature requirements of some battery manufacturers.

The capabilities of air cooling versus liquid cooling is mostly a question of power density. Each method will have a power density limit that it is capable of cooling. The balance of size, weight, complexity, performance, safety, and cost need to be considered—and will vary depending on the conditions.

Battery Management Integration

The thermal management system should not be an afterthought. Communication with the battery management system is a significant benefit of integration with the battery unit at the design level. Fault mitigation and performance optimization are just a couple of benefits that come to mind. The combination of a Battery Management System (BMS) and a Thermal Management System (TMS) make many more options and proactive actions available to quickly and actively suppress and eliminate thermal fault events. A well designed and executed TMS system that is working with, and receiving key directives from, the BMS can potentially expand the battery unit's operational capabilities to a significant degree.

Other Heat/Cooling Sources

Distributed power will experience a future of significant growth in many applications. Batteries are being combined with multiple types of power generation systems. In combination with a generator, a hybrid system approach in support of a micro grid may incorporate multiple types of power generation. Depending on the system design and operating cycle, the generator could essentially be a free source of heat to maintain the optimum temperature of the batteries.

Cooling sources may also exist. Consider an indoor growing operation that incorporates renewable energy or needs to avoid demand charges. These operations often consume a significant amount of feedwater. Often, heating of the feedwater is necessary as well. The possibility exists to have a mutually beneficial exchange of heat from a battery unit into feedwater that requires warming.

Maintenance

The following are several factors to consider that may help maintain the operational life of the thermal management system. These factors are not unique to thermal management and are likely employed on other components of the battery system.

- **Support From the Manufacturer**: Long-term support from the TMS manufacturer can be critical when issues arise. The option of extended support if desired should be addressed and agreed upon before the system is installed.

- **Serviceable Components**: Wherever possible, the system's designer should include serviceable components. The system construction will include wear items like fans, pumps, and switches. Wear and eventual failure should be expected; up-front sourcing of replacements is critical to reducing downtime.

- **Coolant Fluid Maintenance**: A commonly neglected component of a fluid-based thermal management system is the coolant fluid itself. Over years of use and the addition of make-up fluid, the properties of the coolant may change. These chemical changes may cause material compatibility issues with other components in the system which, in the worst cases, may increase suspended particulates in the fluid. These particles can wreak havoc on components such as heat exchangers and pump impellers. They may eventually degrade system performance and cause failure. Manufacturer recommendations for periodic fluid flushing and replacement should not be ignored.

- **Scheduled Maintenance/Replacement:** The thermal management system must be routinely inspected and assessed. Replacement of wearing parts before end of life will help reduce downtime. The manufacturer may be expected to provide documentation listing service items and replacement intervals.

- **Predictive Monitoring**: Local and remote monitoring of key parameters of the thermal management system should be implemented. In addition, enough information should be collected to be able to assess the performance of critical components. This data can be analyzed to identify deviations from historical trends. The manufacturer should be able to supply equipment that is configured to plug into the overall systems that monitor infrastructure.

Resources

- Electric Power Research Institute, Review of Environmental Life-Cycle Assessments of Lithium Ion Batteries for Grid-Scale Storage, 3002009392, 2017 https://www.epri.com/#/pages/product/3002009392/?lang=en-US (Content available for purchase - free for members.)

- Garrett Fitzgerald, James Mandel, Jesse Morris, and Hervé Touati, The Economics of Battery Energy Storage (David Labrador, 2015), https://rmi.org/wp-content/uploads/2017/03/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport-FINAL.pdf

- Sheng S. Zhang, Kang Xu and T. Richard Jow (2006) *Study of the Charging Process of Li-CoO2-Based Li-Ion Battery*. Power Sources, 2160, 1349-1354, https://doi.org/10.1016/j.jpowsour.2006.02.087

- Jeffery Bausch, What are dendrites and why do they cause fires in lithium batteries? (2016),https://www.electronicproducts.com/Power_Products/Batteries_and_Fuel_Cells/What_are_dendrites_and_why_do_they_cause_fires_in_lithium_batteries.aspx?terms=dendrites%20lithium

- Battery University, BU-410: Charging at high and low temperatures, https://batteryuniversity.com/index.php/learn/article/charging at high and low temperatures

- Feng Leng, Cher Ming Tan and Michael Pecht. (2015). *Effect of Temperature on the Aging rate of Li-Ion Battery Operating above Room Temperature*. Scientific Reports, https://www.nature.com/article/srep12967.

- Taeyoung Han, Bahram Khalighi, Erik C. Yen & Shailendra Kaushik, Li-Ion Battery Pack Thermal Management: Liquid Versus Air Cooling, 11 J. THERMAL SCI. ENGINEERING APPLICATIONS 2, 021009, http://thermalscienceapplication.asmedigitalcollection.asme.org/article.aspx?articleid=2705518 (Content available for purchase.)

- OSHA, *Nationally Recognized Testing Laboratory (NRTL) Program*, https://www.osha.gov/dts/otpca/nrtl/#

- Standards Council of Canada, *Product, Process and Service Certification Bodies*, www.scc.ca/en/accreditation/product-process-and-service-certification

- For the UL 9540 series of specifications cover energy storage systems and equipment, more information about the standard can be found here: https://standardscatalog.ul.com/standards/en/standard_9540_1

ENERGY STORAGE BEST PRACTICE GUIDE 7:

RISK MANAGEMENT

Risk Management

Chapter One: Overview

Chapter Lead: John Mooney, Hugh Wood

Background

Insurance is a means for protecting against financial loss. For a complex issue such as energy storage project development, it is also a means to design risk management strategies that expand opportunities at a lower cost through leveraging the financial assets of the insurance firms. This risk management and allocation focus is especially important for energy storage project development. Project developers and lenders both generally agree that energy storage projects are not fundamentally different than a typical power industry project finance transaction, especially with relation to risk allocation; the deal will not close until the known risks have been addressed, and safeguards are in place for unknown risks. However, energy storage is somewhat different than other power projects, and so the risk management strategy will need to consider storage's unique technology, policy and regulatory mandates, and market issues.

Insurance companies reduce their risk through a detailed understanding of the technology, its operation, and its interaction with the power market. According to energy storage expert Richard Baxter, "Insurance policies are increasingly important to the energy storage industry and, as the industry scales in both number and size of projects, many industry experts believe the underlying requirements for improved insurance will positively impact energy storage by reducing risk, limiting liability, and helping with financing by removing financial liabilities from weak balance sheets."[1]

As the industry matures through a growing body of project development and operational history, the cost of insurance should continue to decline as additional performance data and loss experience help refine the loss potential evaluation of these projects. Lacking sufficient data in emerging industries like energy storage, insurance firms have long been a driver in promoting better testing and standards development (in both equipment, installation, and operation) in order to reduce insured loss through performance degradation or failure. Better information provides these firms with the ability to determine the actual risk premium cost for a variety of project development choices. As the industry gains more experience, re-insurers (insurance for insurance firms) will get involved, reducing further the cost for insurance coverage.

Four areas showcase the development of the insurance and risk management industry in the energy storage industry:

- The improvement of coverage for general insurance for energy storage projects, project continuation strategies, and performance insurance to augment existing product warranties for lenders.

- The equipment risk management product that provides a technical backstop for projects using emerging technologies.

- Exotic insurance options like credit enhancements for OEMs and customers, and performance insurance to provide a financial backstop for the project.

- Surety instruments to protect counter-parties from a contract default.

References

[1]Richard Baxter, "Energy Storage Financing: A Roadmap for Accelerating Market Growth—A Study for the DOE Energy Storage Systems Program," Sandia Report, 2016. http://energystorage.org/system/files/resources/esf_study_report Sand 2016-8109pdf.

Risk Management

Chapter Two: Project Risk Insurance

Chapter Lead: David Tine

Background

Like other power industry projects, energy storage projects will need general project insurance coverage for protection against financial losses. As energy storage projects grow in both number and scale, more insurance firms are rapidly entering the market and offering insurance coverage. Many times, however, they are lacking in experience with these new types of projects. Varying types of insurance services are thus becoming more available for energy storage project developers, but these same project developers need to understand these diverse offerings and their specific needs in order to choose the correct level of coverage.

Insurance firms also need to understand the financial risks and potential exposure that different project developer designs and operational strategies hold for them. Since most insurance firms do not generally maintain staffs of internal engineers and market modelers to evaluate all of the possible risks, to keep insurance fees competitive the degree of risk exposure understood by the insurance firms tends to be highlighted by a reduction in coverage rather than in dramatically higher rates.

Generally accepted and understood levels of insurance coverage are essential for the growth of the energy storage industry. Project developers need comprehensive coverage for their projects, including during construction, commissioning, operation, and decommissioning. The current variation in the type and levels of insurance coverage is thus a hindrance to accelerating the growth of the industry. Because of recent fires at operating facilities, insurance premiums are not expected to decline significantly—nor will coverage be expanded to cover all potential risks—until insurance firms are confident that their coverage does not expose themselves to unanticipated and unnecessary risks.

Potential areas of risk exposure for insurance firms arise from a variety of sources. These include the OEM’s technology, system integrator, construction, operation, market, and natural events.

- **OEM Technology Risk**: Different OEMs have their own chemistry variants, even for a similar technology family like lithium-ion systems. Technology risks here include the materials used, safety designs, and operational limitations and controls (both physical and energy management software control systems).

- **System Integrator Risk:** The firm acting as the system integrator is responsible for selecting and integrating all of the components for the energy storage system. Depending on the size and scope of the project, there can be increased system risk for both dynamic control of all of the modules and the management of equipment in real time in order to support the needed operation.

- **Construction Risk:** The facility's construction introduces another aspect of risk, especially as systems scale and incorporate other unique issues when dealing with location specific requirements.

- **Operational Risks**: Many times, system failures have resulted from units being pushed beyond their design limits. Understanding and ensuring that proper limits are set in the control systems is critical for insurance firms to verify. Also included in this is the degree of experience of the developer in operating energy storage systems in a similar, and previous, deployment.

- **Market Risks**: Energy storage systems operate in a competitive and constantly evolving power market. However, their designs and operating capabilities are typically fixed at the initial design, requiring the developer to choose a design that is both competitive now, and able to remain competitive as the price of products and services changes over time.

- **Natural Event Risks:** A variety of natural impacts ranging from floods, high winds, and seismic events can either damage the energy storage system directly or have indirect negative impacts on the unit.

To address these challenges, insurance companies are developing a variety of flexible insurance coverage policies for the energy storage project development industry. Insurance firms begin by adapting current insurance coverage policies from other power industry projects that have similar design and operational needs. Without significant operational experience, the insurance firms will preempt expected areas of risk such as equipment defects, project cost overruns, etc. Because of the many different types of firms involved as part of the value chain, insurance firms with experience are able to develop comprehensive products for project developers—but must take into account the coverage level of insurance these developers want—many times dictated by the degree of experience of the project developer in question.

Project developers have a need for good project insurance since insurance policies are an effective means to move capital coverage requirements off the balance sheet, thus reducing the amount of capital in the project needed to meet lender criteria. As differing insurance firms provide proprietary products, project developers need, in order to ensure that the coverage offered meets their needs for their particular deployment requirements, a systematic means to evaluate the insurance policies from these different insurance firms. Specifically, they need to understand the factors that determine pricing for the coverage they want so that they can minimize the cost of the insurance, yet also receive the coverage they need.

Energy storage projects require a variety of traditional insurance coverage policies (other policies may apply or be required for specific deployments):

- **General Liability Insurance:** This insurance policy is designed to protect the project from a variety of claims including personal injury, property damage, etc. that can occur during the project's operation. This is considered to be an essential insurance policy for any stand-alone energy storage project.

- **Property Risk Insurance:** This policy protects the physical assets and equipment of the project company against loss from theft, fire or other dangers. This is a first-party insurance product and should be purchased by owners of the project. Specialized property insurance—from development through operation—can be purchased for every stage of a project.

- **Equipment Risk Insurance**: Equipment insurance covers two primary areas: general equipment insurance and equipment breakdown insurance. General equipment insurance is used to cover damaged or missing equipment at the site. Equipment breakdown insurance is designed to cover damage initiated by some aspect of the operation of the facility, such as electrical or mechanical forces. The insurance coverage is used to repair and/or replace the equipment—and any potential other property—directly caused by the operation-related incident.

- **Environmental Risk Insurance:** This policy covers gaps in coverage created by pollution exclusions in General Liability and first-party property insurance policies. This type of coverage will be driven by both the chemicals used in different energy storage technologies and the familiarity with them by different insurance firms and local inspectors. Batteries with electrolytes that could possibly produce a hazardous spill face the most scrutiny here, but impact from battery fires will also potentially expose an enterprise to enhanced scrutiny and exposure. The environmental policy can cover clean-up costs on the premises and to adjoining premises (a third-party exposure).

- **Business Interruption Insurance:** This policy provides for the loss of income after a disruption in operation. The insurance is designed to cover the income loss incurred for the time it takes to get the facility back on-line. A number of insurance providers stress that this coverage does not cover losses from merchant activity or inappropriate operation of the facility that causes the facility to be off-line. This type of policy requires the insurance provider to understand the operational plan for the unit, differentiating between contracted revenue and merchant revenue opportunities (which are not generally covered). To maintain normal operations after a covered loss, an extra insurance expense pays for reasonable and necessary additional costs (e.g., equipment rental) incurred.

- **Expediting Expense**: This insurance coverage is designed to cover expenses above typical operating costs to ensure continuity of operation during repair or refurbishment of the facility stemming from a damaging event. This policy is generally designed to work in conjunction with the aforementioned Business Interruption Insurance.

- **Workers Compensation and Employers Liability**: This insurance coverage provides employees injured during operation of the facility with wage replacement and medical benefits during a specified recuperation time period. These benefits are generally provided in return for the employees waiving their right to sue the employer for negligence. This coverage also provides the employer with coverage against other work-related injuries outside of existing worker compensation statutes.

- **Umbrella Liability**: Provides additional liability protection. Designed to help protect the insured from major claims and lawsuits, it also helps protect assets.

- **Contractor Warranty**: Contractors can provide warranties to the project owner for work undertaken or provided at the energy storage facility. These warranties can provide a variety of coverage, including quality of workmanship, damage to the facility by the contractor, etc. Coverage for lost revenue can be included but would significantly increase the cost. Thus, it is rarely provided to cover the entire output of the facility.

Performance insurance is an emerging area for insurance coverage for energy storage systems. This coverage is intended to protect the owner of the facility against non-performance of the system, typically measured against operational metrics that are tied to the unit's operational performance needed for revenue contracts. It is typically provided as a separate policy and is covered more fully in the exotic insurance chapter.

Energy Storage Challenges

The need for—and benefit of—battery storage technologies is abundantly clear: electric supply systems are facing increasing supply and demand issues, constrained networks, and an aging infrastructure—in addition to increasing peak demand (most evident in higher summer peaks), and the power needs of electric vehicles.

Plus, concerns about resilience and backup power are especially compelling in the nonresidential sector—particularly in deployments in education, healthcare, manufacturing and military contexts where assurance of day-to-day operations is critical.

All these challenges can, in part, be addressed by energy storage. But energy storage is still an emerging market, and incorporating the uncertainties involved with rapidly evolving technologies and rates of commercial readiness can be costly in terms of energy storage insurance products. Indeed, the availability of bundled policies covering energy storage project finance, construction, and operation phases is still somewhat limited.

At their core, energy storage-related insurance products would include:

- Marine: Cargo and hull coverage during construction phase.

- Engineering and construction: Builders' risk, delay in startup/advance loss of profit, and contractors' equipment during the construction phase.

- Liability including inherent defects insurance: Construction operation.

- Professional Insurance (during construction phase).

Project Financing

- ECM (Engineering and Construction Mode) downside weather protection.

- Performance insurance.

- BT&I (Bank, Trade and Infrastructure).

- Surety.

Claims Adjusting

A limited number of adjustors are versed in the energy storage arena. This fact presents a significant challenge for the insurance industry as it gears up to handle energy storage insurance challenges and opportunities.

Equipment Risk

Equipment-related risks will be consistent for all storage technologies, although some risks will be more of a concern given the technology and battery chemistry installed, e.g. lithium-ion, flow battery, compressed air, flywheel, or lead acid. (Figure 7.2.1 illustrates that peak battery temperature is one metric that will impact the risk associated with the selected battery type.)

- Equipment risks include those for the different energy storage technologies (lithium-ion, flow battery, lead acid, compressed air, flywheel) and the balance of system equipment (inverter, controls software, thermal management system, etc.)

Property Risk

- Construction/ Builders Risk.

Operational Risks

- Project information: Size of battery, equipment value, revenue streams, ESA/PPA.

- Team experience: Designer, developer, installer, equipment provider, O&M, and operator.

- Proximity to building/Battery enclosure/ Fire suppression/ Code.
- Natural Catastrophe: Wind, flood, earthquake, fire, etc.
- Fire: Thermal runaway, electrical, etc.
- O&M standards.
- Ability to monitor battery metrics (See Performance section) and battery temperatures, e.g. HVAC system.

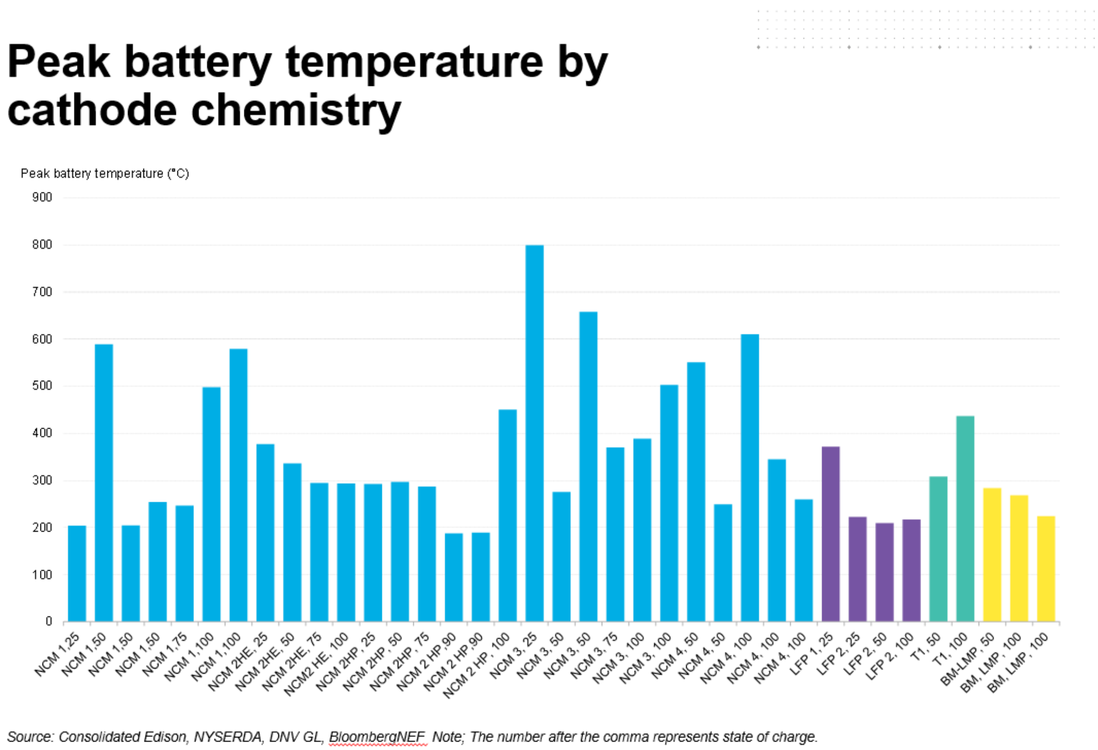


Fig. 7.2.1
Peak battery temperature by cathode chemistry.
Source: Consolidated Edison, *Battery Testing Report*, https://www.nyserda.ny.gov/-/media/files/Publication/Research/Energy-Storage/20170118.

Equipment Warranty

A variety of factors will affect the equipment warranty. They include length of warranty, bankability of warranty provider, the depth of coverage and what is covered, and subrogation potential for the project owner.

Environmental Risk

Exposures will be relative to the equipment technology deployed in the project. For example, compressed air, flywheel, lithium-ion, and flow batteries all pose different environmental risks during the life of the project (construction, operation, end of life).

Business Interruption

- Equipment operation will impact business interruption ratings for energy storage projects. Premiums will be required to cover applicable business interruption (BI) expenses, including the expenses needed to bring the facility back online. Spare parts, lead time for replacements, and access to a trained installer network will be concerns when underwriting BI exposure. Again, these concepts will be viewed differently, depending on the chosen technology.

- How the battery is being utilized. For example, peak demand management and ancillary services will impact the BI exposure.

Best Practice

What Translates from Solar / Wind Markets

Equipment Risks:

- Bankability of equipment warranty provider.

- O&M on equipment.

- Availability of key spare equipment.

- Technical experience of manufacturer, designer, developer, integrator, O&M provider.

What Does Not Translate from Solar / Wind Markets

Equipment Risks:

- Because the complexity and variability of technical solutions is broader with storage projects, more variables need to be considered with respect to equipment degradation and BI losses.

- Different equipment technology will impact performance and the project's lifecycle. Picking the right storage equipment from project design is critical. This relates not just to flow battery versus lithium-ion, but different lithium-ion chemistries (Li Manganese vs. lithium cobalt oxide, etc.).

- Permitting processes will be more complex depending on the battery chemistry. (For an example, see the NY State Permitting and Interconnection Guide for Energy Storage Projects).

Business Income:

- Potentially longer lead times for spare equipment or replacement parts could lead to more downtime—and therefore higher exposure to BI and extra expense.

- Future financial value streams for an energy storage project could impact battery life. Using a battery outside of the intended design could increase equipment breakdown potential, increase degradation, and lead to greater BI exposure.

Resources

- NYSERDA – Energy Storage Permitting and Interconnection Process Guide for New York City: Lithium-Ion Outdoor Systems Guide.
https://www.nyserda.ny.gov/All-Programs/Programs/Energy-Storage/The-Opportunity/Vendors/Permitting-and-Interconnection

- NYSERDA- Battery Energy Storage System Inspection Checklist.
https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Siting/Battery-Energy-Storage-Guidebook

- PV Magazine, January 29, 2018.

- Axis Capital.

- Insurance Journal May 21, 2018.

- Solar Energy Industries Association.
www.seia.org

- NRCAN Canadian Earthquake Hazard Resource.
http://www.earthquakescanada.nrcan.gc.ca/hazard-aIea/interpoIat/index-en.php

- Canadian Solar Industry Association & Ontario Association of Fire Chiefs PV. Fire Safety Handbook https://www.cansia.ca/fire-safety-handbook.htmI

- Canadian Standards Association.
https://www.csagroup.org/industry/energy-power/photovoltaic-pv/

- Electrical Safety Authority.
https://www.esasafe.com/business/alternative-generation-safety/renewable-generation

- OSHA.
https://www.osha.gov

- FEMA Flood Map Service Center.
www.floodsmart.gov

- Availability of key spare equipment.

- Smart Electric Power Alliance.
  www.sepapower.org

- Wood Mackenzie June 19, 2018

- Swiss re-Underwriting.

- Royal Society of Chemistry.

Risk Management

Chapter Three: Exotic Insurance

Chapter Lead: John Mooney, Hugh Wood

Background

In every project there are certain insurance products that fall outside of the realm of traditional insurance. These are highly specialized and may not be required for all projects. They are mentioned here in case they come up in the course of contract negotiations. (Some of these insurance products may be risk transfer mechanisms, while others are the risk management techniques to be employed.)

Weather Hedges

Weather insurance products provide potential relief against possible loss caused by extreme weather events which, while carrying a huge amount of risk, are relatively rare occurrences. Customers interested in utilizing these types of insurance products typically have a large exposure to weather-dependent activity in one or more of their business operations. Understanding the dependence of the firm's activity is also correlated to a particular weather index—with the most commonly used index being temperature. However, other indices such as rainfall, wind speed, and solar radiance may be more appropriate.

Cyber Insurance

Even with protection and cyber security protocols in place, the inevitable network failure, privacy breach, malware attack, or simple mistake can cripple a project. According to energy expert Rob Freeman,

> Smart buildings use internet-connected software to run devices such as thermostats, LED lighting, ventilation, and life safety systems in order to help buildings run more efficiently.[1] Energy storage systems are connected to the internet in order to monitor utility rates, communicate with utility demand response systems, and allow remote access for building engineers, but the internet of things (IoT) can lead to cyber exposures.[3]

Cyber security struggles leave customers and taxpayers exposed. Insurers are limiting how much coverage energy companies can buy to protect their assets against major attacks by hackers—leaving investors, customers and taxpayers liable for sizable losses.

Cyber insurance helps businesses recover from losses to their electronic business information by providing breach recovery resources and serving as a financial backstop. Standard insurance policies, developed to respond to tangible losses and legal liability, are unlikely to provide breach recovery resources, leaving a business that lacks cyber insurance to recover from a loss by using its own capital resources. With the 2017 average cost of a data breach in the USA exceeding $7.8m, this is a large expenditure.

As Rob Freeman writes, "The right smart building cyber insurance provides an additional layer of protection in the event of a software flaw, hack, or an exposure to malware that could be used in reconnaissance by malicious software."[4]

Project Continuation

While similar to security and direct agreements designed to ensure the continuation of an energy storage project, project continuation risk management strategies are much more detailed, and are targeted at the underlying technology know-how. These strategies are designed to put into a "Project Lockbox" all the documentation needed to ensure continuation of operations.

This type of risk management solution is more geared toward emerging technologies with a smaller manufacturing base for replacement options. Here, project continuation insurance first addresses any proprietary material or equipment needed for the project that could be put at risk if the company backing the project were to cease operation. In addition, any process knowledge needed to continue operating the plant by a third-party would also be secured in the Lockbox.

Through this process, lenders have a greater level of assurance that, if there were a potential business disruption at either the parent OEM or project company, the project company could continue its operation through access to proprietary equipment data or know-how.

Credit Enhancements

Credit enhancement is used to obtain better terms for an outstanding debt by improving the credit profile of a firm. Credit enhancement reduces the default risk of non-servicing the debt; with additional resources available to the lender, the lender is, many times, not only willing to provide the debt, but also do so with a lower interest rate. This will, however, remain an issue in the energy storage market for some time as many lenders still consider the energy storage market immature. An often-overlooked issue is that credit risk assessment in this industry extends well beyond the project developer to include other critical providers up the supply chain. They include the various essential subcomponent equipment suppliers that the project would be relying on for warranties, performance guarantees, and project operation and maintenance services.

Through the use of credit enhancements, borrowers reassure lenders of their ability to honor loan obligations by posting additional collateral, getting a third-party guarantee (letter of credit), or obtaining insurance. The insurance policy is on the payments, serving to guarantee that interest payments and principal repayments will be made. Lenders, however, are concerned about the expanding number of thinly capitalized project developers in the energy storage market. Insurance for credit enhancement solves some of the key problems posed by project developers unable to obtain additional capital.

Credit enhancements can also alleviate credit risk for a variety of other participants surrounding an energy storage project. For small OEMs with an emerging technology, they can help provide a financial backstop for corporate and technology risk. For project developers, they can enhance project execution risk management, allowing developers to go after riskier and more lucrative projects. For customers, they can provide assurance and allow them to sign cost reducing contracts if they don't have sufficient collateral.

Trade Credit Insurance

Dovetailing with credit enhancements, according to information extrapolated from a Wikipedia source[5] "…trade credit is an insurance policy and risk management product. They are offered by private insurance companies and governmental export credit agencies to business entities wishing to protect their accounts receivable from loss due to credit risks such as protracted default, insolvency or bankruptcy." Trade credit insurance can include a component of political risk insurance.[6] This can serve "to insure the risk of non-payment by foreign buyers due to currency issues, political unrest, expropriation, etc."

Performance Insurance

Lender requirements are a significant driver of insurance policy purchases for renewable energy projects, including energy storage. The right insurance policy can secure a better rating and, therefore, a lower cost of financing. Performance insurance provides a financial backstop for energy storage projects needing to meet specific performance guarantees. Performance insurance has been initially targeted at projects using energy storage technology firms that lack a large balance sheet. (Large firms can leverage balance sheets for exposure effectively; but firms without some way to ensure belief in the self-provided performance guarantee are unable to compete.) As performance requirements continue to build, other applications of performance insurance will increase.

Project financiers will be concerned with the ability of the energy storage project to deliver on the projected cash flows. The performance of the battery is one risk. Another risk to be considered is the ability of the energy management software system to charge and discharge at the correct time, especially if the battery is being used to reduce peak demand charges.

Insurance providers interviewed for this Best Practice Guide stressed that there is no universal performance insurance; each policy is based on the technology option chosen and the intended application requirement. It is designed to bridge the gap between what lenders want and what OEMs can provide.

The solar industry has also developed performance insurance for projects, but this is for energy (kWh) production, a less complex challenge than what awaits the energy storage market. (See Figure 7.3.1, which highlights the various uses of energy storage projects.)

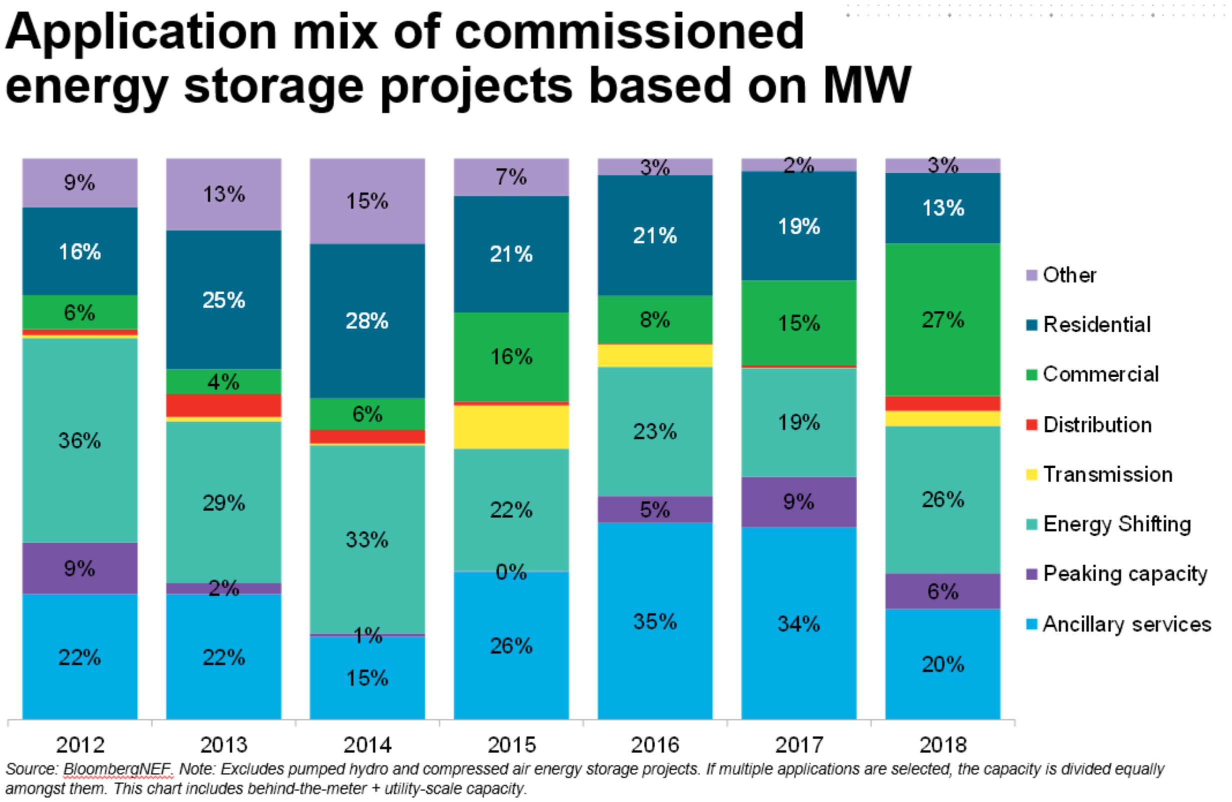


Fig. 7.3.1
Application mix of commissioned energy storage projects.
Source: EN.wikipedia.org/wiki/trade_credit_insurance.

The energy efficiency industry has used risk transfer products like performance guarantees and energy efficiency insurance to cover the technical performance risk associated with the implementation of technology upgrades. Similar Energy Savings Agreements (ESAs) or Power Purchase Agreements (PPAs) can be modified to include the energy storage benefit.

Mentioned many times by insurance providers, and key to any continued conversation on the matter, is a bankability study for energy technology and an independent engineering report for the project. In order to provide a policy, the insurance firm must undertake a deep due diligence dive on the technology and OEM so that the technology is able to maintain its capacity rating (and other required performance ratings) under the expected usage profile. This “deep dive” must show that the firm can support the deployment of the technology over the life of the project and, if not, what steps are required so that there is no technology risk for the lender.

Warranty Extension Products

The energy storage industry is offering long-term warranties of up to 10 years against detects in performance degradation. But these warranties can tie up the manufacturer’s capital and increase the risk of escalating maintenance costs, which has an adverse effect on the manufacturer’s profit. For the manufacturer and project owner having a risk that the storage system requires more maintenance than projected, and that expected maintenance costs could be exceeded, the insurance industry has a product that protects against performance degradation and excessive maintenance costs. Through the use of this product, the risk exposure can be transferred from the manufacturer's balance sheet to the insurance firm through the insurance policy.

Energy Storage Challenges

Energy storage faces a number of challenges including materials, longevity, and project management. Although the continued reduction in cell costs will be beneficial to the electric vehicle industry, the stationary energy storage market requires a host of other performance-related attributes in order to make the deployment successful. To add to the complexity of the energy storage market's needs, these attributes vary depending upon the usage profile required for different applications.

In order to provide the needed operating capabilities, it will be critical to increase the longevity of batteries, and to provide a better means to monitor the state of their health during their operating life. This monitoring need translates into monitoring the system's operating cost, sustainability, safety, and secondhand uses. Pushing the limits of battery technology often has safety consequences. Therefore, environmental controls and containment are gaining in importance. Finally, end of life issues such as recycling the batteries and enabling them to have a second-hand use increases their viability of use in different markets.

Best Practice

Two programs exist that are good models for energy storage projects:

- NYSERDA Distributed Energy Resources – Integrated Data System: Provides access to project locations, project performance, technology information, and policy information.

- US Department of Energy's Federal Energy Management Program (FEMP): Energy savings performance contracts for federal agencies.

What Translates from Solar / Wind Markets

Similar equipment warranty backstops by insurance companies

- PPA- or ESA-backed structures where performance of some type is guaranteed. This can be accomplished on balance sheets, or transferred to a technical insurance company.

- Independent engineering firms will be able to provide reports supporting the use of an energy storage technology for the designed program.

- Technical risk is still core. It can be supported through a warranty, performance guarantee, insurance, or financial products.

What Does Not Translate from Solar / Wind Markets

- More variability with respect to valuing an energy storage project. (However, resiliency, peak demand reduction, ancillary services, capacity, etc. are all potential value streams for an energy storage developer).

- While software and battery deployment are not a concern for standalone solar or wind markets, they are a risk with energy storage projects.

Resources

- US Department of Energy's Federal Energy Management Program (FEMP) https://www.energy.gov/eere/femp/energy-savings-performance-contracts-federal-agencies

- Jones, Richard B. and Tine, David R., "Quantifying the Financial Value of Insurance for Energy Savings Projects." ACEEE 2014 Summer Study on Energy Efficiency in Buildings https://aceee.org/files/proceedings/2014/data/papers/4-180.pdf

- Ghegorghiu, Iulia, "Insurer MunichRe offers 10-year warranty on battery storage performance" Utility Dive https://www.utilitydive.com/news/insurer-munich-re-offers-10-year-warranty-on-battery-storage-performance/550323/

- NYSERDA Distributed Energy Resources- Integrated Data System https://der.nyserda.ny.gov/

References

[1] "Three Types of Energy Storage Insurance for Battery Technologies," Oct. 23, 2017. https://robfreeman.com
[2] Ibid
[3] Ibid.
[4] wikipedia.org/wiki/trade_credit_insurance_
[5] "Three Types of Energy Storage Insurance for Battery Technologies," https://robfreeman.com
[6] "Political Risk, Trade Credit," © 2012 Regionalnetworkalliance.com.
[7] "Trade Credit Insurance," http://beescoin.in/money.html

Risk Management

Chapter Four: Surety

Chapter Lead: Dixon Wright, USI Insurance

Background

Introduction to Surety

A surety bond is a financial product which guarantees that one party to an agreement will comply with their obligations. In the event of a default, the surety will assume the agreement and cure the default.

The surety bond has three primary parties:

- **Principal:** The entity or person principally responsible for performing the terms and conditions of the agreement.

- **Obligee:** The entity or person that requires the Principal to provide a financial guarantee in order to be protected against the default of the Principal.

- **Surety:** The insurance company as Surety that commits to cure a default of the Principal.

The surety bond can have additional parties:

- **Co-Surety:** When there is more than one surety.

- **Dual obligee:** When there is more than one obligee (traditionally a lender).

Surety is underwritten by insurance companies, but it is not insurance. It is a credit product. Insurance is risk transfer, and surety is retained risk. Surety bonds are not contracts that define obligations of the parties; the surety backs the contracts that define the obligations. The surety bond incorporates the obligations as defined in the bonded contract and defines how claims against the bond are handled. (For more information on surety, please refer to the resources provided at the end of this chapter.)

Agreements that can be involved in projects associated with the Smart Grid and, by extension, energy storage, are as follows:

Interconnection

- The Principal is obligated to fund aspects of the planning and implementation of expanding the grid, including withdrawal fees, to accommodate the Principal's specifically identified project with the utility (obligee).

Construction Contracts – Including EPC

- The Principal is obligated to build a facility for the benefit of a project owner (obligee), with mutually agreed terms and conditions that the Principal, Obligee and surety have agreed to.

Energy Facility Operations and Maintenance Contracts

- The Principal is obligated to maintain an energy facility for the benefit of a project owner (obligee), with mutually agreed terms and conditions that the Principal, Obligee and Surety have agreed to.

Energy Facility Operations and Maintenance Contracts with Performance Guarantee

- The Principal is obligated to maintain an energy facility at identified performance levels for the benefit of a project owner (obligee), with mutually agreed terms and conditions that the Principal, Obligee and Surety have agreed to.

Service Contracts

- The Principal is obligated to provide identified, specific ongoing O&M services for the benefit of a project owner (obligee), with mutually agreed terms and conditions that the Principal, Obligee and Surety have agreed to.

Supply Contracts

- The Principal is obligated to supply components for the benefit of a contractor and/or project owner (obligees), with mutually agreed terms and conditions that the Principal, Obligees and Surety have agreed to.

Warranty Contracts

- The Principal is obligated to warranty work already performed for the benefit of a project owner (obligee), with mutually agreed terms and conditions that the Principal, Obligee and Surety have agreed to.

Power Purchase Agreement

- The Principal is obligated to provide a defined level of energy production, including storage, for the benefit of a project owner (obligee), with mutually agreed terms and conditions that the Principal, Obligee and Surety have agreed to.

Decommissioning

- The Principal is obligated to remove all material from the site at the end of the project lifetime for the benefit of the landowner (obligee), with mutually agreed terms and conditions that the Principal, Obligee and Surety have agreed to.

Permit

- The Principal is obligated to comply with all the terms and governmental regulations associated with the project for the benefit of the governing agency (obligee) and enforce regulatory compliance with mutually agreed terms and conditions that the Principal, Obligee and Surety have acknowledged and agreed to.

On Bill Repayment – Energy Services Contract

- The Principal is obligated to repay financing secured through the utility administered On Bill Repayment program.

Energy Services Contract

- The Principal is obligated to terms under an energy services contract.

Surety bonds are financial products that protect counter-parties from a contract default of the other party. These bonds are issued as credit instruments that can be called upon to cure a default and protect against loss. Historically, underwriting has been based on financial strength at the time of underwriting, but also on the surety to understand the risk that underwriters would have to administer if called upon to effect a cure. With new underwriting tools to better understand risks, and the ability to monitor contract performance to mitigate risks with predictive analytics, the surety industry is modernizing both underwriting and claims handling in respect to the needs of the Smart Grid.

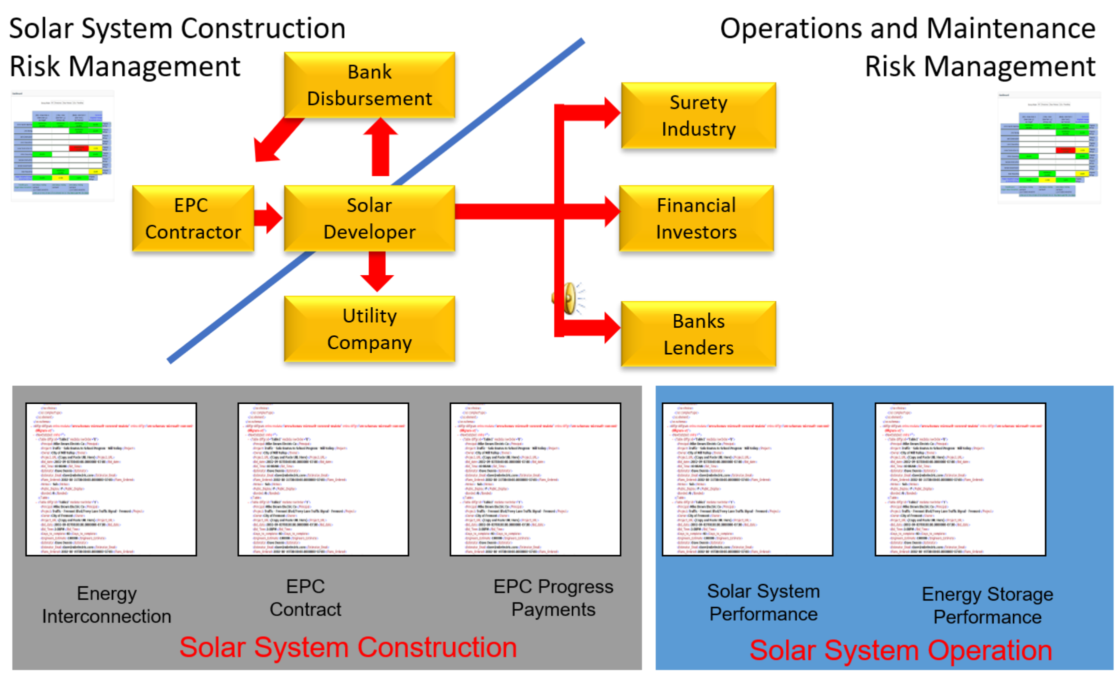


Fig. 7.4.1
Solar system construction risk management/operations and maintenance risk management.
Source: Dixon Wright, USI Insurance Systems.

The energy grid is changing as it modernizes from the old semi-monopolistic "limited stakeholder" energy infrastructure into a new modern digital Smart Grid that features distributed energy production and "multiple stakeholders" throughout the expanded supply chain. This modernization will result in changes to not only how utilities transition to be part of the energy marketplace, but in how the many established traditional financial products and services modernize to leverage new technologies and resources (e.g. data interoperability) in order to be more efficient and cost-effective.

Surety is an example of a financial product that is transitioning from an inefficient product with thousands of formats, forms and coverages that are hard to manage—coupled with an historically poor claim handling reputation—into a valuable project risk management tool with standardized forms and consistent claim processes. This change is enabled by data standards and an interoperability with streamlined applications for underwriting and predicative analytics that result in improved risk management programs. With reliable real time and consistent data now available for system performance data that is monitored across a portfolio, there can be a timely response to potential defaults before they escalate into bigger problems—and long before the project is mired in legal disputes.

As a financial guarantee, surety is an alternative to cash deposits or letters of credit. Letters of credit often require cash collateral, so the aforementioned traditional strategies can be a substantial burden on stakeholders and undermine the financial metrics of a clean energy project.

Surety can often be more flexible in terms of what is required for underwriting. It can also be unsecured. The distinction between a letter of credit and a surety bond is often defined as "On Demand" versus. "On Default." Another more important distinction is how potential defaults are managed as either a "Foreclosure" or "Cure," making surety a uniquely qualified product when counter-party risk is best responded to with expertise that can implement a cure instead of a cash payout—which provides liquidity but no cure, and no expertise to contribute to solutions.

Multiple working groups have been active in exploring ways that emerging data interoperability could enable innovations. These include creating more effective surety products and services to provide predictability and reliability, improve access to credit, and contribute to the evolution of open data standards so that the potential benefits of data analytics can be realized for all stakeholders.

Establishing the data interoperability between the financial markets (banks, capital markets, insurance and surety) and stakeholders in the energy industry was the driving force behind multiple initiatives (the 2012 XBRL Challenge; the 2014 DOE Energy by Design Contest; the Smart Grid Interoperability Panel Priority Action Plan 25; Harmonized Financial Data (SGIP PAP25); Solar Big Data and Infomatics; and the Solar Bankability Data to Advance Transactions and access (SB-DATA) Funding Opportunity), all of which had a focus on how standardized data related to building the nation's energy infrastructure and the Smart Grid, and could be utilized to make solar more bankable.

Those efforts culminated in the 2016 DOE Orange Button. This ongoing platform for collaboration and the exchange of ideas and concepts focuses on making solar and energy storage more bankable by enabling data interoperability and data analytics. The surety industry has been actively developing modernized surety products and services that, by capitalizing on these new capabilities, can leverage third-party innovations created by the emerging FinTech, InsurTech and ConstrucTech start-ups.

The surety of yesterday, which was blind to project issues until the dispute had escalated into a legal situation, is transitioning into a surety industry that can effectively monitor its risk and, with predicative analytics, be proactive in mitigating its exposure on a large-scale portfolio basis. Changing the surety product from the part of the legal quagmire that can engulf a project to an incentivized stakeholder whose success is dependent on effective predictive analytics with predictable and reliable default mitigation expertise, requires developing policies and procedures that benefit all stakeholders on a project. The liquidity of a letter of credit may be best suited in some situations, but if default mitigation and expertise to help navigate problems in order to bring about a cure is the desired outcome, surety bonds are emerging to be the best financial product for those who want a cure more than they do the cash with which to solve it themselves.

Energy Storage Challenges

Surety is Not Well Suited for New Technology

Quite often, projects with new technologies being implemented explore surety as an option to mitigate the risk of new technologies not working. Since the value of surety is implementing a cure or the assumption of the contract, if the surety cannot perform either of those functions, surety is not an option. In the case of new technologies, the surety would have no way to cure performance issues, nor could it assume the contract if no other entities could step in and take over.

Surety works best when project specifics involve normal and customary industry practices and products, and the surety would have a range of options should it be called upon to effect a cure or take over the contract with another entity. The challenge for emerging technologies that want to use surety bonds is being able to demonstrate to the surety provider the ability for the surety bonds to effectively respond to a default—doing so with viable options that are both available and acceptable to the project owners.

Surety Pricing

Surety is often considered as an alternative to letters of credit, but letters of credit are priced differently because they are different products. Because the letter of credit is priced to anticipate a draw of the full amount “on demand,” the pricing is based on pure credit risk and the amount of the letter of credit. Because of the risk of a contract default, it is not considered to be 100% of the contract amount. So, most letters of credit are based on a small percentage of the contract amount to cover the actual risk.

A surety bond anticipates a draw only after a default is proven and/or the Principals are unable meet their obligations. While the pricing is based on the bond amount, the actual credit risk is significantly lower because the surety can take steps to cure the default. For example, if the owner has rights to assume the contract for recovery, and the cost to cure would generally be a fraction of the total contract amount, the statistical maximum probable loss for the surety bond is approximately 20% of the contract amount—which aligns with the percentage amount for most letters of credit. For example, a $1,000,000 contract would have two surety bonds for $1,000,000 each: one for performance and one for payment, both totaling $2,000,000 in surety bond coverage with a statistical risk exposure of $200,000. While the premium is based on the $1,000,000 contract, and the total coverage is $2,000,000, the risk is priced based on a probable maximum loss of $200,000.

The challenge for surety occurs when the bond amounts are reduced to a percentage of the contract save premium, but the credit risk remains as the surety still covers the entire contract, not a percentage. Since the maximum probable loss of risk assumed by a surety is statistically 20% of the contract amount, a percentage bond of 20% does not decrease the risk to the surety, but rather eliminates 80% of the premium in order to take on the credit risk. Thus, it is a challenge for surety providers to price percentage bonds that reduce the premium but not the risk, particularly when pricing is compared against a letter of credit. Sureties are looking to overcome this pricing challenge by adding a surcharge to low percentage bonds to more properly reflect the risk exposure to bond amount.

Appleton Rule

After the financial collapse that caused the Great Depression, The Appleton Rule was enacted in 1939 to prevent insurance companies from being exposed to excessive financial risk. Introduced in early 1900's by Henry D. Appleton - a New York Deputy Superintendent of Insurance, the Appleton Rule states that all insurance companies doing business in New York must abide by New York legislation (strictly complying with the New York Insurance code) irrespective of whether they did business in other states as well.[1] The Rule barred insurance companies from writing all but a few specifically identified financial guarantees in multi-line property and casualty companies. This resulted in insurance companies being required to write financial guarantees in a specific mono-line company that was dedicated solely to financial guaranties.

This structure can be a challenge for stakeholders that are looking for performance and payment, or for supply bonds where the surety would be regarded solely for a payment as a financial guarantee. If the bonded contract only provided for payment in the event of default, some surety markets would consider it a violation of the Appleton Rule, and would then decline to provide surety credit on that basis alone.

To avoid the Appleton Rule, the contract should provide for the surety to cure the default by assuming contract, finding a replacement to assume the contract, or taking other measures to fulfill the obligations of the contract. If a cash payment is the only default remedy, then a letter of credit would be the more appropriate financial product.

Historical Responsiveness of Surety to Default

The lack of responsiveness by the surety to a default is often cited as a concern. As noted, the obligations of the surety are tied to that of its principal, so before any surety can respond, the obligation must be verified. If the principal is not obligated, neither is the surety. Time and distraction can be detrimental to a project, but it can also be avoided with better communication between stakeholders while the problem is escalating, and prior to default.

The U.S. DOE Orange Button has expanded the XBRL taxonomy (a publicly available global framework for the exchange of business information) to improve stakeholder communication and provide early warning data analytics that will prompt default mitigation measures and identify obligations so that a timely response from the surety can be achieved. The challenge is that the practice of traditionally limited, if any, surety engagement, is no longer best practice, but instead invites poor claims response.

Surety's Effectiveness in Managing Defaults

Helpful for understanding the benefits that surety bonds offer public agencies, an analogy for how surety works is when a contract to build or maintain a construction project is in default. While utilities are not public agencies, they are regulated to a certain extent as if they were.

Structurally, the project procurement in public works is a drawn-out process, with bid solicitations, notifications, pre-bid advertising, and a bid award process that follows rigid protocols and procedures. If the public agency accepted a LOC to protect against default, the default would be the public agency's to administer under regulatory oversight and procedures, including the defaulted contract re-letting process—which could require that the same time-consuming procurement process be repeated.

Holding funds of a defaulted entity under a letter of credit also forces the public agency to account for the funds on behalf of creditors, and to return any funds in excess of the loss. A surety bond allows the surety provider to administer curing the default. With legal rights to the underlying contract, the surety can facilitate the most cost-effective way to bring in a new contractor. Despite it being a public works project, there is no procurement process to deal with, and regulatory oversight would be minimal, if at all. The surety would resolve any subcontractor and/or vendor payment issues on the defaulted contract. The public agency, or the publicly regulated utility, could simply look to the surety to cure the default, and to restore the forward progress of the contract.

The challenge for stakeholders is understanding how the surety product works; it operates not as a cash payment source, but as a cure for default. Once stakeholders are comfortable with seeing the surety as a project stakeholder with a self-interest in mitigating any loss, the surety product will become the preferred financial guarantee product. And since surety bonds may not require the same level of cash collateral, the project can be more financially viable and profitable for all stakeholders.

Structure for Surety Products Tailored for the Smart Grid

The same basic premise where the surety assumes the underlying contract and "steps in the shoes" of the defaulted principal, subcontractors and other payment bond claimants, would also apply to Smart Grid-related contracts. Not only would the surety have the right to assume the underlying contract, but to seek to cure the default by bringing in a replacement entity to take over the underlying contract at no loss, cost, or expense to the obligee—and hopefully no loss to the surety.

If assumption of the underlying contract is not feasible or desired, the surety, at its option, can cure the default by simply paying the financial damages as defined in the underlying contract, and let the underlying contract expire. The surety rights and remedies for assumption of the underlying contract with utilities is consistent with the surety rights and remedies on public works contracts. The challenge to surety claims handling is the understanding from project participants how the surety is designed to work to cure defaults, and what it is not meant to be—a blank check that can be cashed on demand.

The Role of Data and Data Interoperability

The capabilities of the surety to monitor and manage its risk is made possible by the work of the DOE Sun Shot Program, DOE Electricity Delivery and Energy Reliability, and all the various trade associations and government initiatives that have developed data standards for their specific niche and constituency—both of which are coming together to enable data interoperability between all those efforts.

Please refer to the chapter on data interoperability (Best Practice Guide 4) for background on the development of standards. The challenge to the surety in providing effective monitoring for risk management is the adoption and implementation of the data standards by the project stakeholders, and access to that data for predicative analytics.

Best Practice

Risk Management – Surety

In a broad sense, the term "risk management" is used to describe any number of activities, policies or procedures employed to manage company risk. This includes risk transfer externally through insurance, which can be expensive for certain exposures, to risk that's retained and mitigated through internal quality control actions like inspections and monitoring— which can be cost-effective if done right.

Counter-party risk management is a term to describe risk management to protect against risk from others in a contract that could undermine the contract, thereby creating a negative impact and financial loss. For contracts that involve the construction and operations of energy facilities, it is common for counter-party risk to be managed with a combination of insurance requirements for insurable risk and financial guarantees like letters of credit or surety bonds. These would cover the entire contract or, under a PPA, specifically identified exposures like energy production.

For Best Practices in contracts that involve construction and operations of energy facilities including energy storage, consideration should be given by all counterparties to the economics of risk management between risk transfer with insurance or risk retaining with letters of credit or surety bonds. Requiring excessive insurance or high limit letters of credit requiring cash collateral may look impressive, but the cost and burden imposed can far exceed the value provided—and undermine the financial sustainability and merits of the project. A proposed Best Practice for the energy storage industry is to cost effectively allocate financial resources, products and services to reduce costs, but still maintain prudent risk management programs to enhance the financial sustainability and merits of the project.

Distinction Between Surety – Insurance and Letters of Credit

The costs associated with providing financial guarantees in support of interconnection to the Smart Grid, along with related power purchase agreements, decommissioning and similar requirements, continue to be a barrier as these costs can undermine financial viability.

Traditionally, bank issued letters of credit have been the instrument of choice given their "On Demand" liquidity, but surety bonds are better suited to manage defaults. And while the "On Default" criteria have often been seen as a negative, the ability of the surety to effectively manage defaults not only makes it a preferred option, but also significantly less capital intensive—which therefore makes solar and energy storage more bankable. The surety industry provides financial guarantee products issued by insurance companies, regulated by the Department of Insurance in each state, and follows regulatory statutes with established legal precedence for how claims are administered.

Although issued by insurance companies, surety is not an insurance product, which is generally described as "risk transfer," but a credit product similar to a co-signer where the ability to retain the risk of the contractual obligations is quantified by the surety during underwriting, and assumed by the surety in the event of a default by the obligation "to cure the default" as prescribed in the underlying contract.

The surety bond guarantees the contractual obligations of the entity that it is principally obligated to perform. And it is required to provide a financial guarantee referred to as the "Principal." The entity the principal is obligated to under the contract is referred to as the "Obligee," and the co-signer that stands behind the obligations of the principal is the "Surety." The unique nature of surety is that as "co-signer," the obligations of the surety are no more than the obligations of the principal; the rights and remedies afforded the principal under the contract are the same rights and remedies for the surety; and the surety's assumption of the contract is only to the extent the principal was obligated and limited to curing the default.

Surety bonds are not stand-alone instruments; they are tied to, and incorporate, an underlying contract such as an interconnection, decommissioning and power purchase agreement. The default and cure provisions in the underlying contract, including notice provisions and timelines for the principal, are the same for the surety. The "on default" and "curing the default" characteristics make the risk of financial loss to the surety substantially less than a bank letter of credit where the obligation to pay is "on demand" –without the benefit of cure provisions within the underlying contract. The ability to defend against an unwarranted demand, along with the ability to cure the default, results in pricing, terms and conditions from a surety that are significantly less costly than letters of credit from a bank.

Better pricing terms and conditions related to securing financial grantee instruments reduce project costs and, with effective default risk mitigation along with predicable claim handling, can make renewable energy projects more bankable—all while providing the highest level of financial protection.

Unintended Consequences of a Letter of Credit

One of the most valuable assets a solar developer has on any project is the guaranteed revenue from a PPA, which could be compromised if external pressures like a bankruptcy of a parent or holding company triggers a project level default and the utility draws down on the letter of credit, exposing the project to bank foreclosure action. Assuming the energy being delivered meets the obligations of the PPA, and therefore no loss to the utility, that drawdown will need to be held in escrow, making the utility a "custodian with a fiduciary responsibility."

If the PPA default compromises the PPA itself, and the PPA is canceled as a result of the default, the impact on the valuation of the solar facility is significantly adverse and will negatively impact any financial restructuring or sale, resulting in even more losses for the solar developer and its lenders. This will also cause more unpredictability for the utility. That is not a preferred position for the utility, the lender, or the solar developer, and does not contribute to an orderly and cost-effective management of the situation.

While the idea of being able to quickly draw funds has appeal, the ramification of the utility having to defend its holding of cash assets and actively engage in a protracted legal process—all while the facility is meeting its PPA requirements, and therefore without loss to utility—adds a level of inconvenience to the utility or corporate offtaker that far outweighs the benefit. Instead of the utility being forced to engage in the legal proceedings associated with foreclosure and contributing to the unpredictability due to deep discounting of project valuation, they could instead refer the problem to the surety to "cure the default." The distinction between a letter of credit and a surety bond is often defined as "On Demand" versus "On Default." Another more important distinction is how defaults are managed by "Foreclosure" or "Cure."

The DOE Orange Button surety structure and bond forms provide for how a default would be handled, and how a surety could mitigate the loss by having a mutually agreed upon process for curing a default, including the disposition of the PPA asset to a restructured entity or replacement buyer. If the project has a track record of performance, and is operationally sound, then a surety structure can protect the PPA as a transferable asset and make it so the default cure mitigates the loss and expedites the resolution— without the usual encumbrance of the legal system and attorney costs. The surety structure does not deny or dilute existing financial interests in the value of the PPA. Rather, it preserves the value for maximum loss mitigation for the project as a whole. The intended benefits of a surety bond are better than the unintended consequences of a letter of credit.

Benefits of Surety over Letters of Credit

Developers

- Reduced cost of capital for financial security instruments.
- On existing projects, part, if not all, of the collateral held by the banks to support LOCs can be returned, and the ongoing debt burden for maintaining collateral would be reduced.
- Better protection against unwarranted draws, with the ability to defend and cure.

Investors

- While loss prevention may not be possible if a default were to occur, loss mitigation would be achievable through (1) protection of the underlying contract and (2) a process that, instead of the more expensive and destructive foreclosure action from the underlying contract LOC being drawn on, focuses on curing the risk of underlying contract default.

Lenders

- No financial exposure for the amount of the LOC. An orderly management of financial restructuring of the asset debt, including the protection of the underlying contract, would preserve the overall asset value and support underwriting considerations.

Utilities

- In the event of a default and draw down on a letter of credit, the utility would not have to hold and administer funds drawn from the LOC, or account to the creditors for funds not required to meet underlying contract obligations.
- A utility would not have a problem asset, with its associated unpredictability, on its grid.
- Surety can act as a financial backstop to facilitate the restructuring or transfer of the asset to a financially sustainable structure, with the efficient management of the underlying asset—the “bonded contract”—acting as a transferable asset.
- Managing and curing the default would be the obligation of the surety, not the utility.
- Codifies the data sets and surety bond forms for building the Smart Grid as contemplated by the DOE Orange Button.

Resources

- **Surety Industry**
  Surety Fidelity Association of America (SFAA)
  National Association of Surety Bond Producers (NASBP)
  SFAA/NASBP Joint Automation Committee
  Small Business Administration
  Suretypedia

- **Glossary of Terms**
  Building Energy Data Exchange Specification (BEDES) Dictionary
  Energy Storage Association Glossary of Terms
  IEEE Explore - Browse Standards Dictionary
  buildingSMART Data Dictionary (bSDD)

- **Orange Button**
  DOE Orange Button
  SunSpec Alliance
  Smart Electric Power Alliance (SEPA)
  National Renewable Energy Laboratory
  kWh Analytics – Orange Button Translate
  XBRL US - Solar - Surety - FinTech

- **Government and Industry Associations**

  American National Standards Institute (ANSI).
  Building SMART International
  Electric Power Research Institute (EPRI)
  Energy Storage Association (ESA)
  Construction Progress Coalition (CPC)
  Global Energy Storage Alliance (GESA)
  Grid Modernization Laboratory Consortium
  Institute of Electrical and Electronics Engineers (IEEE)
  International Electrotechnical Commission (IEC)
  International Electrotechnical Commission Renewable Energy (IECRE)
  International Organization for Standardization (ISO)
  Modular Energy Storage Architecture (MESA)
  National Association of Regulatory Utility Commissioners
  National Electrical Manufacturers Association – Energy Storage Systems
  North American Energy Standards Board (NAESB)
  North American Electric Reliability Corporation
  Solar Energy Industries Association (SEIA)
  State and Local Energy Efficiency Action Network (SEE Action)
  Sustainable Energy Action Committee (SEAC)
  Task Force on Climate-related Financial Disclosures
  Western Electricity Coordinating Council

References

[1] Appleton Rule Definition, https://www.mbaskool.com/business-concepts/finance-accounting-economics-terms/11812-appleton-rule.html.

ENERGY STORAGE BEST PRACTICE GUIDE 8:

CODES AND STANDARDS

Codes and Standards

Chapter One: Overview

Chapter Lead: Charlie Vartanian, PNNL

Background

The DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA indicated that the biggest challenges hindering adoption of energy storage technology (EST) are cost, the ability to deploy Energy Storage Systems (ESS) and lack of standards.[1] Standards, and other documents such as codes and guidelines that collectively establish criteria by which safety, performance and reliability can be documented and verified, can have a direct impact on the cost of an ESS and its installation in terms of material and manpower costs. In addition, the administration of these documents by adopting entities (authorities having jurisdiction), and efforts associated with documenting and verifying compliance with them, affect the ability to deploy the technology and, in turn, the cost.

This Codes and Standards (C&S) BPG is organized into three chapters. The Overview chapter provides a high-level summary of the important cross-cutting issues that are relevant to C&S in general. The next two chapters are organized into two main C&S practice areas: Safety, and Reliability and Performance. These Safety and Reliability and Performance chapters are organized by background, energy storage challenges, and best practices.

Of the two main practice areas to be discussed, Safety—as associated with ESS and, in general, the built environment—is relatively more mature, and is therefore the primary focus of this BPG. Reliability and Performance are relatively early in their development, adoption and application in the C&S lifecycle. The Reliability and Performance cycle will be described in more detail later. Selected specific challenges and supporting guidance will also be provided for this less mature C&S practice area.

What Investors Need to Know

Policies exist to spur the development of early stage ESS and the application and use of commercially available energy storage technologies where the “free market” might not provide sufficient incentives or support. The Department of Energy (DOE) 2014 report “Energy Storage Safety Strategic Plan” has helped guide early development of energy storage safety C&S. David Conover, the next chapter’s lead author, was a contributor to that report. Mr. Conover also led the follow-on effort to implement the DOE’s energy storage safety strategy via the Energy Storage Safety Collaborative website[2] and published products. This chapter draws from, and then extends on, these earlier resources.

Policies also exist to measure and express energy storage technology performance and reliability, as well as establish a basis for what is and is not considered safe. All anyone having a financial interest in any project using energy storage technology needs to understand about standards is return on investment (ROI). The ability to develop and get the technology to market in a timely manner, and then deploy projects that meet established criteria, has a direct impact on ROI. If a sound basis for performance, reliability and safety exists, then one can readily develop, deploy, apply and use ESS to meet their business objectives. If not, then the ROI can be adversely affected and, in some cases, be zero.

As shown here in Figure 8.1.1, time and money are integrally tied.[3] When a decision is made at time zero to invest in either energy storage technology development or the deployment of an energy storage project, a period of time is expended either before the technology gets to the market or the project is approved to operate.

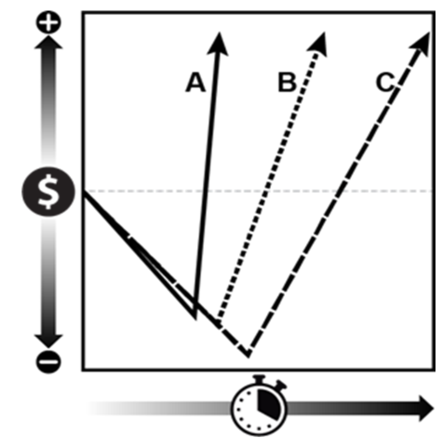


Figure 8.1.1
ESS investment dollar spend as impacted by time.
Source: David R. Conover, *Codes and Standards for ESS Relevance and Importance*, Presentation at the IEEE PES General Meeting, slide 6 (Jan. 23, 2018).

The scenarios shown here represent situations where those who develop and deploy ESS take different paths with respect to standards. Those involved in scenario A "did their homework" in terms of paying attention to, and even helping update, standards by conducting necessary testing and fully documenting the safety, performance and reliability of their technology—or their application of the technology—to a project.

Those in scenario B were "behind the curve" and those in scenario C likely made it to market or proposed an ESS project only to find numerous "surprises." Clearly, those taking path A achieved a good ROI and those tending toward C did not or—much worse—got to market only to find out they had missed a key safety, performance or reliability issue that was a showstopper.

The key message for investors and project developers is not that they need to become experts in the area of standards, but rather that they ask the right questions to those entities in which they are investing. Fundamental questions include the following:

- Has the ESS product been tested and listed to relevant safety standards?

- If not, what about the components of the ESS product?
- If nothing is tested and listed, then why hasn't it been, and how does the technology proponent intend to document the safety, performance and reliability of the ESS product?
- What codes and standards are the project developer applying to the specific ESS installation?
- Who developed the documentation associated with compliance to those codes and standards, and what does the documentation provide?
- Which AHJs will the documentation be provided to and how will the project developer be involved in the review, inspection and approval of the ESS project?

If the ESS product proponent cannot answer the first three questions and the ESS project developer cannot answer all six, an investor should consider postponing any investment decisions until the answers are available.

The next section provides more detail on codes and standards development, adoption and application. Investors are encouraged to review this section to have a better under- standing of the questions above, and the answers that should be readily available. Energy storage system proponents and project developers (i.e., those utilizing the financial and time investments) can use the section to either validate answers they may already have or to better understand the topic so they can develop the answers. As shown in Figure 8.1.1, having the appropriate answers early on will move the technology and its intended project applications toward the "A line."

What Project Developers Need to Know

As noted previously, codes and standards and the activity to document and verify conformity with their criteria are important to the development of energy storage technologies and the deployment of ESS projects. The challenge for proponents of EST and developers of ESS projects is an understanding of the value of codes and standards, how they are developed and adopted, and then, once adopted, how they are applied. If investors understand how codes and standards can impact their ROI, they will be more likely to support ESS development and deployment. With that support, ESS proponents and project developers will be able to pursue their activities and succeed. The key to ensuring success is for proponents and project developers to be able to answer the questions stated earlier and realize the following outcomes:

- Those seeking to employ ESS have confidence in the safety, performance and reliability of what they are proposing and can readily and uniformly document the acceptability of the ESS components, the entire ESS or the planned installation of the ESS to potential users.
- Those seeking to purchase or specify the technology have a recognized set of acceptable codes and standards to reference in their procurement documents.
- Documentation of safety, performance and reliability results in fewer project delays because the necessary information is available and the codes and standards are clear about what to measure, how to measure it, and what is acceptable.
- Given the possibility of a project delay in securing approval for ESS as a new technology, those who purchase the technology are less likely to avoid the technology to complete their project and generate revenue because it does not pose any codes and standards driven deployment challenges.
- Specific CSR that address the acceptability of the technology provide a common ground for all technology proponents in securing necessary approvals and offer uniform specifics for ESS installations that are safe, reliable and will perform as desired.
- Uniform and acceptable codes and standards provide a focused foundation for education and training on, and support services for, the technology.
- Technology installers and inspectors know what to expect as the criteria governing all installations is more uniform.
- Those involved in addressing incidents at installations (e.g., first responders) have fewer problems; if they do have to respond, their ability to address an issue with an ESS is vastly improved.
- Ongoing operation and maintenance as well as repair or refurbishment of the technology can be undertaken based on clear direction from adopted codes and standards in a more timely and less burdensome environment.

Fig. 8.1.2
Keys to ESS success.
Source: Pacific Northwest National Laboratory, OVERVIEW OF DEVELOPMENT AND DEPLOYMENT CODES, STANDARDS AND REGULATIONS AFFECTING ENERGY STORAGE SYSTEM SAFETY IN THE UNITED STATES (PNNL-23578) (Aug. 2014).

Standards and model codes are the body of criteria or provisions which, when adopted, must be satisfied to design, construct, commission, rehabilitate, operate, maintain, repair and demolish components of the built environment such as buildings, facilities, products, systems and the equipment therein. The provisions in these documents affect the acceptability of energy storage technology on the utility and customer side of the meter,[4] along with the time and resources necessary to bring such technology to market as well as the eventual cost of the technology installation. These provisions create opportunities for the development and use of new technology to address new and emerging issues where proponents of the technology are proactive in either conducting needed research and recommending enhancements to existing standards or developing new standards and model codes covering safety, performance and reliability.

An historical review of these documents in the United States indicates that requirements therein have been developed and deployed to address natural or manmade disasters (building fires, hurricanes, seismic events), new and emerging issues (indoor air quality, radon, accessibility for the disabled) and to provide a basis for the application of new technology (plastic pipe, engineered lumber, non-CFC based refrigerants). Figure 8.1.3. provides a high-level general overview of the development, adoption and deployment process in the United States.

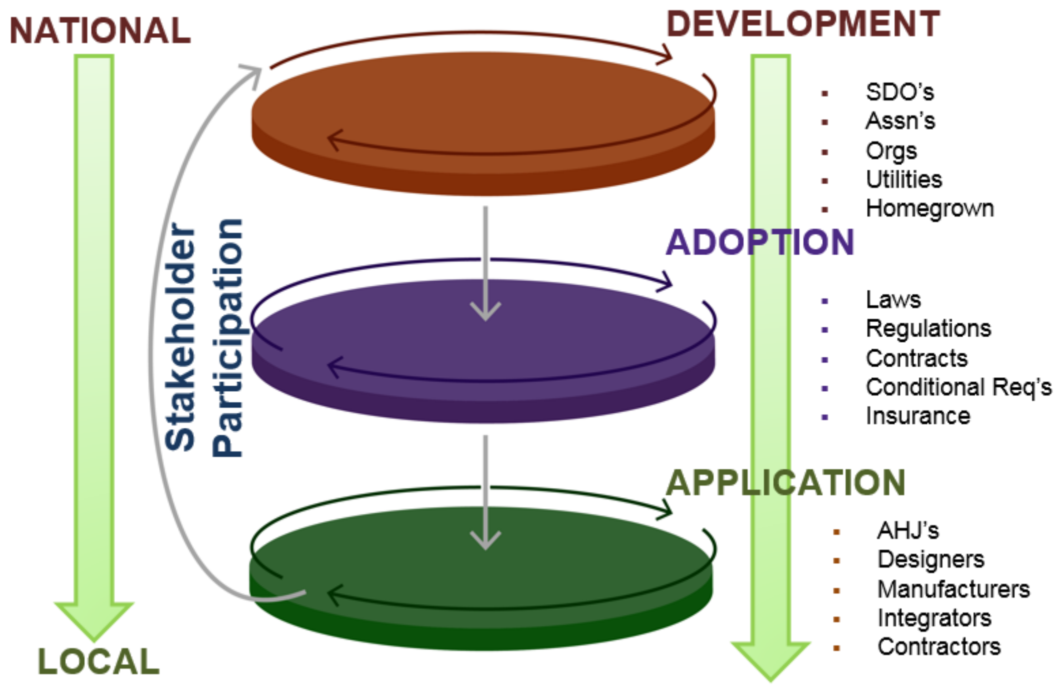


Figure 8.1.3
U.S. documentation process.
Source: David R. Conover, *Energy Storage Technology Safety Overview*, Presentation at the World Bank (Jan. 15, 2019).

The basis for requirements adopted in the United States are standards and model codes developed and published by organizations in the private sector.[5] These documents exist separately to address a specific purpose and scope provided in each standard or model code. Collectively, they are part of a comprehensive set of laws, rules and regulations (i.e., requirements) covering all aspects of the built environment that are required either to be satisfied, or to provide a basis for technical communication (e.g. measurement of how a technology performs in relation to any number of topics) because they have been adopted.

Voluntary sector standards development organizations (SDOs) exist in the United States as private sector entities with (among others) the mission of developing and publishing standards and model codes[7] to address specific issues, technologies and design/construction solutions. The documents developed are generally focused on specific areas or issues and impact, among others, stakeholders who want to deploy technology. Two important issues to recognize about the process that each SDO employs are that development occurs on a particular schedule and each SDO organizes and manages the process. The provisions in the documents published by the SDO are not developed by the

SDO but are instead developed by all interested and affected parties under a process provided and administered by the SDO. Whether acting alone or as the ESS "industry," any revisions to existing standards and model codes will have to account for SDO schedules and deadlines and be initiated by someone other than the staff of the SDO.

To ensure that documents are current and accurate (while being sensitive to the interests of all parties), proponents of an ESS need to understand the SDO process and be involved early on in the development of new standards and/or the updating of existing standards and model codes They also need to be involved in documenting compliance with documents as they relate to the ESS product. Project developers need to be able to rely on what ESS proponents provide them, in addition to being involved with the development of standards and model codes covering ESS installations. In addition, they need to be intimately familiar with the range of AHJs that will impact any of their projects and how to document compliance with what those AHJs have adopted.

Deployment includes what happens after standards and model codes are developed in the voluntary sector and published. It involves the processes associated with their adoption as laws, rules or regulations and the entities involved in that process. It also covers how compliance with those documents is documented and verified through conformity assessment.

Adoption can be by any entity including a person, corporation, insurance carrier or utility as well as by federal, state or local legislative bodies or governmental agencies. The act of adoption through a law, rule, regulation, statute, contract specification, tariff or any other vehicle is intended to ensure that what is contained in the model codes and standards developed in the voluntary sector, or developed by the adopting entity, is fully satisfied, and that there is a basis for enforcement to ensure compliance. While federal, state, and local governments and other adopting entities have the authority to develop standards and model codes, most adopt those developed in the voluntary sector by adding amendments, additions and deletions that will address any specific needs that are not addressed in those documents.

The federal government does not generally have the authority to mandate the adoption of standards and model codes by state or local governments. However, federal agencies can influence what is adopted through other means such as the availability of federal funding. Aside from buildings owned or leased by federal agencies and, in a few instances, where the federal government has preemptive authority,[9] Congress or federal agencies can adopt specific standards and model codes, and state and local regulations, that will apply to the built environment—which would include an ESS installation. For an ESS on the grid side of the meter, equipment and buildings owned or operated by the utility are covered by what is adopted by the utility in coordination with relevant regulators (e.g. FERC/NERC for the wholesale market segment, and PUCs for the retail market segment).

Demonstrating compliance involves the ESS product itself and, in addition, its application and installation. The project owners or their agent (e.g., the project developer) must be able to document compliance with any adopted safety, performance or reliability requirements. In doing that they will also rely on the manufacturer of the ESS product and associated components to provide the necessary documentation to verify that what they provide to the project complies with the adopted standards and model codes. All of these activities are typically included under the broader term "conformity assessment." This includes testing, certification, quality assurance, calculations, simulation and other activities—all of which are intended to document the degree to which the applicable requirements are satisfied. In turn, the documentation is presented to the approving authority that will use it to validate compliance with the applicable requirements as they have been adopted by the AHJ in the design stage, and will then engage in various inspections during the construction stage as well as through commissioning, operation and use—and even decommissioning (e.g., retirement and recycling or disposal of the system or system components).

Resources

- Sandia National Laboratories, DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA (SAND2013-5131) (July 2013).

- Sandia National Laboratories, DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA (SAND2015-1002) (Feb. 2015), available at: https://www.sandia.gov/ess-ssl/publications/SAND2015-1002.pdf

- U.S. Dept. of Energy, Office of Electricity Delivery and Energy Reliability, Energy Storage Safety Strategic Plan (Dec. 2014).

- Pacific Northwest National Laboratory, Overview of Development And Deployment of Codes, Standards and Regulations Affecting Energy Storage System Safety in the United States (PNNL-23578) (Aug. 2014), available at: https://energystorage.pnnl.gov/pdf/PNNL-23578.pdf.

References

[1] It is important to clarify that a lack of standards can be interpreted to mean no standards exist or simply that the standards that do exist need to be updated to better address ESS. Also, as discussed in this chapter, it is important to understand there are myriad of documents that can be considered standards and include model codes, codes, guidelines, and guides. A key determining factor is if a document contains normative (e.g. shall) enforceable requirements or informative (e.g. should or may) unenforceable.
[2] While the utility may be the authority having jurisdiction (AHJ) with respect to utility systems and federal, state or local authorities, territories and Indian Tribes the AHJ for installations on the customer side of the meter (e.g., non-utility systems), safety of ESS is to a large extent "blind" as to which side of the meter the ESS is located. For that reason, the development of codes and standards covering safety is generally applicable to all installations, while the adoption and conformity assessment processes associated with those documents may differ on either side of the meter. With respect to reliability and

performance issues, the AHJ will more likely be the entity investing in an ESS project such as a utility or facility investor or owner.

[3] David R. Conover, *Energy Storage Technology Safety Overview*, Presentation at The World Bank, (Jan. 15, 2019)

[4] Note that while standards and model codes may be considered voluntary when developed in the private sector, they become mandatory when someone adopts them and either requires conformance to them or makes conformance a prerequisite for some other consideration (e.g., ability to secure insurance or a reduced insurance rate premised on a decision to adopt one or more documents).

[5] For the purposes of the discussion on development, standards and model codes are the focus when discussing development in the voluntary sector. Subsequent to their adoption, they are considered regulations as are any "home grown" criteria developed and adopted directly by a legislative body or regulatory agency.

[6] The terms "standard" and "model code" can be considered the same for this general discussion on development.

[7] Examples include those responsible for verifying the safety of an ESS application that would have to develop their own "home grown" criteria in the absence of what is developed in the voluntary sector. They also include proponents of ESS applications who in the absence of standards and model codes developed at the national level for adoption would face increasing challenges to respond to a possible "crazy quilt" of differing requirements across the United States, affecting energy storage systems, their components and the installation of systems.

[9] Examples are product labeling (FTC), appliance efficiency (DOE) and manufactured housing construction (HUD).

Codes and Standards

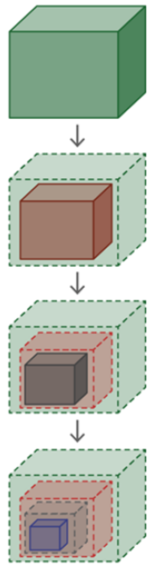
Chapter Two: Safety

Chapter Lead: Dave Conover, PNNL

Background

Safety standards and model codes can be organized "from the top down" or "bottom up." It starts with testing ESS components, followed by listing them as having met applicable safety standards. The installation of the ESS would subsequently be in accordance with adopted standards for the installation, as well as the overarching standards and model codes that cover many topics including ESS safety. One important distinction related to adoption, and the relevant AHJ, is the location of the ESS in relation to the grid and primary electric meter. Those on the grid side of the meter would be subject to the documents the utility has adopted. Those on the other side of the meter would be subject to what has been adopted by the AHJ(s), based in part on location, ownership, and other variables (e.g., federal, state, local, tribal, territorial, insurance, etc.). If those happen to be owned by an electric utility, but are on the customer's side of the meter, the requirements and processes associated with both scenarios might apply.

Figure 8.2.1 provides a snapshot of key safety-related standards, model codes and guidelines that apply to energy storage systems—beginning at the overall built environment and ending at components associated with an energy storage system. Other documents that can augment those shown in Figure 8.2.1 are listed in the Resources section of this chapter as numbers 6-11.



BUILT ENVIRONMENT

- ICC International Residential Code and International Fire Code
- NFPA 1 (Fire Code)

INSTALLATION / APPLICATION

- IEEE C2 National Electrical Safety Code
- IEEE 1635/ASHRAE 21 Guide for Ventilation and Thermal Management of Stationary Batteries
- NFPA 855 Standard for the Installation of ESS
- NFPA 70 National Electrical Code
- NECA 416 Recommended Practice for Installing Stored Energy Systems

ENERGY STORAGE SYSTEMS

- ASME TES-1 Safety Standard for Thermal (molten salt) ESS
- UL 9540 Energy Storage Systems and Equipment
- UL 9540A Test Method for Evaluating Thermal Runaway Fire Propagation in Battery ESS
- NFPA 791 Recommended Practice and Procedures for Unlabeled Electrical Equipment

SYSTEM COMPONENTS

- CSA C22.2 No. 340 Battery Management Systems
- UL 810A Electrochemical Capacitors
- UL 1973 Standard for Batteries for Use in Stationary Applications
- UL 1974 Evaluation for Repurposing Batteries

Figure 8.2.1
Major ESS standards, codes and guidelines.
Source: Pacific Northwest National Laboratory.

These documents are updated on published schedules by each SDO and most vary from three- to five-year cycles (with a new edition being developed and published with each cycle). Some, such as UL, accept suggested changes at any time and develop and publish a new edition as warranted. The documents listed in Figure 8.2.1 under system components apply to specific components (i.e., parts) of an energy storage system and would be used as a basis for testing and listing those components (e.g., if tested and listed to a specific standard, then the component would be considered as meeting that standard). To validate product acceptability, an exception is UL 1974, which can be applied to those recycling vehicular batteries for use in a stationary ESS. The documents listed in Figure 8.2.1 under energy storage systems would be used as a basis for testing and listing an entire system and, in one case (ASME TES-1), also include installation related criteria. The documents listed in Figure 8.2.1 under installation/application address how an ESS installation can be considered safe. Those listed in Figure 8.2.1 under the built environment are documents that are broader in scope and cover many topics, one of which is ESS. These documents generally adopt by reference the other documents below them in the figure.

The relationship between an SDO-developed and administered standard and a listing by a certifying entity is illustrated by the Institute of Electrical and Electronics Engineers (IEEE) 1547 Standard and UL 1741. While IEEE 1547 sets the technical requirements for connecting power systems with distributed energy resources, UL 1741 provides requirements upon which an interconnection device can be evaluated, and then listed to UL 1741, by an accredited third-party certification agency. It can then be used to verify compliance with the performance requirements of IEEE 1547. The point is to highlight the interrelationship between an SDO's standard, and a third-party certification agency's use of that standard, as the basis for certification as exhibited in that agency's listing of the product. An additional insight relevant to ESS project developers is that certifying entities, including UL and CSA, can leverage their infrastructure used for listing to support other forms of third-party due diligence to evaluate and manage the risk of an ESS project. Some examples of these additional services—provided by certifying entities that are used by developers and financers for project due diligence—include witness testing and special inspection/field evaluation.

Another example of leveraging certification infrastructure is specifying the alternate levels of verified safety or performance that are custom tests that (1) do not result in an accredited certification test report or mark, and (2) do not require ongoing factory or production evaluation. Examples of less-than-full-certification compliance requirements are sometime referred to as "design to" or "test to," e.g., "designed to UL-1741-SA." As to the value of "design to," the above simply points to the ability to facilitate the acceptance of an EST. The application of an EST (e.g., installation as an ESS) can be similarly facilitated by a field evaluation from a third-party certification agency as well as through the efforts of a licensed engineer who prepares and seals a set of plans that documents that the proposed ESS installation complies with the adopted codes and standards. Where ESS installations are the same or similar, that sealed set of plans should be acceptable to multiple AHJs but only as long as what they have adopted is covered by those plans.

One major challenge that applies to codes and standards in general is the issue of "who is the Authority Having Jurisdiction," and what is their role specific to a project. Part of the challenge is the impact of location and market(s) within which the ESS will operate. Location and market(s) largely define which AHJs may be relevant to which codes and standards, and also how the codes and standards are used. But, in general, any and all AHJs who adopt and apply codes and standards to address any aspect of a technology or its application have the authority and duty to document and verify that whatever is proposed, meets the criteria they have adopted (e.g., standards and model codes, etc.). It is virtually impossible for all AHJs (individual utilities, federal, state, local, territorial, tribal entities, insurance providers, etc.) who adopt and require compliance to individually determine if an EST meets specific standards, or to conduct factory inspections to certify that continued production is consistent with the individual EST that was tested and found to comply. For this reason, third-party testing and certification agencies in the private sector accredit and conduct these activities. When an EST is found to comply, the agency will issue a test report and also authorize the manufacturer to put the mark (i.e., label) of the agency on the EST (i.e., to list the EST). This is analogous to securing one dental Magnetic Resonance Imaging (MRI) from a recognized dental lab and having all dentists accept that MRI in lieu of them each having to order a new MRI.

Energy Storage Challenges

The availability of standards and model codes to address all EST and ESS installation scenarios—whether to cover what is and is not safe, or how to measure and express performance or reliability—is a challenge. According to a report prepared in 2014 by PNNL for the DOE, the absence of years of experience with standards-based criteria "upon which to evaluate technology performance, reliability and safety leaves those seeking to move ESS into the market, and those responsible for public safety, system performance, or reliability 'with little upon which to base a decision that the system and its installation are sound and will perform as expected.'"[1] Until existing standards and model codes are updated and/or new ones are developed that specifically address the range of ESS technologies and installations (and those documents are subsequently adopted), it is difficult to uniformly document what is safe, and then determine what can be approved, in a uniform and timely manner.[2] The DOE also states that it is also impossible to have a meaningful technical discussion about ESS performance or reliability. In some instances, the lack of specifics limits progress until appropriate criteria are available. In other instances, outdated criteria can be conservatively applied to the technology affecting the cost of the installation or limiting its application.[3] However, there has been activity across key industry communities, including SDOs, to address this earlier identified gap. These activities and the current status of standards and model codes are discussed in this chapter's best practices section.

It is important to note, as the PNNL report reminds all parties dealing with safety issues, that

> until standards and model codes are specifically updated to address new EST and ESS applications, those documents do provide a path to documenting and validating compliance. They do so on the basis that what is proposed is no more hazardous nor less safe—and performs at least as well—as other technologies that are specifically covered by existing standards and model codes. While affording approval, this path requires the development of criteria to document and determine "equivalent safety" by each entity responsible for enforcing the adopted documents. As a result, proponents of an ESS installation may have to develop a "custom" documentation package for each AHJ where an ESS is desired on the customer side of the meter, or for each utility when on the grid side. In addition, those AHJs may not be inclined to permit this path to compliance because they would have to develop those criteria, spend time assessing the evidence that documents equivalent performance, and then actually sign off, on that basis, that the installation is safe.[4]

While it is preferable to quickly have clear and established standards and model codes to document and validate ESS safety, this process is, however, a time-sensitive process.

Best Practice

Best practices can be simplified by being able to provide specific information related to safety, as well as performance and reliability. Practices are as follows:

- The ESS product has documentation that verifies it has been tested to relevant safety standards and its performance and reliability have been measured and are reported in accordance with applicable test standards covering performance and reliability.

- The ESS product has been listed by an accredited third-party entity involved in a conformity assessment that validates that the continued production of the ESS product is consistent with the product sample(s) tested per practice item one.

- The installation and commissioning of the ESS product is in accordance with the codes, standards and regulations that directly apply to the site where the ESS product is installed, and that its operation, maintenance and any addition, repair, or renovation to the ESS meets those same codes, standards, and regulations.

- Where the ESS product and installation does not conform to the aforementioned practices, it has been field evaluated by an accredited or recognized third-party entity to document that it is at least equivalent in terms of safety, performance, and reliability.

Ideally, the proponent of an ESS product will provide documentation related to practices one and two, and the project developer will include that documentation with the documentation they provide pursuant to practices three or four. A further best practice is to standardize the documentation so that it can be readily used from project to project. Where projects are the same, that documentation can be reused without revision. Where projects vary, the core documentation can be used as a foundation for each project, and then adjusted to address the nuances and differences associated with each project. This practice saves time and money and forms a foundation for continued improvement over time. Examples of its use nationwide and internationally include the U.S. Department of State for all U.S. Embassy buildings overseas, and corporate construction by companies such as Target and Marriott.

Resources

- Sandia National Laboratories and Pacific Northwest National Laboratory, ES Safety Collaborative, Codes and Standards Update (PNNL-28551/SAND2019-2358R) (Mar. 2019).

- Sandia National Laboratories and Pacific Northwest National Laboratory, Energy Storage System Safety – Documenting and Validating Compliance with Codes and Standards (PNNL-28150/SAND2018-12330) (Nov. 2018).

- Sandia National Laboratories and Pacific Northwest National Laboratory, Energy Storage System Safety - Development and Adoption of Codes and Standards (PNNL-SA-136683/SAND2018-8857 M) (Aug. 2018).

- Pacific Northwest National Laboratory, Inventory of Safety-related Codes and Standards for Energy Storage System, (PNNL-23578) (AUG. 2014).

- Pacific Northwest National Laboratory, Inventory of Safety-related Codes and Standards for Energy Storage System, (PNNL-23618) (Sept. 2014).

- DNV GL, Recommended Practice: Safety, Operation and Performance of Grid-Connected Energy Storage Systems, (DNVGL-RP0043) (Sept, 2017), available at: https://rules.dnvgl.com/docs/pdf/DNVGL/RP/2017-09/DNVGL-RP-0043.pdf

- FM Global Property Loss Prevention Data Sheet #5-33, Electrical Energy Storage Systems, 2017

- Institute of Electrical and Electronics Engineers, IEEE 1578-18, Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management (Oct. 2018), available at: https://standards.ieee.org/standard/1578-2018.html. (Content available for purchase – free for subscribers.)

- NECA 417-19, Recommended Practice for Designing, Installing, Maintaining, and Operating Micro-grids.

- UL, UL 1642, Standard for Lithium Batteries (5th ed. 2012, as revised through June 23, 2015), available at: https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=23985. (Content available for purchase.)

- UL, UL 1741, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources (2nd ed. 2010, as revised through Feb. 15, 2018), available at: https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=23985. (Content available for purchase.)

- CSA Group, A Quick Guide to the Product Certification Process (Oct. 2018), available at: https://www.csagroup.org/documents/resources-insights/general-tic/CSA_Group_Quick_Certification_Guide_White_Paper_NA_English.pdf.

- North American Electric Reliability Corporation, Generator Availability Data System Reporting Instructions, Appendix B15: Pumped Storage/Hydro Unit Cause Codes (June. 1, 2019), available at: https://www.nerc.com/pa/RAPA/gads/DataReportingInstructions/Appendix_B15_Pumped_Storage_Hydro_Unit_Cause_Codes.pdf.

- David R. Conover et al., Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems (PNNL-22010 Rev.2/SAND2016-3078 R) (Pacific Northwest National Laboratory and Sandia National Laboratories Apr. 2016.

References

[1] Pacific Northwest National Laboratory, "Overview of Development and Deployment of Codes, Standards and Regulations Affecting Energy Storage System Safety in the United States," (PNNL-23578), at 1.10 (Aug. 2014), available at: https://energystorage.pnnl.gov/pdf/PNNL-23578.pdf
[2] Id.
[3] Id.
[4] Id. at 1.11.

Codes and Standards

Chapter Three: Reliability and Performance

Chapter Lead: Ryan Franks, CSA Group

Background

Compared to safety-related codes and standards, documents to address reliability and performance are at relatively early stages of development, adoption, and application. The selected reliability and performance information below highlights references and early industry practices that are available and most relevant to the financing and development of grid-connected[1] energy storage projects.

Reliability

The North American Electric Reliability Corporation (NERC) is responsible for setting the reliability criteria for resources that fall under Federal Energy Regulatory Commission (FERC) jurisdiction. Requirements set by NERC typically flow down through to projects that have an agreement to provide wholesale energy, capacity or ancillary services.

FERC has certified NERC as the Electric Reliability Organization (ERO) for the U.S., as required by the Federal Power Act. As an ERO, NERC has developed, and maintains, reliability standards that are enforceable in the U.S. and are recognized throughout much of Canada. According to NERC's website, its mission is "assure the effective and efficient reduction of risks to the reliability and security of the grid." To support this mission, NERC develops, adopts and enforces reliability standards, and also monitors the bulk power system and connected resources.[2]

Performance

Voluntary sector standards specific to grid connected ESS, and that cover how to measure and express the performance of such systems, are under development by a number of standards development organizations (SDOs), including the IEEE's active project to write the IEEE 1547.9 Guide for ESS interconnection.

At this stage, there are several technical references that are relevant to ESS performance. Performance related documents applicable to emerging ESS design, deployment, and use include:

- ASME PTC-53-2018 DRAFT: Mechanical and Thermal Energy Storage Systems (Draft Standard for Trial Use) (2018).

- IEC TS 62933-3-1:2018 Electrical energy storage (EES) systems - Part 3-1: Planning and performance assessment of electrical energy storage systems - General specification.

- NEMA ESS 1-2019: Standard for Uniformly Measuring and Expressing the Performance of Electrical Energy Storage Systems.

- SANDIA/PNNL Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems

Energy Storage Challenges

Reliability

From an investment and development perspective, a significant and often used reliability-related metric defined and monitored by NERC is the Availability Factor (AF). With the relative inexperience in the energy storage market, however, there is no industry "norm" for defining this important metric, which is often used in specifying contractual performance-related obligations. The challenge is that while this metric is commonly used in setting ES project performance requirements regarding the technical scope or other contractual requirements for ES contracts for services (e.g., PPAs) or system purchases, the energy storage community does not have a significant operating or engineering basis to develop a standardized methodology—a methodology which will measure and express a reasonable representative metric, or series of metrics, for a level of reliability that is equitable for all parties.

For resources in general (including pumped storage), AF is defined and reported through NERC's Generator Availability Data System. The AF equation as defined by NERC is shown in Figure 8.3.1 (Note: PH = Period Hours—the number of hours in the period being reported that the unit was in the active state. AH = Available Hours—the sum of all Service Hours (SH) + Reserve Shutdown Hours (RSH) + Pumping Hours + Synchronous Condensing Hours).[3]

Availability Factor – AF

$$\mathbf{AF} = \frac{\mathbf{AH}}{\mathbf{PH}}\ \mathbf{x\ 100\%}$$

$$\mathbf{AF} = \frac{\mathbf{RSH + SH + Synchronous\ Condensing\ Hours + Pumping\ Hours}}{\mathbf{PH}}\ \mathbf{x\ 100\%}$$

Fig. 8.3.1
Availability Factor equation.
Source: Pacific Northwest National Laboratory.

NERC's Generating Availability Data System (GADS) provides the reporting requirements for pumped storage energy storage. Currently, there is a gap for Battery Energy Storage System (BESS) project reliability reporting requirements. The GADS requirements for pumped storage could provide a starting point for developing BESS

GADS reliability reporting requirements, along with the standardized methodologies needed to determine a value for metrics considered relevant to ESS reliability.

Performance

At this early stage of grid energy storage market maturity there are very limited SDO-approved and -published standards for measuring and expressing ESS performance. However, there are industry-led entities that are developing technical references that can be used for determining appropriate metrics relevant to contracting and evaluating key ESS attributes—as well as for how to measure and express those metrics. They include, among others, capacities (power and energy), round trip efficiency, and battery degradation rate. EPRI's Energy Storage Integration Council (ESIC) is an example of an industry-led group developing technical references that can provide a basis for ESS project specification, design, design review, and testing.

Best Practice

Reliability

For specific project commitments through contracting, and for verification after the system is in service, a recommended best practice is to use the NERC information and instructions for the definition and derivation of AFs.

Performance

In the absence of approved and published voluntary consensus standards on representative charge/discharge cycling profiles for grid storage applications, as a best practice the PNNL and SANDIA report "Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems"(PNNL-22010 Rev. 2/SAND2016-3078 R), often known as the "Protocols Report," can be used to provide proxy time series representations of charge/discharge power over time for use in design, factory acceptance testing, commissioning, and/or periodic testing over a project's service life. The Protocols Report also provides guidance on how to measure, derive and express relevant metrics including round-trip efficiency and degradation. (Round-trip efficiency and degradation are metrics typically referenced in the specification and contractual commitments for ESS systems.)

Until standards for measuring and expressing the performance of ESS under specific grid application cycling are developed (such as through the ASME and NEMA (U.S.) and IEC (International) documents mentioned earlier in this chapter), the Protocols Report is an available industry-vetted open source reference that can provide neutral third-party technical guidance for all stakeholders (e.g., seller, buyer, regulator, and owner/operator) of an ESS project.

Resources

- Sandia National Laboratories and Pacific Northwest National Laboratory, ES Safety Collaborative, Codes and Standards Update (PNNL-28551/SAND2019-2358R) (March 2019).

- Sandia National Laboratories and Pacific Northwest National Laboratory, Energy Storage System Safety – Documenting and Validating Compliance with Codes and Standards (PNNL-28150/SAND2018-12330) (Nov. 2018).

- Sandia National Laboratories and Pacific Northwest National Laboratory, Energy Storage System Safety – Development and Adoption of Codes and Standards (PNNL-SA-136683/SAND2018-8857 M) (Aug. 2018).

- Pacific Northwest National Laboratory, Inventory of Safety-related Codes and Standards for Energy Storage Systems (PNNL-23618) (Sept. 2014).

- Pacific Northwest National Laboratory, Overview of Development and Deployment of Codes, Standards and Regulations Affecting Energy Storage System Safety in the United States (PNNL-23578) (Aug. 2014).

- DNV GL, Recommended Practice: Safety, Operation, and Performance of Grid-Connected Energy Storage Systems (DNVGL-RP-0043) (Sept. 2017), available at: https://rules.dnvgl.com/docs/pdf/DNVGL/RP/2017-09/DNVGL-RP-0043.pdf.

- FM Global Property Loss Prevention Data Sheet # 5-33, Electrical Energy Storage Systems, 2017.

- Institute of Electrical and Electronics Engineers, IEEE 1578-18, Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management (Oct. 2018), available at: https://standards.ieee.org/standard/1578-2018.html (Content available for purchase).

- NECA 417-19, Recommended Practice for Designing, Installing, Maintaining, and Operating Micro-grids.

- UL, UL 1642, Standard for Lithium Batteries (5th ed. 2012, as revised through June 23, 2015), available at: https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=23985 (Content available for purchase).

- UL, UL 1741, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources (2nd ed. 2010, as revised through Feb. 15, 2018), available at: https://www.shopulstandards.com/ProductDetail.aspx?productId=UL1741_2_B_2

0100128(ULStandards2) (Content available for purchase).

- CSA Group, A Quick Guide to the Product Certification Process (Oct. 2018), available at: https://www.csagroup.org/documents/resources-insights/general-tic/CSA_Group_Quick_Certification_Guide_White_Papaer_NA_English.pdf.

- North American Electric Reliability Corporation, Generator Availability data System Reporting Instructions, Appendix B15: Pumped Storage/Hydro Unit Cause Codes (June 1, 2019), available at: https://www.nerc.com/pa/RAPA/gads/DataReportingInstructions/Appendix_B15_Pumped_Storage_Hydro_Unit_Cause_Codes.pdf.

- Sandia National Laboratories and Pacific Northwest National Laboratory, Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems (PNNL-22010 Rev 2/SAND2016-3078 R) (Apr. 2016).

- EPRI Energy Storage Integration Council (ESIC), https://www.epri.com/#/pages/sa/epri-energy-storage-integration-council-esic?lang=en-US.

- The American Society of Mechanical Engineers, Mechanical and Thermal Energy Storage Systems (Draft Standard for Trial Use) (PTC 53-2018) (2018), available at: https://www.asme.org/codes-standards/find-codes-standards-ptc-53-mechanical-thermal-energy-storage-systems (Content available for purchase).

- International Electrotechnical Commission, Electrical Energy Storage (EES) Systems – part 3-1: Planning and performance assessment of electrical energy storage systems – General specification (IEC TS 62933-3-1: 2018) (Aug. 29, 2018), available at: https://webstore.iec.ch/publicaton/34488 (Content available for purchase).

- National Electrical Manufacturers Association, Standard for Uniformly Measuring and Expressing the Performance of Electrical Energy Storage Systems (NEMA ESS 1-2019) (Feb. 15, 2019), available at: https://www.nema.org/Standards/Pages/Standard-for-Uniformly-Measuring-and-Expressing-the-Performance-of-Electrical-Energy-Storage-Systems.aspx (Content available for purchase).

References

[1] The focus is grid-connected energy storage projects primarily because federal, state, local, territorial and tribal entities who focus on ESS on the customer side of the meter are primarily focused on safety as opposed to addressing reliability or performance. The exception is the application of reliability or performance criteria by the developer, owner or operator of the ESS.

[2] North American Electric Reliability Corporation, About NERC, available at: https://www.nerc.com/AboutNERC/Pages/default.aspx
[3] Amit Jain and Kamal Garg, "System planning and protection engineering-An overview," (IEEE, 2009),available at: https://ieeexplore.ieee.org/servlet/opac?punumber=5436187.