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Energy Storage Financing:
A Roadmap for Accelerating Market Growth

A Study for the DOE Energy Storage Systems Program

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Abstract

Project financing is emerging as the linchpin for the future health, direction, and momentum of the energy storage industry. Market leaders have so far relied on self-funding or captive lending arrangements to fund projects. New lenders are proceeding hesitantly as they lack a full understanding of the technology, business, and credit risks involved in this rapidly changing market. The U.S. Department of Energy is poised to play a critical role in expanding access to capital by reducing the barriers to entry for new lenders, and providing trusted analytical benchmarks to better judge and price the risk in systematic ways.

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- Keynote Alfred Griffen, President of the NY Green Bank
- Host Sutherland Asbill & Brennan LLP
- Partner Energy Storage Association
- Sponsor Enovation Partners

Finally, the author would like to thank all of the survey participants who made the project possible. A list of all those involved can be found in Appendix A.

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NOMENCLATURE

AC	Alternating Current
ARPA-E	Advanced Research Projects Agency-Energy
ARRA	American Recovery and Reinvestment Act
BOMA	Building Owners and Managers Association
BTM	Behind the Meter
CAFD	Cash Available For Distribution
CEC	California Energy Commission
CEFIA	Clean Energy Finance Investment Authority
CPUC	California Public Utility Commission
CRL	Commercial Readiness Level
CSR	Codes, Standards, and Regulations
DC	Direct Current
DER	Distributed Energy Resources
DOE	Department of Energy
EES	Electrical Energy Storage
EPC	Engineering Procurement and Construction
EPRI	Electric Power Research Institute
ESA	Energy Storage Association
ESIC	Energy Storage Integration Council
ESPC	Energy Savings Performance Contract
FERC	Federal Energy Regulatory Commission
HVAC	Heating Ventilation and Air Conditioning
IEC	International Electrotechnical Commission
IPO	Initial Public Offering
IRP	Integrated Resource Plan
IRS	Internal Revenue Service
ISO	Independent System Operator
ITC	Investment Tax Credit
kW	Kilowatt
kWh	Kilowatt hour
LBL	Lawrence Berkeley Laboratory
LCOE	Levelized Cost of Energy
LCOS	Levelized Cost of Storage
LPO	Loan Programs Office
MACRS	Modified Accelerated Cost Recovery System
MBTF	Mean Time Between Failure
MESA	Modular Energy Storage Architecture
MLP	Master Limited Partnership
MW	Megawatt
MWh	Megawatt hour
NEC	National Electrical Code
NECA	National Electrical Contractors Association
NEIS	National Electrical Installation Standards

NEMA	Association of Electrical Equipment Manufacturers and Medical Imaging Manufacturers
NFPA	National Fire Prevention Association
NRECA	National Rural Electric Cooperative Association
NYSE	New York Stock Exchange
NYSERDA	New York State Energy Research and Development Authority
O&M	Operation & Maintenance
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PACE	Property Assessed Clean Energy
PG&E	Pacific Gas & Electric
PLR	Private Letter Ruling
PNNL	Pacific Northwest National Laboratory
PPA	Power Purchase Agreement
PUC	Public Utility Commission
PV	Photovoltaic
R&D	Research & Development
REIT	Real Estate Investment Trust
REV	Reforming the Energy Vision
RFP	Request for Proposal
RTO	Regional Transmission Organization
SBIR	Small Business Innovation Research
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SGIP	Small Generator Interconnection Procedures (FERC)
SGIP	Small Generator Incentive Program (CPUC)
SNL	Sandia National Laboratories
SPE	Special Purpose Entity
TRL	Technology Readiness Level
UL	Underwriters Laboratories

EXECUTIVE SUMMARY

Role of Financing

Project financing is emerging as the linchpin for the future health, direction, and momentum of the energy storage industry. Market leaders have so far relied on self-funding or captive lending arrangements to fund projects, along with support from government grants (e.g., the American Recovery and Reinvestment Act Energy Storage Demonstration Projects as well as state grants). New lenders are proceeding hesitantly as they lack a full understanding of the technology, business, and credit risks involved in this rapidly changing market. The U.S. Department of Energy is poised to play a critical role in expanding access to capital by reducing the barriers to entry for new lenders, and providing trusted analytical benchmarks to better judge and price the risk in systematic ways. A Roadmap based on the needs of the market can provide a series of steps to extend relevant work already underway, and then build on that to give financial industry participants an analytical framework and the tools to develop acceptable contracts to enable successful project development activity.

For many years, the energy storage industry has made great progress in developing the technology, standards, public policy and market rules that has formed the basis of today's market. These elements have led to the expanding opportunities for energy storage that now seem almost limitless—but in reality those opportunities are severely inhibited by the lack of available and cost-effective capital. The low level of understanding and discomfort of lenders on these issues is preventing many from making an informed and timely decision as to which project to back.

Beyond the much needed capital, the structure through which capital is accessed can have an even wider impact on the development of this early stage market. In an environment with limited funds, the choice of project to back by those lenders willing to lend capital will greatly influence where the market leaders operate and which business models are most common. Those developers able to self-fund their capital needs thus are at an even greater advantage to establish the very important first-mover advantage in a market where customers are wary of committing to a company, platform, or technology that may not be here in a few years. Therefore, those developers able to access capital and provide enticing offers to customers early define the accepted business model for future customers, and even the default business models that follow on public policy is built around when attempting to support further growth in the market.

Lenders are still having a hard time understanding all of the key issues in this constantly evolving market, and thus cannot accurately judge and price the risk now, or for the future. Although some lenders have entered the market and are enabling some of the current market leaders, in general they have been slow in responding, based on the limited track record lack of clarity as to which business model is the right one. Lacking guidance, they remain interested, but unsure of what to do. How is the industry going to overcome the typical technical maturity challenges? Are there unique challenges for energy storage project developers that lenders need to take into account? What are the key questions they don't yet even know to ask?

Lenders are taking steps to answer these questions along a number of avenues; including deeper due diligence for a better understanding of the technology, market analysis to gain greater insight into possible revenue streams, and tighter scrutiny on the equipment to get a deeper visibility on the costs. Using this knowledge is allowing them a better understanding of the different business models and which ones have a greater potential for success—or at least avoiding the ones poised for outright failure.

One strategy followed by project developers to allay the fears of lenders now contemplating the energy storage market is to show the effective adaptation of contracts and financing structure that proved successful in other markets (who in turn had adopted them from other markets). By showcasing that—although different—the energy storage industry is following the same development path as the wind, solar, and energy efficiency markets towards larger numbers of standardized income producing contracts that can be aggregated and securitized to reduce the risk further. Larger pools of debt that have increasing levels of certainty of revenue lower the cost of capital, and help open up new and even lower cost types of capital, reducing the cost of a project further and accelerate the market growth in a virtuous circle.

Project financing is becoming central to the future of the market; who, where, and how growth occurs is increasing being determined by the availability of cost-effective capital, not just the quality of the technology. Other factors are contributing to the trend; contracts that determine how the financing is structured, the Government policy that define the opportunity and incentives that can change project profitability substantially. Multiple financing structures are available and are relevant depending on the position in the market, type of project being financed, its scale, and the confidence around stable revenue.

Commercialization Challenges

The energy storage industry has finally entered the early phase of real commercial development and accelerating market growth. Many describe the industry's current status as a "Tipping Point" where a number of market conditions have aligned to promote a self-perpetuating and accelerating growth stage. The viewpoint of many project developers is that energy storage technologies have finally reached a level of technical maturity sufficient to begin commercial projects in earnest. First movers are already taking advantage of these conditions to drive their initial commercial growth. As these early deployments are followed by others, momentum is gained, and consumer demand pulls the industry forward, most times following the path of least resistance—the patterns set forth by the first movers. Over time, the costs of these leading systems will to decline and their operating capabilities will increase—supporting an accelerating and widening deployment. Other energy storage technologies will follow, up the maturation curve, opening up new roles and opportunities for the industry.

Transitioning a working prototype energy storage technology from the lab to commercial status requires building out a supporting framework to enable the asset to operate successfully as part of the electric power system; not just as a technological product, but as a complete engineered system. As with other projects in the power sector, this growing class of systems requires technical and operational ecosystems of supporting equipment, market rules, and business practices which must be developed to support the cost effective use of the technology in order to be deployed industry wide.

Four challenges in particular are critical for successful development of the energy storage market:

- ***Technology*:** Does the technology work? Has it been designed into a working system?
- ***Codes, Standards, and Regulations*:** Is the system able to be installed and operate within the wider electric power system?
- ***Public Policy:*** Is the market structured to allow it to operate in an economically effective role?
- ***Finance*:** Is there sufficient interest to develop projects profitably?

To answer these questions, the energy storage industry can look to the wind, solar, and energy efficiency industries as a guide for how nascent industries grow and overcome obstacles in the power market. In many areas, the opportunity for energy storage deployment is actually these very markets, so understanding them is essential. The energy storage industry can gain valuable insights as to how each of these industries improved their technology maturity and established a commercial presence. Rewriting interconnection standards, market rules, and siting ordinances is difficult, but these have been the basis for development of these other industries, and thus it will benefit the storage industry greatly to glean hard won lessons learned from these other markets.

Insights & Lessons Learned

A clear theme of three potential and real risks concerning energy storage system deployment was evident throughout the interviews: technology risk, business risk, and credit risk. Overcoming each of these can bring significant additional cost to a project, so it is important to reduce their impact. Beyond their direct impact, we attempted to understand the current understanding of the study participants around these issues, and what factors would be critical in changing their perception, planning, and progress towards successful energy storage system deployments.

- ***Technology Risk*** is concerned with the level of sophistication of the technology—is it sufficiently mature enough to work as promised? Typically, manufacturers stand behind their products through providing a warranty on the product. Most manufacturers will provide a 1 to 2 year manufacturing defect warranty, although some have been extending that for many more years with the purchase of an extended warranty contract.

- ***Business Risk*** is concerned with the ability of a user of an energy storage system to operate it profitably—is there an actual need for people to buy these systems? This would of course cover the profitability of the system, but also takes into account its long-term performance, and the unit's durability and flexibility to remain profitably operating in the event of changing market conditions and market rules.

- ***Credit Risk*** is concerned with the financial health of the companies involved on provisioning the energy storage system to the customer—is there a risk of default by key groups? This type of risk typically is expressed in the higher costs for lending, insurance premiums or lack of financial flexibility given to smaller firms with lower reserves than larger firms able to essentially self-insure against any potential business risk interruption is necessary.

Roadmap to Accelerate Market Growth

The U.S. Department of Energy has been a critical catalyst in the early development of the energy storage industry; its opportunity now is to help establish a robust, sustainable, and competitive commercial market. What is lacking is not the further development of the technology or market applications, but enabling the financial industry to better understand the risks involved in energy storage project development, and help developers access cost effective capital to accelerate market growth sustainably.

The U.S. Department of Energy is uniquely positioned to drive this development. It is already trusted to provide the fundamental understanding of the technology and market applications. What is needed now are metrics and benchmarks grounded in this understanding to better judge and price the risk in systematic ways. Through these tools, the U.S. Department of Energy can expand access to capital by reducing the barriers to entry for new lenders.

The first part of this strategy is to coordinate a number of areas where the U.S. Department of Energy is already active and plays a key role, and extend these efforts to improve the environment for project development. These include:

- **Data & Analysis**: collecting, analyzing, and disseminating technical and economic information about energy storage technologies and projects.
- **Safety & Standards:** ensuring a safe design and operating environment for energy storage systems.
- **Demonstration Projects**: leveraging prior experience and outside support to showcase new commercial roles for energy storage systems.
- **Innovative Project Financing:** providing support to grow and deepen the financial industry's engagement with the energy storage industry.

The second part of this strategy builds on these existing efforts to assist the financial industry in understanding the potential risks involved in energy storage project development, develop analytical framework to price that risk, and means to accommodate that risk through insurance and contracts. These include:

- **Performance Ratings:** support a broader effort to develop application specific performance metrics to allow the scoring based on the capability of different systems for commercial contracts.
- **Performance Guarantee:** enable a means for the performance ratings to be incorporated into operational contracts, and develop a means to allow energy storage OEMs to purchase cost effective insurance to they can provide performance guarantees in the market.
- **Energy Service Performance Contracts:** standardized, financeable contract tailored for Behind-the-Meter energy storage projects to enable "storage as a service".

1. ROLE OF FINANCING

As the energy storage industry accelerates into sustained commercial growth, project financing is emerging as the linchpin for the future health, direction, and momentum of the industry. For many years, the energy storage industry has made great progress in developing the technology, standards, public policy and market rules that has formed the basis of today's market. These elements have led to the expanding opportunities for energy storage that now seem almost limitless—but in reality those opportunities are severely inhibited by the lack of available and cost-effective capital. The low level of understanding and discomfort of lenders on these issues is preventing many from making an informed and timely decision as to which project to back.

Beyond the much needed capital, the structure through which capital is accessed can have an even wider impact on the development of this early stage market. In an environment with limited funds, the choice of project to back by those lenders willing to lend capital will greatly influence where the market leaders operate and which business models are most common. Those developers able to self-fund their capital needs thus are at an even greater advantage to establish the very important first-mover advantage in a market where customers are wary of committing to a company, platform, or technology that may not be here in a few years. Therefore, those developers able to access capital and provide enticing offers to customers early define the accepted business model for future customers, and even the default business models that follow on public policy is built around when attempting to support further growth in the market.

Lenders are still having a hard time understanding all of the key issues in this constantly evolving market, and thus cannot accurately judge and price the risk now, or for the future. Although some lenders have entered the market and are enabling some of the current market leaders, in general they have been slow in responding, based on the limited track record lack of clarity as to which business model is the right one. Lacking guidance, they remain interested, but unsure of what to do. How is the industry going to overcome the typical technical maturity challenges? Are there unique challenges for energy storage project developers that lenders need to take into account? What are the key questions they don't yet even know to ask?

Lenders are taking steps to answer these questions along a number of avenues; including deeper due diligence for a better understanding of the technology, market analysis to gain greater insight into possible revenue streams, and tighter scrutiny on the equipment to get a deeper visibility on the costs. Using this knowledge is allowing them a better understanding of the different business models and which ones have a greater potential for success—or at least avoiding the ones poised for outright failure.

One strategy followed by project developers to allay the fears of lenders now contemplating the energy storage market is to show the effective adaptation of contracts and financing structure that proved successful in other markets (who in turn had adopted them from other markets). By showcasing that—although different—the energy storage industry is following the same development path as the wind, solar, and energy efficiency markets towards larger numbers of standardized income producing contracts that can be aggregated and securitized to reduce the risk further. Larger pools of debt that have increasing levels of certainty of revenue lower the cost of capital, and help open up new and even lower cost types of capital, reducing the cost of a project further and accelerate the market growth in a virtuous circle.

Project financing is becoming central to the future of the market; who, where, and how growth occurs is increasing being determined by the availability of cost-effective capital, not just the quality of the technology. Other factors are contributing to the trend; contracts that determine how the financing is structured, the Government policy that define the opportunity and incentives that can change project profitability substantially. Multiple financing structures are available and are relevant depending on the position in the market, type of project being financed, its scale, and the confidence around stable revenue.

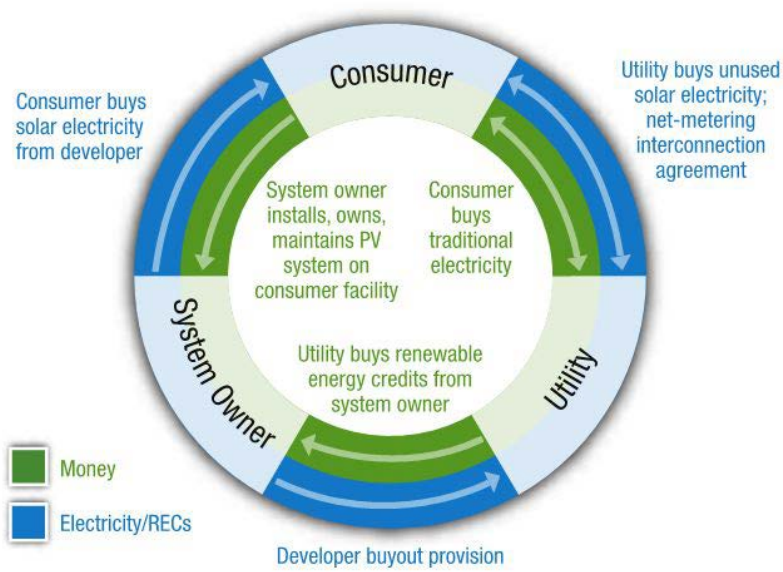
1.1. Contracts

Contracts define the terms and conditions of a project being developed, and thus are key to successfully commissioning an energy storage project. There are two primary contract types that will be important to the energy storage market: the power purchase agreement (PPA), and the energy savings performance contract (ESPC).

1.1.1. Power Purchase Agreement

A Power Purchase Agreement (PPA) in the wholesale power market is typically a contract between a generator of electricity (seller) and the one looking to purchase (buyer) electricity and/or capacity of grid services. The PPA is generally regarded as the central document in the development of independently financed electric power assets as it defines the term and requirements for the agreement and is used to obtain financing for the project.

Figure 1 - Contracts and Cash Flow in Power Purchase Agreements



Source: NREL

The PPA structure is useful when the project revenue is uncertain because although the PPA's structure is formal, it allows for variability in the underlying contract details based upon an agreed upon performance criteria. Through its use, a typical PPA for a power generation facility can allow the generators a guaranteed revenue stream, while the purchaser receives stable delivery of electricity, many times at a discount because of the lower risk of non-payment. The contract terms may last anywhere from 5 to 20 years, with an agreed upon price, including any annual escalation in the cost. The PPA also defines how much energy will be delivered, including penalties for missing delivery. The contract will also typically require the seller to meet certain performance standards however, specific performance guarantees including availability may be covered under another agreement.

A number of energy storage PPA's have already been signed, and utilities (the groups so far offering them) are rapidly learning from each other to improve the quality and coverage of their agreements. The typical means of developing a PPA for a new industry is to adapt an existing one from a more mature market. For solar and wind, thermal power project PPAs were available and covered many of the same issues. However, in energy storage we see a different starting point and a fundamentally different mode of operation, and so the development of more comprehensive energy storage PPAs is requiring some rethinking in approach. For instance, an energy storage PPA could be written so that the seller provides a guarantee on availability while the buyer actually controls the operation of the facility. Due to the limited discharge duration of a storage facility, the amount of output available (state of charge) is determined by the recent activity of the unit. Therefore, availability and control must be linked for an energy storage system. Although issues like that are obvious once framed, some early PPA contracts did not take that fully into account.

Things are rapidly getting better. Because of the multifunctional capability of an energy storage facility, energy storage PPAs will always have more complexity to them than other PPAs found in the power industry. In order to keep their progress moving forward, industry groups such as EPRI's Energy Storage Integration Council (ESIC) are working to harmonize the technical supporting language between differing utilities so that the industry is able to build towards a more common framework for these contracts. Recent examples of a well thought out PPA structure are shared as is the case with San Diego Gas & Electric's (SDG&E) PPA tolling agreement[1] can be seen in Figure 2.

Although starting slowly, energy storage PPAs are being signed, and are growing in number and scale with the upswing in Utility RFPs (Request for Proposals) for energy storage products and services. Showcasing a maturing deployment capability, AES Energy Storage[2] on Nov 5, 2014 was awarded a 20-year PPA with Southern California Edison to provide 100 MW / 400 MWh of interconnected battery storage. The facility will be built south of Los Angeles at the Alamitos Power Center in Long Beach, CA. The PPA is an outcome of SCE's 2013 Local Capacity Requirements Request for Offer (RFP) for new capacity in the Western Los Angeles Basin. Financial terms were not released.

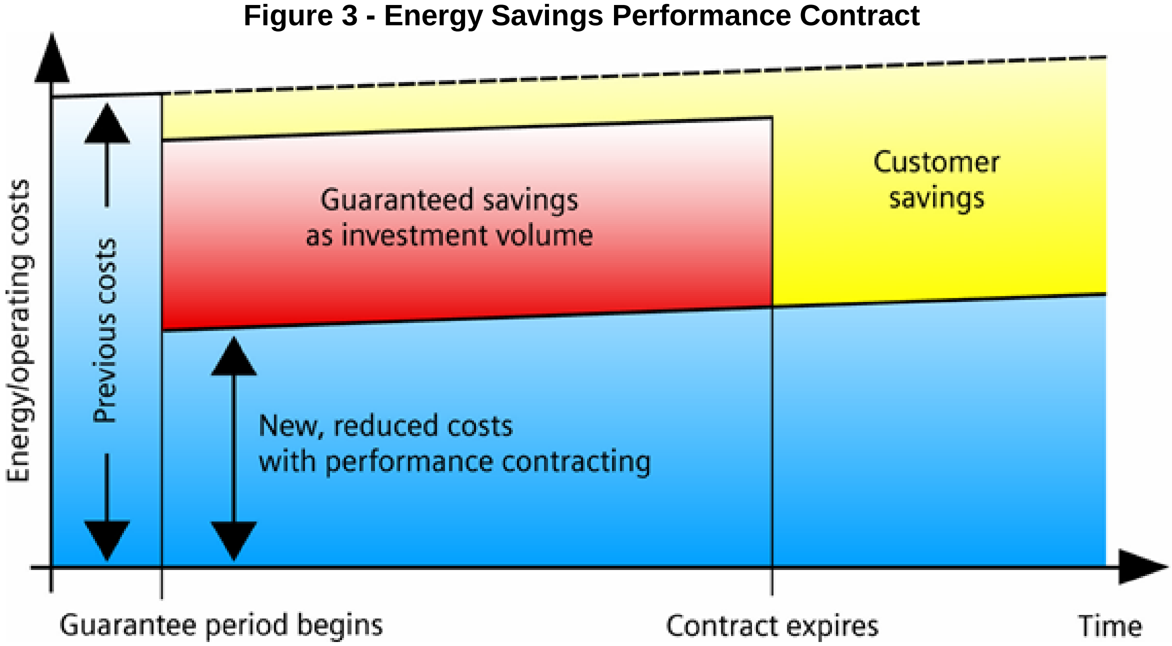
Figure 2 - Energy Storage System Power Purchase Tolling Agreement Between SDG&E & Seller X

A key sticking point for PPAs is the performance guarantee as there are many factors that are interrelated. Effectively guaranteeing a performance level in one metric (e.g. efficiency) assumes holding 2, 3, (or 7) or more other factors fixed. Work is progressing, and the growing experience of project developers is supporting the growth of contract language that is acceptable to everyone.

1.1.2. Energy Savings Performance Contract

An Energy Savings Performance Contract (ESPC) provides a similar role for Behind-the-Meter (BTM) opportunities as the PPA does for projects in front of the meter by defining the term and requirements for the project. The ESPC has been used widely throughout the energy efficiency market to help customers pay for energy efficiency upgrades to their facility through a portion of the cost savings over a set time period, eliminating the need for the customer to pay up-front for the desired project.

Figure 3 - Energy Savings Performance Contract



Source: Building Owners and Managers Association

Project developers offering these types of contracts to customers usually arrange the financing from a 3rd party financing company, with the contract typically in the form of an operating lease. In this way, the ESPC is a contract defining a turnkey service for the scope of work desired by the client and which meets the investment criteria of the lender. The contract provides for guarantees that the savings produced by a project will be sufficient to finance the full cost of the project. The operation of the project is then monitored to verify the savings, but also provides data on availability to manage operational performance and preventive maintenance.

The experience of the energy efficiency industry is proving to be insightful for how these contracts will develop in the energy storage market. In the energy efficiency industry, many players developed their own version of these contracts. Although this led to innovation in the market, it also led to a number of different and somewhat unique (e.g., proprietary) contracts, so that customers and lenders both required education on the various offerings from different service providers limiting the number of counter-parties groups could rationally support, and thus limiting competition in the market. To accelerate market growth and improve competition, the Building Owners and Managers Associations (BOMA) and the Clinton Climate Initiative developed standard energy performance contracts to execute energy efficiency retrofit programs for buildings. The *BOMA ENERGY PERFORMANCE CONTRACTING MODEL (BEPC)*[3] was designed to provide an easier way for private building owners or managers to develop and execute investment-grade energy efficiency retrofits. Essentially, by developing an industry sponsored standard contracting model, building owners and energy service providers have a better starting point from which to tailor an energy performance contract for a specific customer, while still providing the core operational similarity in structure. The model provides transparency on pricing and performance expectations and gives building owners a high degree of confidence that the project will meet the stated goals in a competitive manner.

Energy Savings Performance Contracts are well suited for the behind the meter commercial and industrial energy storage market. Commercial and industrial customers are increasingly exposed to higher and more volatile electricity rates as utilities shift more of the service charge from a commodity (kWh) basis to a demand (kW) basis through rising demand charges in their tariffs. These customers are of course interested in lowering their energy service costs, but are hesitant to sign procurement agreements with private energy service firms that cannot guarantee savings without greatly impacting their operation. In the energy efficiency market, lighting and HVAC upgrades allow the energy service firms a means to lower the overall usage, but not control the timing of the reduction (outside of “all of the time”). The energy storage asset allows for the targeted reduction of load, without impacting the operational profile of the facility. By coupling the Energy Savings Performance Contract with an energy storage asset to effect the guarantee, the customer and the energy service firm are able to enter into an agreement where greater cost savings from demand charge reductions can actually be guaranteed. Including the capital cost of the battery equipment within the contract allows for the customer to enter into an operating lease agreement providing guaranteed cost reductions that some service providers utilizing energy storage have called “storage as a service,” where customer get the benefit of an on-site storage asset without having to buy the equipment.

1.2 Government Support

Deployment incentives for project development were critically important in the early phases of the wind and solar markets. The support reduced some of the outstanding risk for private developers when the lack of knowledge about the technology and operational capability was curtailing lender participation. As the energy storage market is transitioning through a period of early stage growth similar to what these two other markets experienced, targeted government support can have an important and positive impact. For the long-term health of the market, however, direct project support cannot remain the primary factor in project success. It is critical then to make sure that the incentives are structured to be phased out as milestones are reached and to accelerate self-supporting market growth.

Two of the most potentially critical government programs for energy storage deployment are Federal tax incentives and investment grants, typically at the State level.

1.2.1. Federal

Potential Federal tax incentives for energy storage projects would include both an accelerated depreciation schedule and an investment tax credit. Depreciation allows the cost of the asset to be recovered over time and provide a valuable tax shield for near-term project income. The current depreciation system in the United States is the Modified Accelerated Cost Recovery System (MACRS); projects utilizing a specific list of renewable energy technologies were given a 5-year MACRS depreciation schedule (energy storage is not currently included on this list) rather than a more typical longer period. By including stand-alone energy storage projects in the list of other technologies that already enjoy this tax treatment, energy storage projects would be able to improve their near-term cash flow position. The IRS has recently allowed one project to utilize a 5 year depreciation schedule in a private letter rule (PLR 201543001), so there is hope this will transition into a wider ruling for all potential energy storage projects.

An investment tax credit (ITC) is a dollar-for-dollar reduction in the income taxes owed by a business or person based on capital equipment purchased as an investment in themselves. It is a stable, multi-year incentive that encourages investment in these projects most advantageous for investors with large outstanding tax liabilities. The ITC has recently been crucial in supporting deployment growth in the solar industry.

Currently, energy storage systems do qualify for the 30% solar ITC and accelerated MACRs depreciation when integrated into qualifying solar energy property under specific conditions, but there are substantial limitations[4]. In a Private Letter Ruling (PLR 201308005), batteries used to store solar electricity did qualify for the 30% ITC. However, if the battery draws power from both the solar system and the power grid, it is defined to be “dual-use property,” and there are significant limitations as the battery is now subject to a more stringent set of recapture rules. If the battery draws power from the grid, the ITC will be reduced proportionally by how much energy is drawn from the grid as a percentage of total energy cycled through the battery. Importantly, if the amount of energy drawn from the grid exceeds 25% for the year, then the entire ITC credit for that year is eliminated, and eliminated for all following years. This draconian treatment keeps many developers possibly interested in coupling energy storage into their PV systems from developing highly grid-interactive systems, hindering development, and limiting the learning opportunities for the industry. Some developers have implemented work-around solutions to prevent crossing the threshold through operation control and scheduling of battery charging to correspond with solar production.

There has been significant effort to develop a stand-alone ITC for energy storage projects for many years. Although no Bills in Congress have yet to be passed, a number of Bills have been introduced over the last few years to provide support for energy storage deployment. The earliest incarnation was the Storage Technology for Renewable and Green Energy Act of 2010 (STORAGE ACT)–S. 3617 (111^{th} Congress) sponsored by Senator Jeff Bingaman (D:NM). After failing in the 111^{th} Congress, variations of the Storage Act bill was reintroduced in the 112^{th} (Storage Act 2011) and 113^{th} Congress (Storage Act 2013), but was still unsuccessful. The STORAGE Act of 2013 (S.1030) was introduced by Sen. Ron Wyden (D: OR) Sen Susan Collins (R: ME) and H.R. 1465 by Rep. Christopher Gibson (R: NY 19^{th}) and Mike Thompson (D: CA 5^{th}). The Storage Act of 2013 received some of the most widespread support as it was designed to lower consumer energy costs through utilization of energy storage systems, and to encourage the expansion of renewable energy generation. The Storage Act of 2013 offered a 20% (Senate Bill) and 30% (House Bill) ITC (up to $1 million per project) to behind-the-meter businesses and residential homeowners that invest in energy storage systems. The Storage Act of 2013 would have provided a 20% ITC (up to $40 million per project), for energy storage system placed into operation on the wholesale power market, and it would have also made energy storage systems eligible for new clean renewable energy bond financing. The legislation would have had a $1.5 billion budget of tax credits and included language allowing the market to decide which storage technologies are best suited for installation.

Another recent proposed avenue of support was the Master Limited Partnerships (MLP) Parity Act. MLPs are a publicly traded partnership structure that is widely used in the oil and gas industry to fund projects. This Bill (S.795) was introduced in 2013 (113^{th} Congress) by Sen. Chris Coons (D: DE) and was designed to expand the availability of the MLP corporate structure to include companies the use renewable energy and energy storage technologies. This Bill has been re-introduced in the 114^{th} Congress (S. 1656 and HR.2883) by Sen. Chris Coons (D:DE), Sen. Jerry Moran (R:KS), Rep. Ted Poe (R- TX 2^{nd}) and Rep. Mike Thompson (D:CA 5^{th}).

Efforts to support energy storage in other ways continue to be proposed. Most recently in the 114^{th} Congress the Energy Storage Promotion and Deployment Act of 2015 (S. 1434) was introduced by Senator Martin Heinrich (D: NM) to require utilities to deploy energy storage systems. According to the Bill, investor owned utilities would be required to hold energy storage system capacity equal to 1% of their peak demand by 2021, and hold energy storage system capacity equal to 2% of their peak system load by 2024. This proposed legislation would result in 8,000 MW of qualifying energy storage systems to be deployed by 2021, and roughly 18,000 MW by the end of 2024. Even if this specific Bill does not pass, it is clear that a growing effort is being made at the Federal level to support the energy storage industry through these proposed up-front incentive payments for individual projects and long-term mandates.

However, it is at the State level that legislation has actually been successfully passed, driving much of the Policy effort to support the energy storage industry to the State level.

1.2.2. State

State governments have long played a crucial role championing the deployment of energy storage systems—for many years through focused research and development grants, deployment opportunity, and manufacturing support. States have now increasingly begun to focus on supporting the financing of projects to encourage deployment. The goal of the States varies, but typically they are interested in economic development and project deployments, plus direct and immediate benefit for customers through the operation of these systems.

In recent years, direct incentive support for commercially deployed system has become a key driver for market growth—especially for behind the meter installations. The two States that have long been leaders in the support of energy storage technologies are California and New York—through R&D programs (California Energy Commission (CEC) and the New York State Energy Research and Development Authority (NYSERDA)). These states are now moving to support that market growth and reap the benefit of greater storage deployment.

To support the deployment of energy storage systems, the California legislature passed Assembly Bill 2514 (Energy Storage Systems) in 2010 which mandated the use of energy storage systems by the public utilities on the State's power grid. In all, 1,325 MW of cost-effective energy storage systems will be deployed throughout the State in a staged process through 2022. These systems would be deployed on the transmission and distribution systems of the 3 major investor owned utilities—San Diego Gas & Electric (SDG&E), Pacific Gas & Electric (PG&E), and Southern California Edison (SCE). California has also been interested to get energy storage systems behind-the-meter at commercial and residential locations. Toward this goal, the State has relied on the Self Generation Incentive Program (SGIP), which provide an incentive of $1.80 per watt of deployed systems, with a goal of having 200 MW of energy storage deployed behind the meter by 2020.

Utilities in New York have also developed an incentive program for behind-the-meter storage deployment. In response to the potential closing of the Indian Point nuclear facility, the utility ConEdison included 100 MW of load reduction measures, which included demand response, thermal energy storage, and battery storage. The incentive for thermal energy storage was $2,600 per kW, and $2,100 per kW of battery systems (capped at 50% of project cost).

New York has other policy efforts supporting energy storage, including the New York Reforming the Energy Vision (REV) program to modernize the power grid which included funding for seven energy storage deployment projects. In addition, the NY Green Bank—which aims to enable greater private investment in New York State's growing clean energy economy—has also begun to evaluate ways to support projects that represent an installation of early stage technology in order to build momentum toward commercial status.

Other States have also begun to target their efforts on supporting energy storage industry clusters and project development. Many other States have recognized benefits these technologies can bring to their constituents. Some, like Hawaii deal with high electricity rates, and are eager to support the introduction of new technologies that will improve consumers' electricity choice and lower their costs, with that State launching an RFP in 2014 for up to 200 MW of energy storage.

Further, the job development opportunity inherent in the energy storage market is beginning to be seen and States are beginning to position themselves to act on them. Other States are looking to leverage existing unique strengths each has and are following the example of New York and California to support a number of avenues of development. Some like New Jersey are awarding $6 million for energy storage projects through its resiliency bank, while Arizona is looking to have energy storage represent 10% of peaker capacity– requiring 10MW of procurement by 2018.

Although all States approach the market differently, similar programs and targeted benefits showcase a general arc of deepening involvement with energy storage projects. Most early program emphasis centered on R&D support for technology developers looking to develop manufacturing jobs, but much more emphasis is now being focused on deployment of energy storage systems and the electrical contractor market jobs that type of work brings. These States are looking to use these development funds to enhance consumers' benefits and further the re-envisioning of the electric power industry and its impact on the wider economy. For example, Massachusetts has recently set aside $10 million provide support deployment of a wider range of energy storage systems, with some parts of the program targeted at also expanding a policy framework in order to determine and quantify the value of energy storage to the state. Oregon (HB 219-B) and Connecticut (SB 1078) are also working to define the value of storage which will be the basis of structured procurement plans into the future.

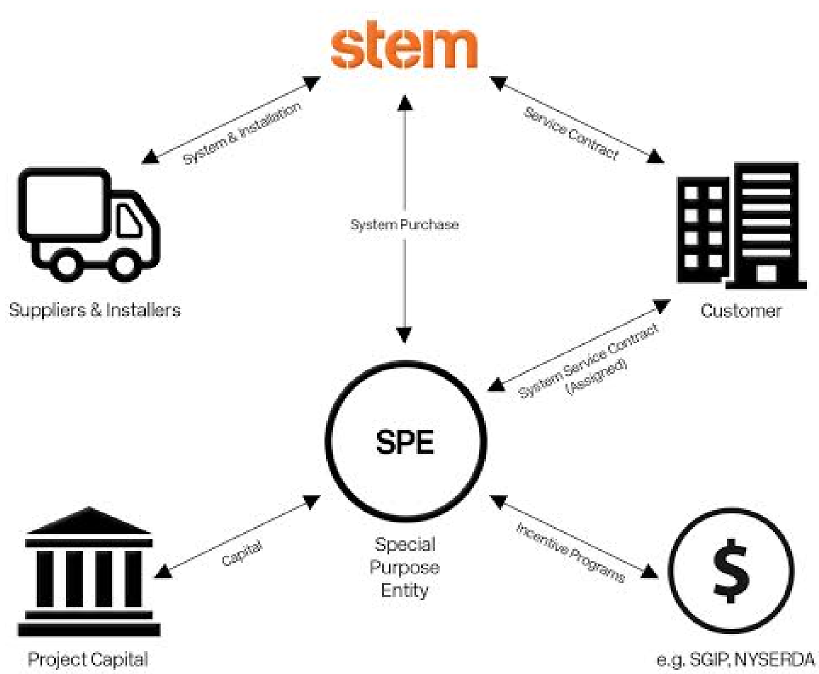
1.3 Financing Options

Access to cost-effective project financing is critical for energy storage project development. In the early days of energy storage project development, self-financing was typically the only option for developers, and is still common for many of the larger players today. Different financing options have been developed to solve the capital needs of other industries, and so the challenge now is to determine which of these options will be best suited for the different market needs within the various segments of the energy storage industry. Part of determining that fit will be to see if the energy storage project needs to be financed as a stand-alone project, or can it be integrated into a larger project that qualifies with lenders using some other type of financing option. The emerging finance market for energy storage projects is still new, with new announcements being made daily in either, structures, sizes, or partnerships. Some of these 3rd party financing options for energy storage projects are viable now, while others will only be viable at some point in the future. These include Operating Lease, Master Limited Partnerships, Real Estate Investment Trusts, YieldCos, and bonds.

1.3.1. Operating Lease

A lease is a contract that allows for the use of an asset but does not convey the rights of ownership to the asset. The type of lease offered by companies providing energy storage systems to companies is an operating lease to fund a special purpose entity (SPE) for each project, which is not capitalized and accounted for as a monthly rental expense by the customer. During the operating lease period, the asset remains the property of the lessor, and is depreciated as such.

Figure 4 - Leasing Arrangement for Energy Storage Systems



Source: STEM, Inc.

This type of financing structure can be very useful to customers behind the meter for a variety of reasons. Obviously, if the customer chooses not to purchase equipment, either by choice or through capital constraint, this method is a very effective means for the customer to still have access to the benefits of the equipment without a large and immediate outlay of capital. A lease is also useful when customers are not familiar with the technology and/or if the technology is perceived to be expensive, but with strong price decline expected in the near future.

The operating leasing model has been credited as one of the key drivers for the hugely successful residential and commercial solar PV market. In that market, there are a variety of operating leasing business models, including where the customer paid no upfront cost, some of the system cost, or purchased the system prior to end of the lease term. Due in part to its success in developing a mature market, third party ownership of solar is expected to start declining as a percentage of the overall market as the cost of the PV system has dropped sufficiently to where people can afford a loan for the system and alternative financing options like PACE (Property Assessed Clean Energy) allow choice to finance the purchase of the system.

Table 1. Notable 3rd Party Energy Storage Financing Arrangements

Storage Developer	Financing Group	Available Financing
CODA Energy	Fortress Investment Group	$6.4 Million
Green Charge Networks	TIP Capital	$10 Million
Green Charge Networks	K Road DG	$56 Million
Solar City	Credit Suisse	Undisclosed portion of $1 Billion financing for Solar and Storage
STEM	Clean Fleet Investors	$5 Million
STEM	B Asset Managers	$100 Million
ViZn Energy Systems	LFC Capital	Up to $5 Million per project

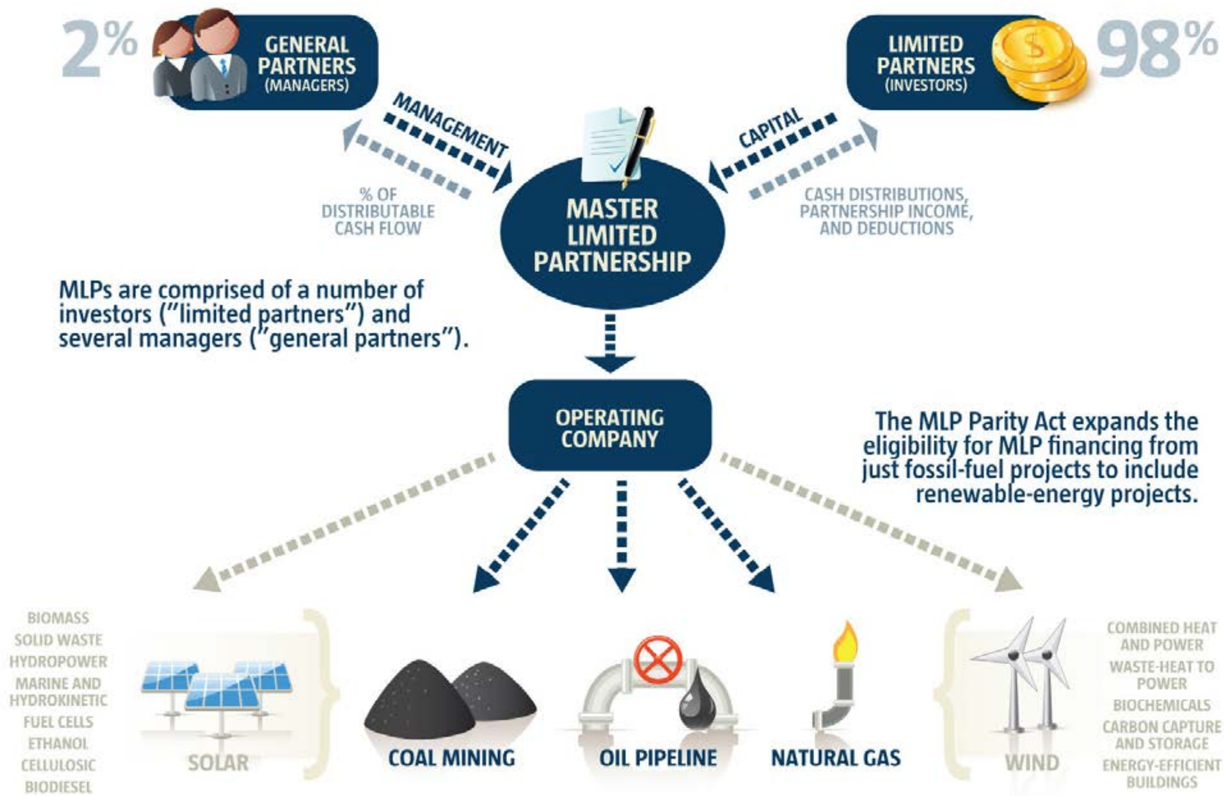
Leasing programs in the commercial energy storage market have accelerated over the last few years as companies such as Solar Grid Storage (purchased by SunEdison), STEM, CODA Energy, ViZn Energy Systems, and Green Charge Networks, etc. have been able to partner with financial groups to provide a funding facility for the energy storage company to finance the energy storage asset and execute an operating lease with the customer. The length of the lease varies between the companies, spanning anywhere from 3 to 10 years.

The energy storage system in these arrangements is primarily used to reduce demand charges, high time of use rates, and as an onsite source of energy for critical systems in the event of a power outage. Shorter time spans are typically more problematic for the leasing company to earn a sufficient return on the transaction, but in states such as California, incentive programs assist in making the transaction cost effective. As the energy storage industry matures, the need for capital will increase dramatically from current levels as additional customers look to take advantage of this option to mitigate rising electricity usage costs as demand charges are expected to continue to rise.

1.3.2. Master Limited Partnership (MLP)

A master limited partnership (MLP) is a type of limited partnership that trades on an exchange. This combines the liquidity of a publicly traded security (equity) with the tax benefits of a limited partnership. Through this, groups are also able to raise low cost capital for investments through IPOs and secondary offerings. MLPs do not pay State or Federal corporate tax, and pass through the majority of their income to investors in the form of regular quarterly distributions which are tax deferred. To qualify as an MLP, the partnership must generate more than 90% its income from activities related to the infrastructure investments in the production, processing and transportation of natural resource industries, such as timber, oil, natural gas and coal. MLPs have seen tremendous growth, with a current total market capitalization of $494 billion.[5]

Figure 5 - How Master Limited Partnerships Work



Source: Office of U.S. Senator Chris Coons, Delaware

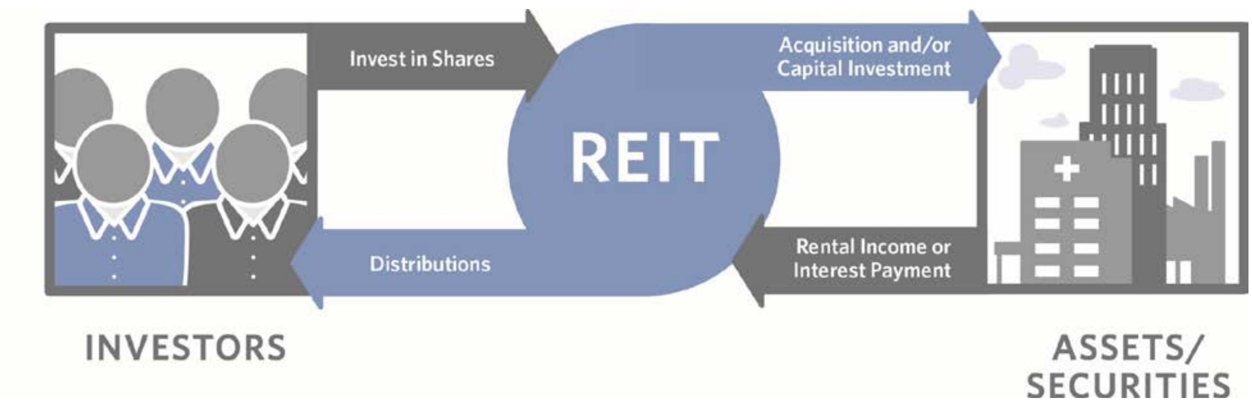
The U.S. Federal government allows these types of investments into the MLP because of the very stable incomes these infrastructure investments provide. There has been some effort to extend these benefits to renewable energy markets due to the proven track record for stable incomes from existing long-term power purchase agreements.

The reintroduction of the Master Limited Partnerships (MLP) Parity Act in the 114th is designed to expand the availability of the MLP corporate structure to include companies that use renewable energy technologies. It is hoped that if passed, energy storage systems could be included as related equipment or as stand-alone technology.

1.3.3. Real Estate Investment Trusts (REIT)

Real Estate Investment Trusts (REITS) were instituted in 1960 by federal legislation to give real estate investors the same tax investment opportunities as investors who buy into mutual funds that are comprised of other asset classes. REITs raise funds through IPOs or secondary offering; they are not subject to corporate tax but rather pass through the tax obligation so earnings are taxed only once at the personal level. However, tax credits do not pass through a REIT to its shareholders. As of August 31, 2015, there were 225 publicly traded REITs registered with the Securities and Exchange Commission in the United States (NYSE), containing $878 billion in assets.[6]

Figure 6 - How Real Estate Investment Trusts (REITs) Work



Source: CNL Securities

REITs are able to invest in electric power industry projects—but with significant limitations. At least 75% of a REIT's assets must be "real property." The definition of this being that it must be "inherently permanent"—including no moving parts and not be an "asset accessory to a business." Specifically, to discourage REIT's from engaging in activities outside of their primary objective—the development, ownership, lease, and/or management of real property, the IRS rules impose a 100% tax on REIT income from the sale of inventory—with electricity so far assumed by most to qualify as inventory. To use a solar PV project as an example, the land and metal support structures would qualify for investment, whereas the solar panels would not. At least 95% of a REIT's annual gross income must be derived from these real property assets, and the REIT must distribute at least 90% of its taxable income annually to its shareholders as dividends.

There are ways for a REIT to broaden their investment into including the entire electric power project. This is important, since, as one study interviewee mentioned, and taking the last example of the PV project—it is rather difficult to make a solar project pencil out without the solar panels. With gross oversimplification, real property assets are considered "good" assets, whereas those generating electricity are "bad" assets. In reality, the IRS makes this determination on a case by case basis. By balancing the good and bad assets, a REIT can successful create a workable portfolio of assets. The ownership structure is critical. For example, a REIT could own and operate solar power equipment that is installed on the roof of a REIT owned building, as long as the power produced is completely used by the building's tenants. This type of system would qualify as good REIT assets. Otherwise, the REIT could include it in its portfolio as a bad REIT asset.

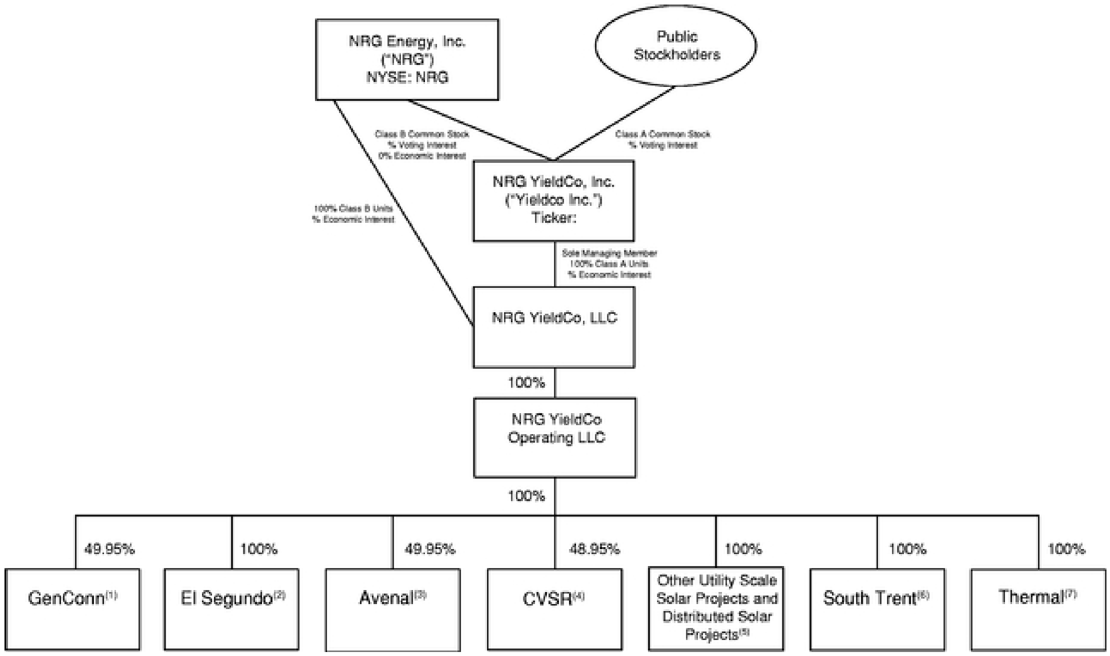
Energy storage equipment would face many of the same challenges trying to qualify as a solar project due to its nature to be an asset accessory to a business. Exacerbating this is the point that since the IRS makes rulings on this on a case by case basis, there simply are too few decisions that include energy storage being put into a REIT—so there is little guidance to the rest of the industry. Since the proportion of inherently permanent equipment in an energy storage asset is significantly smaller than in a solar PV project, there is even less opportunity for REIT investment into the energy storage market directly without structural legislative changes.

That is not to say that REITs will not be able to include energy storage systems into their asset base. As mentioned above, if energy storage systems are integrated into the building systems itself—and the move towards Net-Zero Buildings continue (utilizing energy storage) it will become more and more difficult for the IRS to determine where the integrated building management system ends and the wholly integrated electrical or thermal energy storage system begins. Therefore, behind-the-meter opportunities should continue to appear as groups receive Private Letter Rulings from the IRS that build an expanding case for inclusion of energy storage systems as an integral part of the rapidly evolving building energy system landscape.

1.3.4. YieldCo

A YieldCo is a publicly traded company that acquires and owns power industry infrastructure assets and their associated long-term off-take contracts (PPA's, etc.) that provide predictable cash flows for investors. They are sometimes referred to as an adaptation of the REIT structure designed to invest in renewable energy assets. The first YieldCo in the renewable energy market was Brookfield Asset Management's Brookfield Renewable Energy Partners in 2012 (NYSE:BEP)[7]. The term YieldCo was first coined when NRG Yield Inc. (NYSE:NYLD) IPOed in July of 2013. Many groups have quickly entered the market, and as of September, 2015, fifteen U.S. and European YieldCos had raised $12 billion through IPOs. Enjoying rapid growth, their market values had climbed to a peak of almost $28 billion[8]. Greentech Capital Advisors predicted the assets of YieldCos would grow to more than $100 billion in the near term at the Bloomberg New Energy Finance Conference in April 2015.

Figure 7 - Typical YieldCo Structure



Source: NRG Energy, Inc.

Available cash flow is a central focus of a YieldCos operation. YieldCos distribute almost all of their available cash flow to investors through quarterly dividends based on an internal calculation–CAFD (Cash Available for Distribution). There is an expectation for YieldCo dividends to grow over time, so managing the cash flow from the projects is critical as missing a dividend payment would doom the YieldCo in the stock market. Since a YieldCo distributes almost all of the operating net cash flow, YieldCos must either borrow or raise equity to make new acquisitions. Although YieldCos do not have the tax advantages of a REIT, YieldCos can avoid paying most taxes as long as the depreciation of an asset will cover its income during the early years of asset ownership. Therefore, a YieldCo must add new assets both to generate income for the expected rise in dividend payouts, and to provide new assets to generate depreciation.

Table 2. Notable North American YieldCos

Company Name	Ticker	IPO Date	Assets
Brookfield Renewable Energy Partners LP	BEP	11-Jun-13	Hydro
NRG Yield, Inc.	NYLD	16-Jul-13	Solar, Wind
TransAlta Renewable	RNW	9-Aug-13	Wind, Hydro
Pattern Energy Group, Inc.	PEGI	26-Sep-13	Wind
Abengoa Yield Plc	ABY	26-Jun-14	Solar, Wind, Other
NextEra Energy Partners	NEP	26-Jun-14	Wind, Solar
TerraForm Power	TERP	17-Jul-14	Solar
8point3 Energy Partners LP	CAFD	18-Jul-15	Solar

YieldCos must continually acquire new assets to assure the growth of income for distribution to shareholders. One way is to acquire new assets through open market acquisitions, but this can become expensive if a number of groups begin bidding on the same project. Secondly, a YieldCo can establish a relationship with a project developer (or be owned by one) to gain access to their development pipeline in order to buy all or a portion of the projects. This can benefit the development company as it frees up a large portion of its capital to develop another project, but holds on to a portion of the completed project if it choses. A number of YieldCos in the renewable energy market are using this strategy.

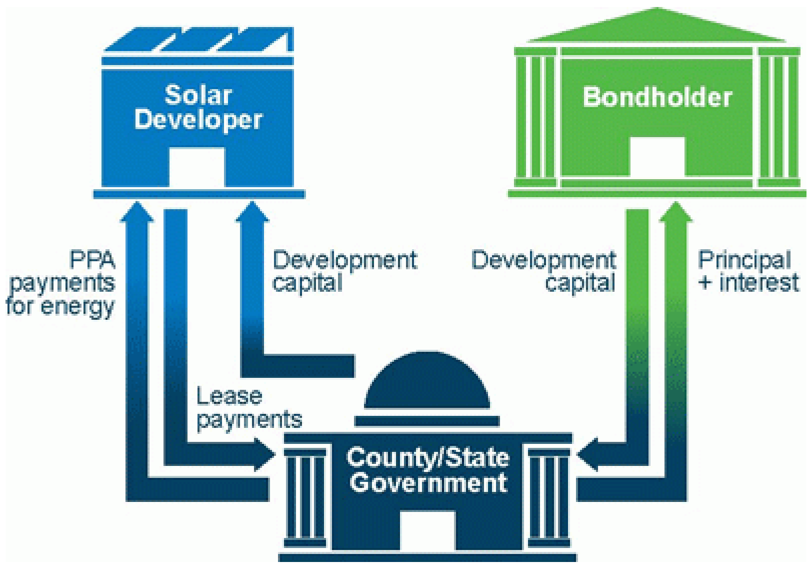
The recent collapse in YieldCo share prices suggests that this market is has not yet reached an equilibrium, and thus projecting its future path forward over the next few years is problematic. By many accounts, the YieldCo market in late 2015 is saturated, and is driving up asset price for wind and solar projects from the increased competition, reducing the return on investments for the winning YieldCo purchaser. Others YieldCos have chosen not to make offers for some assets as they had felt priced out of the market, not being able to maintain a profitable enough return on certain assets at the inflated prices. Extending that trend, other groups who recently were planning their own IPO listing of YieldCos have changed their minds and are looking into other financing options due to the recent share price declines experienced by YieldCos in general. As the market for these entities matures, it is expected that share prices will recover somewhat, but a maturing of the market will continue to focus these groups on maintaining profitable operations.

YieldCos are enticing to energy storage developers because of their voracious appetite for new assets. However, because of their need for extremely stable and reliable cash flow, energy storage assets are not currently high on the priority list for YieldCo managers. As with most lenders, what is more likely is that YieldCo managers may contemplate including energy storage assets into the YieldCo first as part of a hybrid storage/renewable system that has proven itself to generate a reliable cash stream. As for stand-alone energy storage projects, the first kind that might possibly be included into a YieldCo portfolio would be small (less risk) with a well-defined market contract. However, even as energy storage projects gain experience quickly, the uncertainty of units performing a multi-functional role will undoubtedly cause YieldCo managers to contemplate storage systems with a simple contractual structure as their first foray into the energy storage market.

1.3.5. Bonds

Bonds are the most traditional 3rd party financing option, and typically the lowest cost source of capital for funding power industry projects. Bonds are a debt obligation of the issuing entity, and are publicly traded (over the counter) securities. To qualify for the lower interest rate available from this source of capital, virtually all risk must to be eliminated from the equation, or clearly spelled out citing ample, and widespread operating history. It will always take some time for the market to become comfortable with the risk profile of a new technology class. However, their reticence can be overcome—the financial market gained experience with different renewable energy technologies, and portfolios were able to be securitized through bond issuance. Governments in particular have been able to take advantage of the bond market by providing an inherently permanent host for renewable project bond financing.

Figure 8 - Government Renewable Energy Project Bond Financing



Source: NREL

Some notable bond offerings in clean energy financing include:

- **Wind**: FPL Energy American Wind LLC - (Parent company was FPL Energy—now NextERA Energy Resources) sold $380 million in a private bond offering during 2003 with a coupon rate of 6.639% for 20 year senior secured bond offering. This was one of the watershed events for the wind industry and ushered in a growth phase for an industry in need of deep pools of capital for the large transmission level projects that followed. The bonds were backed by cash flow from a portfolio of 7 wind farms, representing 680 MW of wind turbines, and received a Standard & Poor's rating of (BBB-)..[9]

- **Solar:** In November 2013, solar leasing company SolarCity sold $54 million in bundled cash payments by pooling together more than 5,000 residential and commercial solar contracts in the solar industry's first Asset Backed Securitization (ABS). SolarCity was then able to take the proceeds from this sale and invest them in other assets, highlighting securitization's effectiveness in raising capital.[10] A recent study from the Michigan Technological University showed that securitization could lower the cost of capital for solar photovoltaic projects by 5 percent to 13 percent.[11]

- **Energy Efficiency.** Energy efficiency projects have been quick to enter the debt market. This is notable since the underlying contracts are for energy savings and not power sales, and thus could serve as a guide for behind-the-meter energy storage projects. In July 2013, Connecticut's green bank—the Clean Energy and Finance Investment Authority (CEFIA) bundled C-Pace loan portfolio bonds. The bonds were issues by the Public Finance Authority and backed by $30 million commercial PACE loans funding energy efficiency in commercial buildings in the state of Connecticut. The assets have an average life of 8.77 years, the senior bonds issued have a coupon of 5.1 percent. [12]

Green bonds are a recent phenomenon and were developed to enable project developers to raise capital for projects with environmental benefits. The type of project that could benefit is wide ranging, including renewable energy, energy efficiency, sustainable waste management, sustainable land use, biodiversity conservation, clean transportation, and clean water projects. The growth in Green Bonds has been strong, with 35 organizations issuing $36.6 billion in 2014, more than triple the amount in 2013. Estimates are for the Green Bond market to grow by $100 billion in 2015, and eventually reach $1 trillion to $2 trillion.[13]

Stand-alone energy storage projects are simply not ready for traditional bond financing; even the opportunity to utilize bond financing to fund a project incorporating energy storage technologies is not expected for a number of years—depending upon the credit-worthiness of the recipient and what guarantees have been made. Typically, bond financing is for large infrastructure projects, requiring that the scale and reliability of revenue for energy storage projects would need to grow substantially. Prior to typical bond issuance, the ratings agencies need a large number of transactions to occur with some performance history in order to assess the likelihood of default.

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2. COMMERCIALIZATION CHALLENGES

The energy storage industry has finally entered the early phase of real commercial development and accelerating market growth. Many describe the industry's current status as a "Tipping Point" where a number of market conditions have aligned to promote a self-perpetuating and accelerating growth stage. The viewpoint of many project developers is that energy storage technologies have finally reached a level of technical maturity sufficient to begin commercial projects in earnest. First movers are already taking advantage of these conditions to drive their initial commercial growth. As these early deployments are followed by others, momentum is gained, and consumer demand pulls the industry forward, most times following the path of least resistance—the patterns set forth by the first movers. Over time, the costs of these leading systems will to decline and their operating capabilities will increase—supporting an accelerating and widening deployment. Other energy storage technologies will follow, up the maturation curve, opening up new roles and opportunities for the industry.

Transitioning a working prototype energy storage technology from the lab to commercial status requires building out a supporting framework to enable the asset to operate successfully as part of the electric power system; not just as a technological product, but as a complete engineered system. As with other projects in the power sector, this growing class of systems requires technical and operational ecosystems of supporting equipment, market rules, and business practices which must be developed to support the cost effective use of the technology in order to be deployed industry wide.

Four challenges in particular are critical for successful development of the energy storage market:

- ***Technology*****:** Does the technology work? Has it been designed into a working system?
- ***Codes, Standards, and Regulations*****:** Is the system able to be installed and operate within the wider electric power system?
- ***Public Policy:*** Is the market structured to allow it to operate in an economically effective role?
- ***Finance*****:** Is there sufficient interest to develop projects profitably?

To answer these questions, the energy storage industry can look to the wind, solar, and energy efficiency industries as a guide for how nascent industries grow and overcome obstacles in the power market. In many areas, the opportunity for energy storage deployment is actually these very markets, so understanding them is essential. The energy storage industry can gain valuable insights as to how each of these industries improved their technology maturity and established a commercial presence. Rewriting interconnection standards, market rules, and siting ordinances is difficult, but these have been the basis for development of these other industries, and thus it will benefit the storage industry greatly to glean hard won lessons learned from these other markets.

2.1. Technology

The first commercialization challenge is to achieve technical maturity of the product. To accelerate the resources of the firm developing the technology, Governments have long supported technological research and development. As the technology emerges into commercialization, manufacturing and system integration advances are also necessary in order to support the development of a fully integrated system ready for deployment.

2.1.1. Government Support—From R&D to Deployment

The Federal Government has been crucial in driving the technical development of energy storage technologies and incentivizing developers through financial support of early demonstration projects and improving market rules.

2.1.1.1. Technology

The U.S. Department of Energy has long played a crucial role facilitating the research and development of energy storage technologies with a focus spanning research in the lab to early commercial development. This development comes through support at U.S. Government labs and supporting projects through State level programs. Besides the importance of the long critical role played by the DOE's Energy Storage Program the DOE also supports energy storage technology research through ARPA-E (Advanced Research Projects Agency-Energy). Other entities at the Federal government have also played a key role in technology development, including Small Business Innovation Research (SBIR) grants, and research and deployment grants through the U.S. Department of Defense. Critically, these groups supported both the technology and early demonstration deployments of early prototypes.

2.1.1.2. Grants

The U.S. Federal Government has also long played a crucial role supporting deployment of early commercially ready energy storage systems through a series of grant programs. A critical difference and strength of this effort is the leveraging of private sector funds through providing funds through matching grants, leveraging the resources of the private sector. These matching funds are critical to help overcome high costs typical of early deployments – high cost equipment because the firm has not been able to gain the benefit of the economies of scale, and NRE (non-recurring expenses) costs such as upfront system engineering expenses.

One of the highest profile and effective grant programs of the U.S. Department of Energy had funds originating through the American Recovery and Reinvestment Act (ARRA) of 2009. As a next step beyond straight government R&D support, the ARRA program's grants leveraged private developer's efforts and financing to develop early demonstration projects, with the majority of the funding coming from the developer. Through this program, the U.S. Federal Government supported twelve energy storage projects with grants amounting to $185 million that were matched with $585 million in cost sharing provided by the private developers.

2.1.1.3. U.S. DOE Loan Program Office

The U.S. Department of Energy established the Loan Programs Office to accelerate the deployment of innovative clean energy projects across the United States. The US DOE Loan Program Office traces its beginning to The Energy Policy Act of 2005 which included Title XVII (Incentives for Innovated Technologies) that created Section 1703 loan program. Initially focused on wind and solar projects, the DOE's Loan Program Office has increasing looked at ways to bridge the gap when private equity or other groups may not fund the early commercial development of energy storage projects. As such, the DOE's Loan Program Office maintains a deep knowledge and understanding of different energy technologies in order to evaluate them from a project developer's perspective.

The Loan Program Office supports these projects through co-lending, securitizations, and generally attracting new equity lenders and tax equity investors. By helping to develop some of the first commercial projects of innovative technologies, the wider financial market can see actual operating projects and gain much needed familiarity so addition projects can be successfully funded by other commercial lenders, and help usher a new class of innovative energy technologies through the "Valley of Death."

2.1.2. Technology Readiness Level (TRL)

A standard measure of technology development is the Technology Readiness Level (TRL). This is used to track the early stage development for various technologies, and has been used extensively in the energy storage market in various government funding programs. The TRL scale is important as the rating implies adherence to a set of standardized technological progress milestones giving comfort to users that there will be continual progress toward a working prototype.

The TRL scale was developed by NASA in the 1980s. The TRL scale ranges from 1 (basic principles observed) through 9 (total system used successfully in project operations). Over time, this scale was adopted by other U.S. Federal government agencies as it proved superior in identifying the actual technology maturity and preventing premature deployment by the federal government.

TRL1 ***Basic principles observed and reported.*** The beginning of scientific research towards translating scientific principles into research and development (R&D).

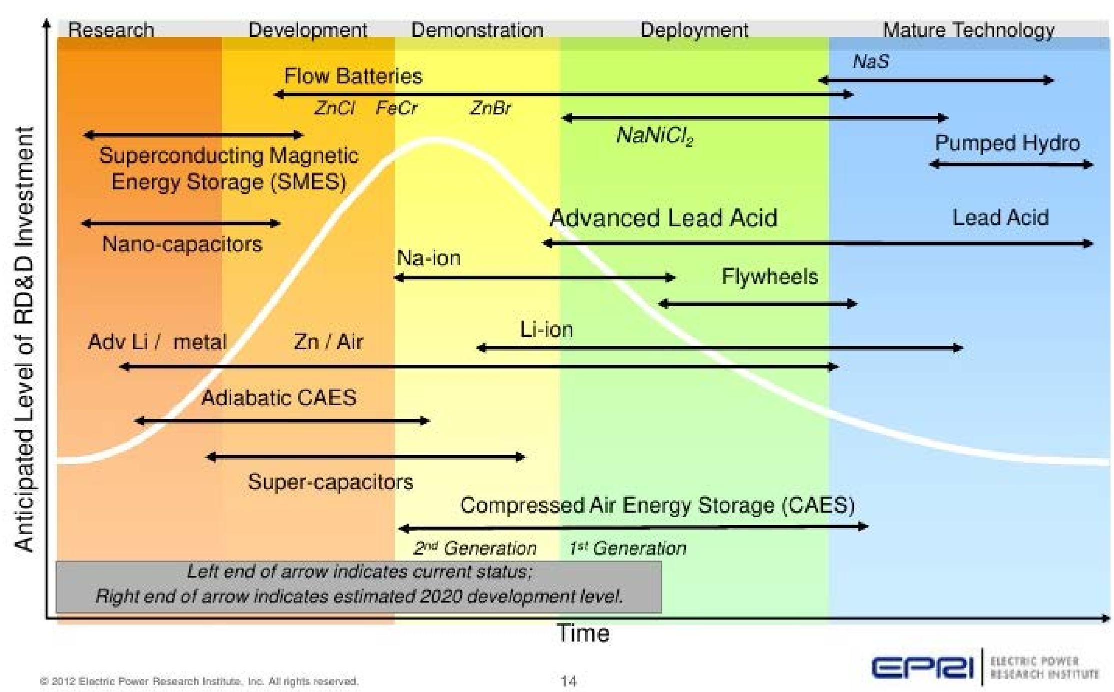
TRL2 ***Technology concept formulated***. After observing basic scientific principles, applications—typically highly speculative—are envisioned.

TRL3 ***Proof of concept***. Validating initial predictions through analytical and laboratory R&D programs.

TRL4 ***Component validation in laboratory.*** Integrating basic components of the proposed system to prove that they will work together.

TRL5	***Component validation in a simulated world.*** A complete set of system components are integrated in a simulated environment for initial testing to confirm they will operate as expected.
TRL6	***System demonstration under normal conditions.*** A prototype system is fully integrated and deployed into a real-world environment for operation; typically the major demonstration of the technology's readiness.
TRL7	***System demonstration in operation.*** Ongoing operational experience allows refinement of the design into a commercial product.
TRL8	***System qualified through test and demonstration.*** Establishing the technology is able to operate commercially through qualifying the system under all pertinent regulations and certifications.
TRL9	***System proven through operations.*** Commercial operation of fully mature system in actual environmental and applications conditions

Figure 9 - Technology Readiness of Energy Storage Technologies



Note: This graph was produced in 2012

A key distinction must be made between a technically mature and commercially ready technology. Even if a technology has progressed through TRL 9 that is not typically sufficient for it to be a commercial success. For instance, many project developers and most lenders are typically only interested in deploying a technology that already has 4 or 5 commercially operating units in the field with extensive experience.

2.1.3. Commercial Readiness Level (CRL)

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 giving comfort to 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 ranges goes from 1 to 9.[14]

CRL1 Knowledge of applications, use-cases, & market constraints is limited and incidental, or has yet to be obtained at all.

CRL2 A cursory familiarity with potential applications, markets, and existing competitive technologies/products exists. Market research is derived primarily from secondary sources. Product ideas based on the new technology may exist, but are speculative and unvalidated.

CRL3 A more developed understanding of potential applications, technology use-cases, market requirements/constraints, and a familiarity with competitive technologies and products allows for initial consideration of the technology as product. One or more "strawman" product hypotheses are created, and may be iteratively refined based on data from further technology and market analysis. Commercialization analysis incorporates a stronger dependence on primary research and considers not only current market realities but also expected future requirements.

CRL4 A primary product hypothesis is identified and refined through additional technology-product-market analysis and discussions with potential customers and/or users. Mapping technology/product attributes against market needs highlights a clear value proposition. A basic cost-performance model is created to support the value proposition and provide initial insight into design trade-offs. Basic competitive analysis is carried out to illustrate unique features and advantages of technology. Potential suppliers, partners, and customers are identified and mapped in an initial value-chain analysis. Any certification or regulatory requirements for product or process are identified.

CRL5 A deep understanding of the target application and market is achieved, and the product is defined. A comprehensive cost-performance model is created to further validate the value proposition and provide a detailed understanding of product design trade-offs. Relationships are established with potential suppliers, partners, and customers, all of whom are now engaged in providing input on market requirements and product definition. A comprehensive competitive analysis is carried out. A basic financial model is built with initial projections for near- and long-term sales, costs, revenue, margins, etc.

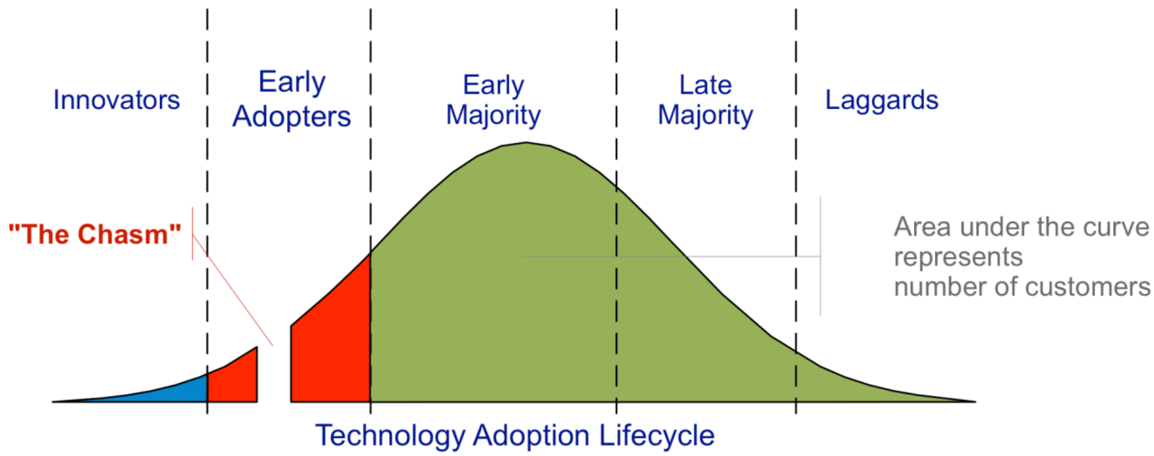
CRL6 Market/customer needs and how those translate to product needs are defined and documented (e.g. in market and product requirements documents). Product design optimization is carried out considering detailed market and product requirements, cost/performance trade-offs, manufacturing trade-offs, etc. Partnerships are formed with key stakeholders across the value chain (e.g. suppliers, partners, customers). All certification and regulatory requirements for the product are well understood and appropriate steps for compliance are underway. Financial models continue to be refined.

CRL7 Product design is complete. Supply and customer agreements are in place, and all stakeholders are engaged in product/process qualifications. All necessary certifications and/or regulatory compliance for product and production operations are accommodated. Comprehensive financial models and projections have been built and validated for early stage and late stage production.

CRL8 Customer qualifications are complete, and initial products are manufactured and sold. Commercialization readiness continues to mature to support larger scale production and sales. Assumptions are continually and iteratively validated to accommodate market dynamics.

CRL9 Widespread deployment is achieved.

Figure 10 - Adoption Lifecycle of New Technologies



Source: Craig Chelius

The TRL and CRL indexes have been a key part in the successful development and deployment of energy storage technologies. Through their use, projected milestones could be met, critical challenges identified, and forward progress maintained through government sponsored programs. If there are setbacks, these indexes highlight the area where targeted support should be applied that will provide the most effective improvement—if a number of aspects of the technology are still needed to be improved, then the index highlights the ones which should be done first (i.e. those in the lower index ranking).

These indexes serve another use; as can be seen in Figure 12, innovators and early adopters are the first to adopt a technology—but by far a small part of the customer base. By providing a structured development cycle, the federal government has helped prepare emerging energy storage technologies for the eventual and inevitable period—“valley of death” or “chasm”—where early adopters and funders expect others to follow suit, but do not.

2.1.4. Manufacturing

Besides establishing that that technology is technically ready to operate in a commercial environment, the manufacturers of the technology must also develop a manufacturing process able to support the commercial development of the product.

This would include the ability to:

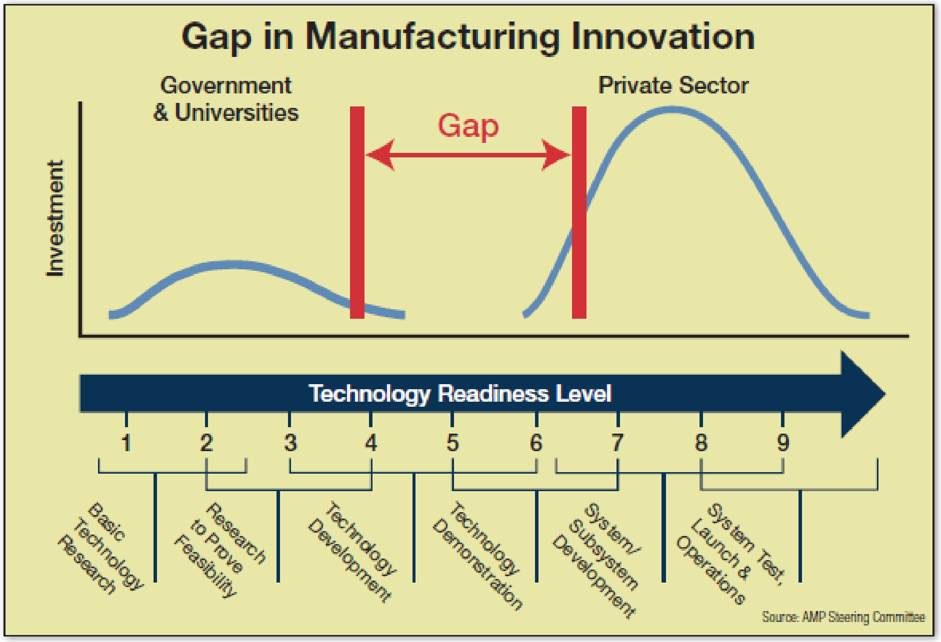
- Scale manufacturing to meet demand. Most production processes are limited by gating steps in the production process, with cost effective production scale-up coming in discrete step changes. This is also linked to the ability to support this manufacturing expansion with sufficient numbers of trained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

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

- Design the product and components to support the development of a full product line family. Manufacturers utilize a modular component design approach in order to support multiple designs to serve different markets while keeping the number of components needed to be developed small. For interoperability, manufacturer look to product standards so that they can continue to focus on the overall design of the system while giving them the possibility to purchase sub-components from outside vendors while still ensuring these new components would fit and operate properly with the rest of the system.

Manufacturing of emerging technologies like energy storage typically suffers from a gap in innovation and funding as OEMs transition from low volume production as the technology emerges from R&D labs to higher volume during commercial production. This is another aspect of the much touted “Valley of Death” as early stage firms emerge with new and innovative technologies. Not just in raw manufacturing capacity, but also in design capability to scale production while maintaining high quality and stable margins. Often over-looked, the ability to manufacture at scale, with a high yield, and in a cost effective manner takes its first formative steps during the technological development stage.

Figure 11 - Gap in Manufacturing Innovation



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. Some still profess that the market still remains fuzzy, but it is moving quickly and they want to establish themselves in the industry before all the good partners are taken as they notice many of their competitors already in motion. 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 developer's business plans.

2.1.5. System Integration

As the industry evolves and matures, the need to develop an integrated and stable design for the system is becoming essential. Therefore, even if the core energy storage technology is advanced, it is ultimately how the technology is integrated with inverters, control systems, software, and any other required balance of plant equipment.

Common manufacturing standards are essential for multiple suppliers to be able to specialize in different components and have confidence that the different components will be easily integrated together in a plug-and-play capacity. In the early growth phase of commercialization, leading system integrators commonly design and manufacture many of the power electronics and controls equipment, but ease of component integration will be required for less sophisticated system integrators to be able to enter the market.

2.2. Codes, Standards & Regulations

The development of Codes, Standards, and Regulations (CSR) are critical for the successful commercial development of energy storage systems. CSRs provide essential guidance in the design, installation, and operation of energy storage system. In particular, these mean[15]:

- **Standards** define criteria for the design and construction of energy storage systems, materials, components, and related products.

- **Codes** serve as a model for regulatory agencies to adopt as law or for utilities to adopt as part of energy storage system specifications and generally contain references to relevant standards.

- **Regulations** are model codes that have been adopted by Federal, State, or local government that addresses safety and performance of energy storage systems.

These frameworks are essential for safety, but also enabling the ease of integrating all of the components into a complete system, the interoperability of the subsystems and the overall system into the wider electric power network. CSRs also benefit manufacturers of complete systems and those that are responsible for assembling complete systems on site as they will be easier to site and commission.

2.2.1. Framework

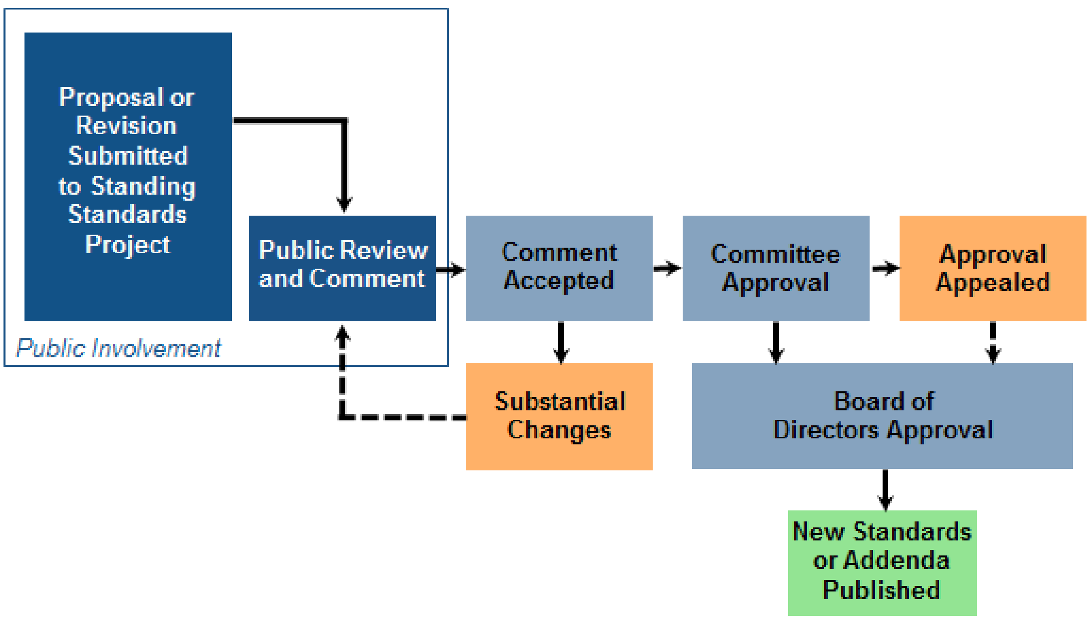
The first step in developing a framework of CSRs for energy storage systems is to first decide on the basic physical approach on setting standards for this technology class. For instance, will there be separate standards for each of the individual components, or will there be a standard for a complete system? For many new technologies, standards for the individual components (battery modules, inverters, etc.) are the first to be developed with the more complex total system standards being developed later. This framework has significant implications for the eventual testing and verification of the systems as it tracks the performance in a far more discrete way. However, this can be a disservice for multi-functional systems like energy storage where testing and design emphasis might be better suited at the full system level to ascertain the unit's actual capability and the primary focus of metrics.

To that end, the International Electrotechnical Commission (IEC) developed the Technical Committee 120: EES (Electrical Energy Storage) Systems in 2013 to oversee the development of international standards that address all different EES technologies in a systems approach. The goal of this Technical Committee is to accelerate the introduction of renewable energy into the grid, and enable a more reliable and efficiency supply of electrical energy. Other established standards bodies are also moving forward in a similar fashion. For instance, UL recently published UL9540 *Energy Storage Systems and Equipment* as a comprehensive approach to charging, discharging, protection, control, etc. As the energy storage industry continues to grow, this approach of providing an integrated framework to systems will benefit customers by having OEMs focus on system, rather than component, level design.

2.2.2. Development

Developing new CSRs begin with a lengthy scoping process that includes significant input from a number of involved parties to develop metrics for testing, review, and approval. For energy storage technologies, the U.S. Department of Energy has been one of the key leading entities working to develop standardizing efforts across the industry through multiple line of effort that includes its Safety program, efforts to measure performance, and the definition of standardized applications themselves.

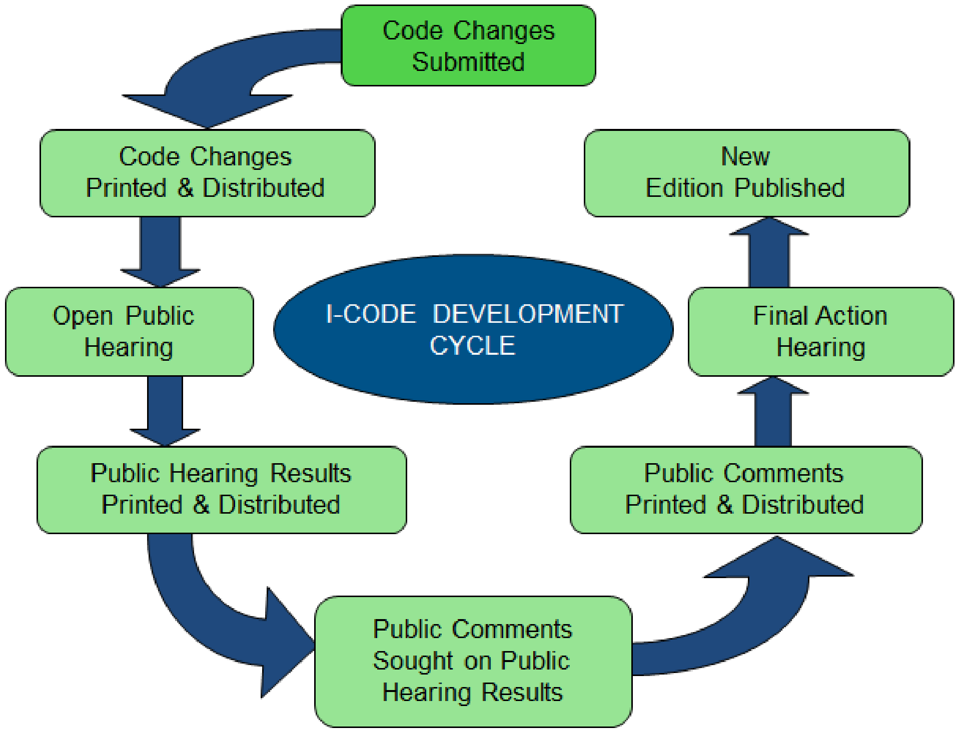
Figure 12 - Standards Development Process



Source: Energy Storage Codes & Standards, NEMA Workshop, 2013

In concert with the U.S. Department of Energy, EPRI's Energy Storage Integration Council (ESIC) has been an industry led effort to develop common approaches amongst utilities and OEMs to common solutions to definition and deployment for distribution system-connected energy storage system. Interoperability is a key facet for standards development to support the plug-and-play goal for most distributed resources. Here, IEEE's P2030.2 provides a Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure. Other groups have a more targeted focus, such as the Modular Energy Storage Architecture (MESA) Standards Alliance which is supporting the development of a common communication/software interface between subsystems.

Figure 13 - Code Development Cycles



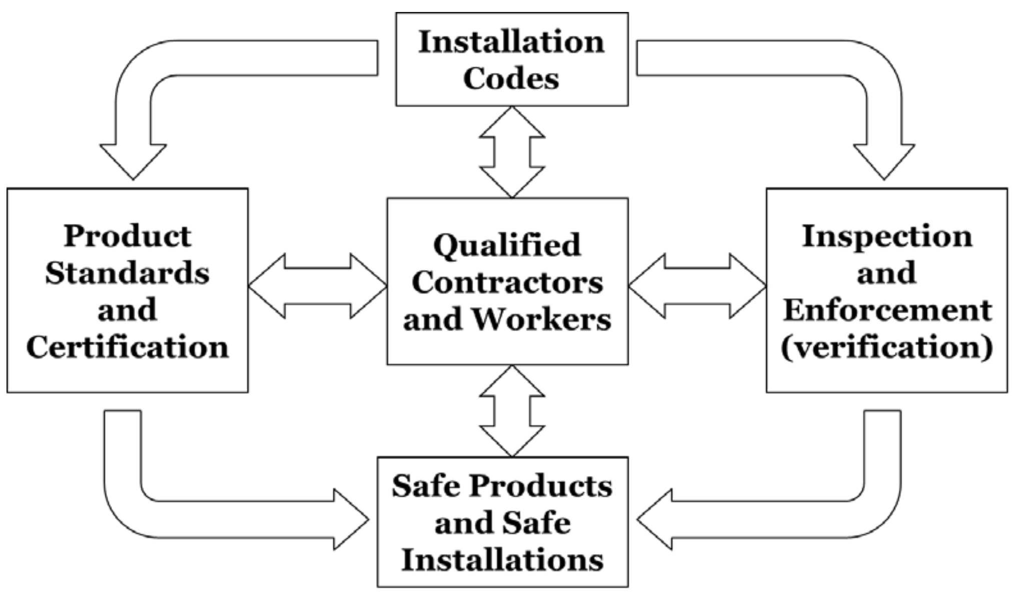
Source: Energy Storage Codes & Standards, NEMA Workshop, 2013
Note:" I-Code" refers to International Codes

It is an unfortunate fact that CSRs defining the application and installation of any new technology tend to lag technical development of the equipment themselves. This leaves providers of a new technology needing to utilize sometimes ill-suited CSRs simply to be deployed (to conform with the need for the technology to comply with some existing standard in order to be deployed.) with the result being that the full potential of the new system is either not fully utilized, or economically inefficient. This situation can be especially true for something like energy storage where the technical environment and market rules where it is to operate (for instance, frequency regulation) was designed without the energy storage technology in mind. Other times, a technology (lead acid batteries) has been deployed for specific applications (UPS) so some CSRs already exist which can be updated to include other technologies in their coverage while still retaining the safety protection for the user. If—as in the case of energy storage technology—technological development continues to open up new applications, revisions to existing CSRs and new CSRs can be expand upon the existing library of work. Although it is possible to develop new CSRs as each new technology emerges into maturity, it is preferred to update existing CSRs than add new ones. In either event, building a new body of CSRs for a new technology class (especially for new applications) can be facilitated through the first development of widely accepted protocols and bench standards that—while not a formal CSR (yet)—can be used in the short term to ensure safe use and operation of the technology and serve as a basis for expanding CSR development.

2.2.3. Installation

One particular area of effort not to be overlooked is for the development of relevant CSRs is the installation, operation, and maintenance of energy storage systems. In particular, NECA-NEIS (National Electrical Contractors Association—National Electrical Installation Standards) will be publishing in later 2015 an energy storage installation standard that mirrors other efforts the group covers in the safe installation and maintenance of electrical equipment throughout the power industry. Focusing on this area quickly is critical as without a set of installation guidelines and subsequent training programs, the actual deployment of equipment can be restrained due to safety concerns stemming from a lack of trained installers. As most market forecasts quickly scale from millions to potentially billions of dollars in deployed assets per year, this would amount to the equivalent of thousands of 40' containerized solutions deployed per year. Although design and safety standards are critical, local codes and ordinances will play a critical role in the development of the industry. Here, the 2017 NEC® (National Electrical Code) / NFPA 70 update will begin to specifically include energy storage system integration and help the deployment process at the local level.

Figure 14 - Role of Installation Standards



Source: NECA-NEIS

This growing body of relevant work will be essential as those engaged in validating compliance of equipment to be integrated into existing power system will have an easier time approving energy storage installations when the components are validated as complying with applicable standards. Finally, as the body of CSR work grows, communication of and training for the body of relevant work will be critical to having all of the relevant groups including this will be critical. This is obviously important to designers and integrators, but also must include end-users such as facility management, electrical workers, and first responders who will have to address any incidents created by an energy storage system.

2.3. Public Policy

Public Policy is the third commercialization challenge that helps define the extent and direction of the commercialization of energy storage systems. Policy development is important because it crafts a framework by which these technologies are used and valued. Policy development at both the Federal and State level will have a critical impact on the development of the energy storage market.

2.3.1. Federal

The Federal Government's impact through Policy support for energy storage technologies has been fundamental to the development of the market opportunities that exist today. As the energy storage technologies shows promise for helping with the modernization of the grid, additional Federal and State financial incentives could be provided to put storage on the same playing field as other clean technology sectors.

2.3.1.1. Federal Energy Regulatory Commission (FERC)

The Federal Energy Regulatory Commission (FERC) is an independent agency within the U.S. Department of Energy that regulates the interstate wholesale markets for transmission of electricity, and distribution of natural gas and oil. FERC has made providing an open and competitive market to enhance customer choice and improve service a priority. For example, under former Chairman Jon Wellinghoff, FERC drove efforts to provide a more level playing field for new entrants into existing electricity markets, while shifting payment of those services towards a pay-for-performance model. By continuing to remove barriers and create rules for storage to provide a full suite of services, these rulings have been instrumental in laying the groundwork for energy storage projects though establishing the legal and operational framework for energy storage technologies the ability to provide market services governed by FERC. These Orders help to ensure fair market access and transparent pricing for electricity storage technologies.

Some of the key FERC Orders focusing on energy storage have included:

- **FERC Order No. 890** (issued 2007) removed barriers to energy storage systems by prevented discrimination in transmission services and specified that certain ancillary services could be provided by non-generation resources.

- **FERC Order No. 719** (Issued 2008) improve the operation of organized wholesale markets by setting standards for transmission system operators to call on "non-generator resources" for ancillary services.

- **FERC Order No. 1000** (issued 2011) reformed the traditional planning requirements for public utility transmission providers. These entities were required under this rule to establish clear procedures to identify existing and future transmission needs, evaluate cost effective solutions, and allocate funds for new transmission facilities. By re-evaluating the planning and construction process of transmission lines, this Order allowed transmission providers to include energy storage as a possible alternative to transmission facilities on the basis of being a more cost effective solution.

- **FERC Order No. 755** (issued 2011) ushered in a wholesale change in the market design for frequency regulation and grid stabilization services by mandating that any technology—including energy storage—would be allowed to provide these services and that compensation for these services would be based on performance. This change was important as previously, the full value of providing the services was not available to energy storage providers. This Order also laid the groundwork for greater transparency of energy storage projects by developing standardized reporting rules to systematically track costs from these projects, including installation, maintenance, and operating costs.

- **FERC Order No. 784** (Issued in 2013) addressed existing barriers by fostered competition in the ancillary services market by requiring utilities to consider speed and precision when purchasing ancillary services. The Order also addressed accounting and financial reporting for new electric storage technologies by creating FERC accounts to record the costs of energy storage assets.

- **FERC Order No. 792** (Issued in 2013) reformed the Small Generator Interconnection Procedures (SGIP) to allow fast track development of eligible projects—including energy storage. Importantly, the Order clarified the definition of a "small generator" to include energy storage facilities, and the method for determining the size of an energy storage system when undertaking interconnection study.

2.3.1.2. Legislative

Federal legislative support for the energy storage industry can come in the form of grants, tax benefits, and targeted mandates. Grants have proven helpful in both the research and development phase, and also the early project deployment phase. Both of these are capital intensive undertakings, and thus grants or incentive payments have proven highly effective in supporting a desired outcome, be it either moving the status of technological development to the next milestone in maturity, or helping the first few key deployments of a commercially ready technology maintain forward momentum during the first few deployments when there will be high one-time expenses (first of a kind engineer expenses, etc.) to showcase its effectiveness.

Tax benefits have long been a tool of the legislative branch, and continue to provide some of the most targeted support available to many renewable technologies today in the form of the Investment Tax Credit or accelerated depreciation. Finally, targeted mandates are another avenue for the Federal Government to support the deployment of a technology. However, because typically these are considered for fast developing industries, it is sometimes a somewhat inexact tool, leaving other options better suited and more flexible to obtain the desired outcome.

2.3.1. States

State support for energy storage technologies has been increasingly effective to overcome commercialization challenges. Here, State governments have similar incentive grant opportunities as at the Federal Level, but one of the major factors is the Public Utility Commission regulation of the electric utility market. Through this framework, some State governments have been able to include energy storage technologies into the IRP (Integrated Resource Plan) process for the state-regulated utilities, ensuring that certain storage deployment targets be enacted, or storage can be simply included as an option for utilities to utilize as they obtain the necessary capacity additions to maintain reliability of the power system.

An important aspect of this regulatory oversight is the definition of energy storage technologies as a generation or transmission/distribution asset. This is important for the future direction of energy storage technologies in different States as, depending upon the level and direction of deregulation in the State, generation and transmission assets are allowed to operate or compete in different areas of the power grid, with separate accounting rules governing their treatment. Since energy storage technologies can provide many of the same functions or services as either class of technology, it matters a great deal as to how these technologies are defined at the State level. As one industry leader said recently, "I can deploy storage anywhere I want—I just can't get paid for it."

2.4. Finance

Financing energy storage projects is the basis for the commercial development of the energy storage industry, with the preceding sections (Technology, CSRs, and Public Policy) taken by most developers as a prerequisite to be solved—or at least a clear path forward—already in place. First movers like AES Energy Storage get into the market prior to these issues being finalized and leverage their hard-won experience. However, most developers—and especially lenders, are primarily focused on having clarity into the financial model for a project—the revenue streams, costs, and current risks. With these, they will evaluate the potential profitability of a particular project, and desiring to have a comfortable handle on the possible movements of each prior to moving forward.

2.4.1. Revenue

As a first step, project developers and lenders must ensure that there is sufficient revenue to support the proposed energy storage project over its lifespan. To confirm this, they look for stable and secure (contractual) revenue streams that are sufficient meet their internal hurdle rates. Preferably, the developers will look for opportunities for multiple revenue streams as a single revenue stream is typically not sufficient typically to cover the costs of the project. Optimizing the mix of possible applications for maximum gain can easily be quite complex, increasingly so as higher numbers of applications are needed to cover the project costs and the control algorithm has to decide which pattern of application support provides the greatest return at the lowest risk.

Public policy development has been crucial in forming market opportunities for energy storage projects. In the wholesale market, regulatory changes were necessary to unlock potential ancillary services revenue by changing the compensation for market services to a non-discriminatory and performance based approach. Wholesale markets are unfortunately volatile by nature, leading to unsteady cash flows from any one particular market service, requiring the storage asset to access multiple revenue streams—requiring additional and more far reaching regulatory reform. For opportunities behind-the-meter, deregulation to expand the reach of time-of-use rate (and transition to more focus on demand charges) is producing a structural opportunity. As regulatory changes bring opportunity, care should also be made for changes that would work against energy storage. For instance, demand charged for a particular customer class can always be adjusted up or down by the utility, greatly affecting the competitiveness of an option such as behind the meter energy storage. These charges can also be transformed into another form such as a flat rate charge, that—while still providing the utility revenue—does not actually incentivize customers in a dynamic way (i.e. depending on the load) towards a particular outcome.

A critical aspect of a secure revenue stream is not just the source of the revenue, but the contractual basis which defines the revenue reliability. Contracts lower the risk for both parties—they provide assurance to customers of the unit's performance and provide a framework for compensation if that performance does not reach the stated levels. Contracts also benefit project developers as they help make a project "bankable"—ensuring that the developer can access lower cost capital to purchase the equipment. For merchant projects, the Power Purchase Agreement (PPA) structure covers the compensation for products or services rendered in the power market; for behind-the-meter opportunities, the energy savings performance contract has been used extensively in the energy efficiency market. Unfortunately, industry wide standardized contracts for energy storage systems are not yet available, leaving developers without a financeable revenue stream.

2.4.2. Cost

As the revenue portion of the profitability equation becomes more understood, a growing focus is on the cost side of the equation. Here, most initial interest is centered on the purchase price, but as the operational role of energy storage systems becomes more understood, more emphasis is being placed on a more integrated cost framework which takes into account items such as operating and maintenance, battery replacements, and the impact of the operational attributes over the life of the system. To incorporate all of these different costs into a something that would be useful for a project pro-forma model, many people are turning to a levelized cost approach. LCOS (Levelized Cost of Storage) is an approach that is gaining interest in the energy storage industry now to compare different technologies for a specific use case or market opportunity which would describe a projects lifespan, power rating, and duty cycle, etc. Besides operating costs, additional project based costs such as installation, interconnection, and site specific work could be included to achieve the actual cost of utilizing a particular energy storage technology in a market application.

The purchase price of a battery system represents the first aspect of the capital cost. Because of the modular design of energy storage systems, there are a variety of capital costs metrics quoted regularly, and care should be taken to not confuse them. For instance, cell prices is the most basic level, yet to be useful, discrete storage technologies like batteries must be integrated into modules, where battery management systems are included to provide protection and control. Above that level, modules are linked together in standard racking towers, and then a number of towers are placed into a 20’ or 40’ ISO container with integrated cooling systems and other power electronics and software. This complete DC power system is then integrated with the PCS (power conversion system) to constitute the actual energy storage system that can be integrated into other AC power systems and connected to the power grid. Developing rules of thumb for how much each component of the final system will cost can be difficult as how the system is designed will dictate relative costs. For instance, if a storage system is designed to provide frequency regulation, the system will be more power (kW) centric, and the inverter will represent a larger share of the price, whereas a system designed for long duration of low discharge will be more energy (kWh) centric and have a proportionally larger share attributed to the energy storage module.

A second aspect of capital costs of an energy storage system is the planned replacement of equipment over the life of the project. This will normally include planned battery replacements, but may also include the power electronics if the project is long-lived. Determining the amount of these costs will vary greatly, depending upon the usage profile of the system, and the storage technology chosen. For example, each energy storage industry has its own set of degradation curves that impact—and are in turn impact on other factors—such as the fade rate, the depth of discharge, the state of charge (SOC) operation, cycle life, and operating temperature.

An emerging underlying framework for much of the capital cost calculation is the concept of "usable energy." All energy storage systems have some discrete levels of energy storage capacity, and this storage capacity will typically decline over the life of the system (fade rate) depending on the technology chosen and the usage profile of the application. Because of the rather complex nature of the calculations needed to ascertain this outcome, many customers are moving to a novel stance—they want the storage vendor to figure it out and provide a product tailored to their needs in a way they understand. Typically this means that the storage OEM or project developer will oversize the initial system or institute some type of regular battery replacement schedule so that the customer will always be assured of having a stated amount of usable energy to cycle through the system at any time during the unit's operating life.

Operation and maintenance costs are also important, and representing a growing area of interest, if not outright concern for developers and potential lenders. Because the technology is still maturing—and there are a number of types of energy storage technologies—the exact cost of O&M for these facilities is still to be determined based on more actual field experience. Typical maintenance is expressed as the annual maintenance contract that is sold by OEMs. These generally cover one or two visits per year to visually inspect the system and change out consumables such as air filters for the cooling systems; some contracts also provide for one or two unscheduled visits. Operating costs on the other hand typically are centered around the amount of energy needed to run the power electronics/controls and the environmental control systems. Warranty extension costs are a closely related issue, as the extent of the warranty will typically be based on an ongoing maintenance coverage.

Because of the tremendous power requirements that cooling can demand, significant effort has occurred in recent years around thermal management during operation to take advantage of as much passive cooing as possible. For instance, many early designs typically included the inverters inside the battery container which provided a clean integrated design, especially for installation purposes, but led to additional heat removal requirements. Many designs now install the inverters in an outside container with plenty of pass though air cooling, which reduces the heating load in the battery module, improving battery performance and expanding the space in the container for additional batteries.

Performance guarantees is another area of quickly evolving coverage, and will increasingly be a critical component of operating contracts for energy storage systems. However, still an area of unknown, the core issue covered is not necessarily the cycle life or efficiency of the system stated on the system specification sheet, but the ability of the unit to maintain those capabilities over the life of the unit. The performance of all energy storage technologies will be affected by different degradation rates due to operation. These guarantees are thus an implicit insurance policy the customer can purchase so that as they can have a higher degree of confidence in the unit's future operating performance when building out the project economic model. Unless the energy storage vendor is large enough to self-insure this, vendors are looking for insurance policies to cover these and other typical property insurance needs.

Efficiency loss represents an important operating cost, and can lead to significant operating impact—especially for more active usage profiles. These costs will also vary between technologies as the round trip efficiencies vary widely—flow batteries can achieve into the 80%

round-trip-efficiency (DC:DC), whereas lithium-ion systems routinely achieve 95-97% round trip efficiency (DC:DC). The round trip efficiency is critical as lower rates have higher operating costs due to losses. The other major impact is the local electric rate structure to determine the cost for charging the system. Typically, units behind-the-meter are expected to pay retail tariffs; wholesale projects typically can use wholesale prices for the energy losses due to efficiency losses, but the auxiliary loads may be metered at a separate retail rate—increasing the operating costs somewhat.

The maturity of the energy storage system will have a significant impact on the cost structure of the energy storage system. First, as the storage technology in question becomes more commercially mature, the scale of manufacturing will help reduce the capital cost of the unit. In addition to cost reductions from manufacturing scale up, there will also be cost reductions from design changes and technology improvements that will drive down the cost of the core energy storage module.

There are a number of other components of the energy storage system that will experience cost reductions as the commercial maturity of the system increases. The individual component that stands to experience the greatest cost reduction outside of the energy storage module is the inverter. Currently, energy storage inverter costs are substantially higher than for a comparable PV inverter, due primarily to a somewhat more complex and capable design, but primarily due to the lack of standard designs and low volume.

Another area of cost reduction would be better system integration, which would improve the overall handling of the system as the different components are proven out in a wider array of deployments, increasing the robustness of the overall design. Operation and maintenance costs can be reduced significantly as the design improves from experience. With greater experience, the MBTF (mean time between failure) grows, reducing planned and especially unplanned downtimes, with a typical reduction in parts replacement as more optimized equipment is specified to improve runtimes. As capital and operating costs decline, and the unit's lifespan grows due to a more reliable design, the LCOS improves, positioning the unit as a far more cost effective unit as you compare all-in life-cycle costs when evaluating storage technologies for potential project bids. Finally, a more mature system will typically also have a higher availability rating due to having all of the bugs worked out of integrating the different system components together, providing the owner of the unit more opportunity to generate value.

Finally as costs reduce due to a more mature and reproducible design, the financing cost will also come down. First, as the technology gains more commercial maturity, more lenders will become comfortable entering the energy storage market, reducing the lending costs successfully from allowing reproducibility and access to lower cost sources of capital. Another expected financing cost reduction will be any construction loans needed by the developer. As the system integration improves, so too will installation and commissioning capability – it will become easier and faster to install and commission energy storage systems.

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3. INSIGHTS & LESSONS LEARNED

One important goal of this Study is to highlight the current situation of project financing in the energy storage industry from the position of the market participants themselves. The investigation came through two paths of outreach:

2014 Energy Storage Financing Summit

Our first event of the Study was held on December 16, 2014, as 65 financial and energy industry leaders convened in New York City for a one day Summit to identify the risks and challenges of financing energy storage projects, and to determine a roadmap to accelerate the development of, and investment in, the energy storage industry. This Summit was jointly presented by the U.S. Department of Energy, Sutherland Asbill & Brennan LLP, Mustang Prairie Energy, and the Energy Storage Association at Sutherland's New York office in Manhattan.

The summit began with speakers from the U.S. Department of Energy. Peter Davidson, the Executive Director of the DOE Loan Programs Office, provided the first keynote address on how the federal government is supporting early deployments of innovative energy technologies, and how energy storage projects can benefit from the government's flexible approach. Imre Gyuk, the Program Manager of the U.S. Department of Energy's Energy Storage Program, gave an overview of federal support for energy storage technology development, and explained how that support is extending into the commercialization of these systems.

Alfred Griffin, the President of the NY Green Bank provided a second Keynote address on the activities in New York. His presentation showcased the efforts of the NY Green Bank in addressing current financing gaps and barriers for clean energy projects in New York State, and how that support can benefit energy storage projects.

The Summit contained two panels of industry leaders. The first panel of the day focused on underlying challenges to project financing, such as project bankability, insurance and operating experience, and discussed how these issues will shape the industry going forward. The second panel of the day focused on project financing structures and outcomes. The panelists reviewed current financing models and considered which ones would emerge in the future, and discussed whether lessons could be learned and adapted from the solar, wind and energy efficiency industries.

Interviews

The follow-on outreach effort of the Study was comprised of in-depth interviews with 70 industry leaders from across the energy storage, renewable energy, and financial community. These interviews were wide-ranging, with the focus varying depending upon the expertise of the interviewee. In general, we endeavored to obtain their insights along three avenues of questioning:

What is the state and availability of financing for energy storage projects? Here we were looking for insights into the expectations by both developers and lenders, and what milestones or developments need to happen prior to lenders getting more deeply involved in the market. Included in this would be any insights into what are the key attributes for the underlying contracts that would work best in the energy storage market.

What is your experience in similar markets and what can the energy storage industry learn? Here we were looking for insights into how the availability of financing was critical in building markets such as energy efficiency, wind, and solar. We were also interested in determining how the timing and structuring of the available financing helped shape the growth and makeup of the industry.

What role can the U.S. Department of Energy play to accelerate market growth? Here we were looking for insights into roles where the U.S. Department of Energy could leverage the growing level of private investment and activity to promote growth and maturing of the industry.

Risks

A clear theme of three potential and real risks concerning energy storage system deployment was evident throughout the interviews: technology risk, business risk, and credit risk. Overcoming each of these can bring significant additional cost to a project, so it is important to reduce their impact. Beyond their direct impact, we attempted to understand the current understanding of the study participants around these issues, and what factors would be critical in changing their perception, planning, and progress towards successful energy storage system deployments.

- ***Technology Risk*** is concerned with the level of sophistication of the technology—is it sufficiently mature enough to work as promised? Typically, manufacturers stand behind their products through providing a warranty on the product. Most manufacturers will provide a 1 to 2 year manufacturing defect warranty, although some have been extending that for many more years with the purchase of an extended warranty contract.

- ***Business Risk*** is concerned with the ability of a user of an energy storage system to operate it profitably—is there an actual need for people to buy these systems? This would of course cover the profitability of the system, but also takes into account its long-term performance, and the unit's durability and flexibility to remain profitably operating in the event of changing market conditions and market rules.

- ***Credit Risk*** is concerned with the financial health of the companies involved on provisioning the energy storage system to the customer—is there a risk of default by key groups? This type of risk typically is expressed in the higher costs for lending, insurance premiums or lack of financial flexibility given to smaller firms with lower reserves than larger firms able to essentially self-insure against any potential business risk interruption is necessary.

3.1. Technology Risk

The first area of concern for study participants was technology risk. Virtually all study participants believed that a small number of the energy storage technologies were sufficiently mature enough to begin commercial deployment in a limited number of applications. Their true concern was what was the rate of technical maturity and what will be the implication for improving the ability of proposed projects to be profitable with no governmental incentive support. Beyond the core energy storage technology, another concern was raise about the other key systems (power conversion, etc.) and the sophistication not only in integrating all these systems into a workable solution, but one that is flexible enough to operate in an evolving market such as the current opportunity for energy storage.

3.1.1. Product

Most of the interviewees believe that energy storage systems are technically mature enough to begin commercial deployment. Although there are over a dozen different energy storage technology types, predominately people are viewing the energy storage technology option as that of lithium-ion systems. They have also seen the cost of these technologies decline as 2nd and 3rd generation of systems have been deployed; these cost declines coming from either improvements in the basic technology, or through a more cost effective and efficient design to reduce the amount over overdesign inherent in 1st generation systems. However, it is the long-term quality of the storage technology and the surrounding balance of system still remaining that is a concern for many as they lack deep familiarity with the different technologies. A few noted that utilities who have conducted energy storage demonstration programs for the last few years are much more aware of potential product risks as compared to project developers' this later group is more familiar to the technical maturity level of the solar and wind systems they have been installing recently before turning recently to the energy storage market. Even among the more common lithium-ion batteries, it was noted that the capabilities and qualities varied greatly.

The growing deployment of systems and increasing length of operation is giving many developers confidence in an expanding market role of for energy storage. However, to ensure that the manufactures back their products, the quality and length of the manufacturing warranty is key. Typically the initial warranty is listed as 1 to 2 years with an extension available for purchase through 10-20 years, depending upon the technology. Most interviewees see the expansion of the warranty as a good litmus test as to the belief and ability of the battery vendors to back their own products. However, these warranties become increasingly complex if there is coverage of any operational activity (not just defect-free manufacturing). Until this clears, based on their experience with other emerging technologies, this remains an overhang of concern.

Beyond the core energy storage system, successful system integration of the battery to the AC electronics and the remainder of the balance of plant have become an area of—if not concern—then at least intense focus. Integrating the battery system with the inverter has been a primary area of development; typically this entails building a software library of control software to integrate with the battery management systems (BMS) to best use and protect the batteries during operation. This is a critical issue as each lithium-ion battery chemistry has a different optimal charging and discharging envelope, and without proper management and control, the storage system's operation can either be significantly degraded, or damage to the cells can occur. This has resulted in much more effort than originally envisioned, but it is important to get good performance out of the system. Leading system integrators must invest significant effort into developing these needed software interfaces, so it is not surprising that there is a diminishing return to these groups to continue to develop additional software interfaces for every individual battery provider. Some familiar with the situation expect that the leading battery providers will represent sufficient partnership opportunity to develop the needed software for them, while other, smaller providers will need to either invest in providing the interface software for the integrators, or be relegated to more standardized available software that may not perform to the same optimal level or degree. Most interviewees agree that as the industry matures, this knowledge will filter out to most providers, leading to this issue not being a long-term hurdle for OEMs as it may be now.

Proper system integration is critical for a variety of needs—including driving system operation and project availability. Primary concern among many of the interviewees of project risk was the interruption of operation, shortened lifespan of the equipment, and the impact on the warranty—since the industry is young, many interviewees see the experience level of the storage industry far behind that of solar and wind, and thus expect that warranties must continue to evolve in order to find a balance between operators and the battery vendor needs.

The key takeaway from many of the interviewees with knowledge of deploying energy storage projects is that is important to think of these systems as an integrated project/system. High quality and expensive battery systems can be rendered highly unusable if married with a poor quality inverter, or if other parts of the balance of system components were comprised of inferior parts. Early, high profile system failures of some early battery systems significantly increased the due diligence effort by developers, lenders, and insurers—improving the industry wide level of acceptable design reliability.

An emerging key player in the construction of effective energy storage systems is the EPC (engineering, procurement, and construction) firm, who in many cases is taking on a larger segment of the integration risk. For many larger projects, these groups (or others performing their role) are increasing being relied upon by less technically capable project developers to provide all of the technical due diligence of the various equipment vendors. Separate from this is the independent engineers review to provide a bankability study which encompasses not only the technical merits of the design, but also looks into the actual products used, and the financial health of all companies involved. The EPC's question at the end of the day is how much liability will they be exposed to or expected to assume long term.

3.1.2. Safety

Safety continues to be an area of interest and focus as larger developers with established activity in solar and wind market activity enter the industry. The U.S. Department of Energy has been active in promoting safety design and operation through its Strategic Plan for Energy Storage Safety which many in the industry and a number of interviewees participated. This Program is designed to prevent both injury and property loss through better design, operation, and measurement and verification efforts.

In conjunction with the U.S. Department of Energy Strategic Plan for Energy Storage Safety, significant effort has also been going on within standards bodies to establish design and operation safety standards for the industry. In particular, UL 9540–*Safety of Energy Storage Systems* is seen as a good step towards improving all potential energy storage deployments – although it was noted by some with more experience that many standards bodies are working on providing guidance and support for the energy storage industry, with UL considered a key Standards body for the industry. Many of the interviewees saw this as a critical step in maturing the industry. As of yet there have only been a few project failures that have only had property destruction, with only some insurance losses being attributable to liability of 3rd party damages, but as the projects become more widespread and larger in scale. These dangers are expected to grow as energy storage technology is placed in wider ranging and challenging environments.

3.1.3. Performance

The performance of the energy storage facility relies on a number of issues; chief among these is the overall design of the system. What is meant here is not the specific power/energy rating, but the degree of forethought put into the system's design to both provide flexibility, while balancing capability and cost effectiveness. Essentially this rests on the maturity and experience of the system designers. Higher quality equipment does cost more initially, but many customers are quickly understanding that poor performance—low efficiency, poor response time, etc.—can quickly impact the long-term operating cost and revenue generating potential of the unit. Properly selected equipment also reduces the system integration risk of the different components, potentially leading to lower availability during operation.

Many of these issues point to another aspect of design preference and tradeoff. Some project developers highlight the need for a completely integrated system that they can purchase, install, and operate over the design life without the need for extensive maintenance or equipment replacement. Others point to the need for a system design that expects to have equipment replaced over the lifespan of the project. Both approaches have merit—depending upon the business model approach followed. For example, the first design is crafted to embed all capital costs up-front and operate only within a pre-determined envelope over the unit's life which can be well suited for price-sensitive deployments with an easily defined usage profile. The later relies on more flexible approach to capital costs and applications over the unit's life. By assuming that key components such as battery modules will be replaced over time, the system designer does not have to build in all components of the system into the initial deployment—they can plan to replace components—primarily batteries—over time, taking into account declining costs to lower the overall total cost of ownership. Besides the battery, other components can be replaced as the need arises, depending upon the usage profile. For instance, inverters connected to energy storage systems are expected to have a shorter lifespan than a solar inverter due to the more active nature of the energy storage facility, but are still generally thought to be able to last 10 years or more without replacement or major retrofit.

The design of the system also has also been noted to significantly impact the operation and maintenance costs. For instance, regular monitoring and a preventive maintenance schedule can increase system availability, but also increases cost. These preventive maintenance programs are typically included in maintenance programs. Also, many battery chemistries suffer some type of degradation upon deep or full discharge cycles or operating at high temperature. Therefore, if the energy storage system can be discharged to a level short of that, the batteries will last longer, and they will produce less heat, improving the lifespan of other battery system components.

Installation and commissioning was mentioned by a number of developers as an area of concern as how the units are installed will have long-term impacts. The actual installation process contained a variety of risks needed to be address, requiring front end engineering and design (need of a Professional Engineer to approved set of plans, structural review, etc.) Permitting itself was mentioned as aspect not be overlooked or taken lightly by developers of behind-the-meter projects. Due to the immature nature of the market, there is a wide range of permitting costs (hundreds to thousands of dollars) for the same simple commercial system in different jurisdictions, and area specific ordinances covering energy storage. Ordinances in particular are expected to remain fluid between jurisdiction until the 2017 edition of the National Electrical Code© is released and adopted as this will contain a number of updates covering energy storage technologies and should help provide guidance to local authorities.

3.2. Business Risk

The second area of concern for study participants was business risk. Many of the discussions dealt with the evolving nature of the market, and the challenge of developing a business model flexible enough to evolve with the changes while delivering highly profitable returns. Beyond the exercise of developing hokey-stick sales projections, most market participants focused their effort on the underlying drivers defining the market, and how the company's growth strategy was positioned for potential changes. A few groups with experience dealing with early stage firms also mentioned their concern about measuring the ability of management to execute on the business plan in such a fluid situation where the business plan itself may be evolving.

3.2.1. Market Design

Designing the scale, structure and direction of the market where the energy storage facility operates is the first step. Market rules are critical to define the value of the asset. In the formal wholesale markets (ISOs/RTOs), this has been so far primarily limited to frequency regulation services, but capacity and flexible ramping products are being seen as future next roles. A key business model risk acknowledged by many will be the duration criteria of these services; here, differing technologies with varying duration capacity all have their own market "sweet-spot"—where developers can use an energy storage technology's cost structure for a specific power/energy design could give it an inherent advantage. Groups active behind the meter also acknowledge the importance of the tariff structure and existing demand charges have on the ability for success in the commercial market. On the opposite end of the market spectrum from the formal markets is the remote island market. Here, technical problems outweigh the needs of any market inefficiencies.

3.2.2. Incentives

After the market structure, any existing incentive or other governmental support was listed as a key next step in determining a successful energy storage project development strategy. Many interviewees with experience in the solar market see federal tax benefits a key first step to propel the early years of growth in the energy storage industry. Federal tax benefits include both an Investment Tax Credit (ITC) directly for energy storage projects, and accelerated depreciation (MACRS). It cannot be understated the strong desire by virtually all study participants for a straight energy storage ITC, after the experience of many trying to integrate an energy storage project under the highly limited solar ITC provisions for energy storage assets. Mandates are another source of governmental support—although there has been some effort at the Federal level, most interest was for state-level efforts. Finally, State level incentive payments for deployed systems were noted as a major determination as to making the project economic, with most of this interest focused on the behind the meter deployments. In all cases, the most common request was for government officials to make the incentive structure as simple as possible to enhance the flexibility for designing the project.

3.2.3. Strategy

Determining the “correct” strategy to follow in a market changing as quickly as the energy storage market is difficult, and some have suggested that a series of short term goals will be their company’s path forward until they have sufficient real operating experience. Most freely admit to a lack of this experience, with some viewing this as a benefit as the recent energy storage market has been dominated by immature technologies wholly dependent upon governmental support. To build sustainable business model utilizing energy storage systems their underlying principal is that “we’re going to be doing things differently”. What many of the new project developer entrants did mention was that they probably have even more relevant experience in technical due diligence with proven solar, wind, and energy efficiency systems, which they plan to capitalize on in the energy storage market.

In such a customer acquisition market where sometimes there are more unknowns than knowns, most developers expressed their strong belief in the value of contracts as they showcase what people are really willing to put their money behind. Beyond making the revenue reliable for project economics, contracts also play an important role in providing transparency to various counter-parties for the developers. For instance, the cost and strength for warranties and performance guarantees allows the developer to gauge the belief of technology vendors in their own products; contracts with customers can showcase the true value of potential savings for behind-the-meter peak shaving projects. Another important price-point comparison many study participants brought up was the cost of alternatives which can provide a good hurdle rate for business models. Unfortunately, here too finding exact alternatives for energy storage is difficult. For some roles such as arbitrage, replacement products and services are easy to find and price. However, for many opportunities that groups are trying to apply energy storage systems, an exact match is difficult if not impossible to find. This typically stems from the energy storage asset only being applied to a portion of an alternative’s role, and thus the need to segregate out the structural vs. marginal cost of the alternative service provider to compare to the cost of storage.

Which market to prioritize and what are you going to sell depends on a variety of factors. Key to all markets though, is knowing what type of product or service is needed. For instance, in the frequency regulation market, the capacity to provide regulation is a service, and obtaining a stand-alone frequency regulation PPA is so-far non-existent—hence this market is primarily provided by merchant developers able to hold the asset on their books.

In the utility market, the need for definable market specifications is emerging. In July of 2015, Southern California Edison issued an RFP for “pre-engineered” energy storage systems ranging from 1 MWh to 16 MWh that could be built, shipped, and installed within 7 months of being contracted. Product vendors have stated previously that if leading utility’s such as SCE begin to buy energy storage assets in larger quantities with standardized designs, then these building block systems will become the de-facto standard products that other utilities will also begin to buy, and the vendor will be able to drive down the cost of the unit in earnest knowing that greater sales will follow. Selling into the behind-the-meter market typically has a different economic case, and thus the approach to customers will be different. Typically—especially for the commercial market—the primary goal of utilizing energy storage systems is to reduce the business’ cost of service through targeting demand charges reduction.

3.2.4. Project Economics

Determining if a proposed energy storage project will be profitable requires understanding the underlying and changing market conditions driving profitability. Many survey participants believed there was still significant uncertainty in these fundamentals, but that they were moving in the direction towards clarity and that experience was necessary to be able to fully achieve success when the market begins to expand quickly.

3.2.4.1. Revenue

Project revenue is obviously the first area of concern for the study participants. Many contended that for most projects, there was no long-term clear and reliable price signal; even in areas where the price signal existed (for example, frequency regulation), volatility and regional variations made scaling the business in a reliable fashion to support contract revenue is difficult, leaving the existing opportunity easily captured by only a few companies. For many lenders, this was obviously a problem because they wanted to see a compelling and stable revenue opportunity before evaluating a potential project pipeline further.

Secondly, not all value streams developed by energy storage assets are ever fully monetized as there is currently no contract for most applications. Even those with real revenue potential like frequency regulation are still essentially a merchant play for the developer. Many understand that outside of unique circumstances, multiple revenue streams will be required to successfully develop a project, but many times these different revenue streams compete and are not able to be pursued at the same time. Some also noted that the details of the contract matter quite a great deal, for instance as to the availability of the system to provide services to multiple parties, and any capacity restrictions in the contract. Other questions governed by the contracts exist such as what is the price escalation that is built into the contract? How certain is the developer that will cover any potential cost increases in the future?

Another value stream possible from energy storage systems behind-the-meter is the cost saving aspect from a peak shaving / demand management strategy. Although there was some acknowledgement in pursuing the demand charge reduction opportunity directly, many others expected this type of market activity could also be undertaken by energy efficiency firms utilizing energy storage assets as a physical backstop to their controls based strategy to minimize usage during high cost periods. If both groups (energy storage and energy efficiency) competed for the same role, then many times it would be other factors such as access to a wider potential customer base, existing contracts and insurance, and access to lending institutions that would determine which group had the advantage in securing more clients.

3.2.4.2. Cost

Costs were another area of obvious focus for study participants; here, most felt they had at least a passible handle on the relative cost level and structure of the batteries themselves—they were more concerned with making sure all the other components of the "all-in" costs were identified and reasonable value was available.

Administrative costs were mentioned as an area of focus as many developers are looking at developing a larger number of small storage assets, and thus a lower cost project replicability was vital. Therefore, beyond obtaining a low cost for any of the equipment, developing the ability to use substantially the same material for legal, engineering, logistical line-items were highlighted in order to drive down costs of these services through repeated usage. If one or more of these cost areas were found to be difficult to replicate at a consistently cost-effective level, then possible changes to the business plan were mentioned to reduce the volatility of costs for a certain customer class or region. This thinking also extended to operating costs such as the cost of electricity for charging the system. Here, the existing customer tariff structure was mentioned, plus any possible changes to it either through the ongoing evolution of rate-design by utilities, or—as a few participants mentioned—whether the act of installing an energy storage system would trigger a tariff change for the customer and possible negate the possible savings from utilizing the energy storage system.

As mentioned earlier, costs were not mentioned so much as a series of discrete issues, but rather as part of an integrate framework. Increasingly, LCOS is being used for both aggregating all of the costs into one number, but also utilizing that framework to understand the competitive nature of different designs or chemistries when applied to different use cases. This lasts part is important—energy storage systems have a discrete power rating and energy storage capacity, and thus the cost of a system designed for one application will be different than a system utilizing the same energy storage technology, but designed for a different set of applications. This is a critical difference in comparing an energy storage technology vs. an electric generation technology's LCOE (Levelized Cost of Energy) which typically assumes a significantly longer run-time, thus achieving a lower per-unit output cost structure. Other important issues for dealing with an LCOS calculation deals with simply including all the relative capital costs, and any impact on long-term costs driven by the choice in operating mode (fast, deep charge/discharge cycling will suffer from lower round trip efficiencies and shorter lifespans, for example), and or impact on system availability (based on maintenance program).

Designing the system for a Usable Energy framework also has an impact for capital cost as to the best approach for oversizing the system. During use, virtually all energy storage technologies loose some small bit of energy capacity on each cycle (fade). Also for most energy storage technologies, the deeper the discharge is assumed, the shorter the lifespan of the unit. Therefore, even if an energy storage system is listed as having 1MWh of capacity, you may only be able to use 80% of that (or less) on each cycle to hit a rated cycle life.

The Usable Energy concept starts with the idea that if a customer buys an energy storage system rated at 1MWh of energy storage capacity, they want to be able to use 1MWh each cycle during the life of the unit. The study participants in general agreed that such a customer-centric framework is the future direction of the market. In order to achieve this, then, the energy storage unit will need to be oversized (on a kWh basis) to varying degrees for each technology based on parameters unique to each technology. This oversizing could be done at the outset, or more cost effectively done with the replacement batteries during the life of the system. In general, many of the energy storage industry survey participants with significant design experience are already proponents of the usable energy framework. The energy storage OEMs least interested in the usable energy framework were a few battery manufacturers who are focused on primarily delivering products and not integrated solutions. Unsurprisingly, since the usable energy framework is more customer-centric, most of the financial industry and renewable industry survey participants appreciated the concept, and planned to work toward incorporating it further into their planning process. However, some then mentioned that this requires having a better understanding of the different degradation cures and their impact on the key performance metrics of the energy storage system.

3.3. Credit Risk

The final area of concern for study participants was credit risk. A general definition of credit risk is the risk of default on a debt that may arise from a borrower failing to make required payments. Depending upon the level of default, this could include (for the lender) the disruption of cash flow, loss of interest, or even loss of principal.

Groups on both sides of credit risk—lenders and developers—had a number of concerns on this central issue. Lenders are concerned with evaluating all of the risks properly when even those with some experience in energy storage recognize that it is a fluid market and firm is still a relative term. In particular, lenders are concerned with not knowing all of the other counterparty and network risks the project is exposed to. For these reasons, credit is always hesitantly extended to new borrowers, and only after building trust will lender provide better terms. Project developers, on the other hand, are concerned with how this will impact their ability to do business, as lack of credit availability is generally limiting for small, less will capitalized firms, and provides a competitive advantage for larger firms with access to far more capital.

A common theme on both sides was that there did not seem to be a clear-cut means to gauge their risk exposure from an energy storage project. Both groups were aware that a significant amount of activity was not in their control (for instance, partner bankability), and thus there are definite questions as to what is the proper way to price this risk, and are there steps that could be taken to address this—and who is ultimately responsible?

An answer to these and other credit related questions will not be easy, as survey participants on both sides agree that there is significant work remaining to be accomplished both in crafting workable solutions for those in the market now, in the future as the market continues to evolve. Bankability studies have proven very effective in the solar market to help lenders obtain a 3rd party review of the project, allaying many of the concerns about issues out of their area of expertise; these are quickly being provided by engineering firms for a market such as energy storage where there is arguably more of a need for such support. The availability and coverage level of insurance for the project has also been rising in importance as it is becoming required by lenders as part of expected contracts.

3.3.1. Lenders

Energy storage is a potentially appealing market for lenders—especially for those active in the wind, solar, and energy efficiency market. However, lenders see the energy storage market as a challenging opportunity and they are not willing to compromise their existing portfolio to simply get into the market. To properly analyze the risk for a particular energy storage project, they have to take into account not just the project risk, but all other financing engagements the OEM and developer have. Although a number of lenders have become active funding projects with a few developers, no lender has a significant lead in experience in the energy storage market, and all lenders surveyed mentioned the difficulty staying up to days on all of financial incentives, ongoing changes in technology, market rules, and policy.

Lenders experienced with other project markets—wind, solar, energy efficiency—expect to follow a similar script as they become more deeply involved with energy storage projects—especially as they acknowledge a lack of knowledge in this market. Although they may be currently lacking in deep contextual knowledge of the energy storage market, they know how to structure successful project loans in markets that are in transition. Building off of that proven process, and as they gain insight and proficiency from that experience, lenders plan to refine and modify the process to better suit energy storage projects. One thing lenders have learned in these other markets is that when evaluating storage projects, it is not just the project, but the OEM and its supplier network, and drivers for the project's economics that need to be evaluated. To address the needs of the energy storage market, lenders need a lot more data, and experience to improve to process.

Lenders recognize that they need much more data about energy storage technologies and how they operate to properly evaluate the project; because of their interactive nature these systems are far more complicated than existing renewable energy projects. One problem recognized early on is that before you start collecting data randomly, you need to know what kind of data is important, and what type is important for the different markets. This is doubly important as that the amount of actual operational data available is still small relative to other project classes, due to the early stage nature of the storage market with its variable revenue streams and few and potentially possibly weak contracts. Lenders surveyed recognized their need for continued education on the evolving energy storage technologies, relevant policy, and pertinent market rules. In particular, beyond the facts, lenders expressed an interest in understanding the direction and momentum in the market. Through combining these analyses, lenders are hoping to develop more defensible estimates for energy storage project cash flows so they can stress test the stability of repayment under a variety of scenarios.

Lacking sufficient experience from the storage market, lenders are evaluating their experience in other markets to ascertain when lessons learned they could apply from other markets. For instance, if it's too early for me to provide standardized energy storage financing, are there any rules of thumb that could apply as I gain experience? How far will the solar, wind, energy efficiency models go?

Lenders do have some hard won lessons learned from these other markets. Project financing does not exist in a vacuum – lender must understand how this financing fits in with all stages of financing not just for the project, but the ecosystem in which it lives—the OEM, the project developer, and the project financing of other projects. One lender suggested that the collateral value of the energy storage assets will not be given much weight currently; the market is too early and there is not a sufficiently deep and liquid secondary market for battery systems to dispose of the equipment without significant effort. This could potentially cause scarce cash reserves to be needed to be posted as collateral, along with high equity requirements for early stage project developers.

Although much interest is always placed on what lenders charge, the answer is typically "it depends" and significantly so for early stage markets like energy storage. A variety of components go into establishing the risk profile of an energy storage project: the technology, the developer, and increasingly the legal support needed. Lenders recognize that they do not always have all of the answers, so in order to make sure their clients do, they are increasingly stressing that developers have access to the legal expertise needed to demonstrate a firm understanding of regulatory requirements, interconnection procedures, and customer contracts before lenders will provide funding.

3.3.2. Corporate

Project developers are concerned with how credit risk will impact their ability to put together projects. Many developers feel that small firms with little access to capital worry about being the most constrained, while some with ample credit look for ways to take advantage of that while the market is forming. Piecing together a project can always be a challenge, and the access to capital puts an added strain on this already difficult task. Study participants highlighted the significant up-front costs required for project development: feasibility studies, permitting, interconnection studies, and deposits on equipment and technology. Project participants frequently identified bridge financing as the most difficult type of financing to secure, even though a project qualifies for incentive payments—but only at the end commissioning. Permitting and regulations were singled out for particular emphasis as these tended to vary greatly between jurisdictions, and could be significant on smaller projects.

Many developers see extremely high hurdles to successfully financing an energy storage project. Some small technology providers have met lenders who view financing projects based on their technology (non-lithium –ion) essentially as an equity investor—with the results that any funds offered looks a lot like venture debt. Except for the largest developers, equity requirements were reported to be high, with lenders looking most favorable on borrowers with ample alternative capital resources. Many developers mentioned that these high equity contribution requirements kill projects. Small developers highlighted that they did not have sufficiency funds to do multiple projects this way without an outside firm providing the capital.

Developers related that proving reliability of equipment and technology is critical for lenders. Simply providing banks with testing data is usually inadequate to prove reliability, developers need to show value. Many developers recall the standard line from lenders that they're interested in funding the 4th or 5th project. There are many types of energy storage technologies, each at different level of maturity. Some of these technologies—such as lithium ion batteries—are relatively mature, whereas others still have significant advancement requirements. Experience in both technical and project development was mentioned by developers as key to demonstrate to lenders, or proved they have access to others to successfully permit, construct, and operate the energy storage project.

3.3.3. Bankability

Time and again, study participants stressed the need for bankability studies to ensure financeability of an energy storage project. Bankability studies are widely used in the solar PV industry, and provide a 3rd party project risk assessment to determine if the equipment will perform as predicted by the manufacturer over the project life. However, a bankability study is more than just an engineering equipment report, they are a process to understand the potential risks, and set in place the knowledge on how to deal with them. These studies can provide a full due diligence study on all aspects of the system to provide an independent technical assessment for the client. This includes the design and manufacturing process, the company's supply chain, the design and performance of the asset, its reliability and durability, and the installation operation, and maintenance procedures for the firm all to ensure the security of cash flow from the project.

The bankability study will also contain an evaluation of the technology vendor to ascertain default risks if needed. Many study participants believed that through these deeper dives into the supply chain, the bankability study can provide a deeper insight into potential additional projects undertaken by the developer—have they developed a robust enough set of internal controls to ensure that the project developer will be able to consistently develop high quality systems? This last part is crucial as when unexpected problems arise—and they always arise—especially in nascent markets like energy storage. Lenders want to know there is capability to fix the problem, or that there are capable companies standing behind the product or workmanship.

Bankability studies are important for both lenders and manufacturers. For the lenders and other financial firm interested in participating in energy storage projects, the rapid advancement in the technology has left limited standards to assess equipment performance and reliability. As the industry expands, the challenge for lenders grows, as the number of global manufacturers active in the market grows, each with a possible divers supply chain. For manufacturers, bankability studies act as an impartial technical evaluator who has had experience with other OEM firms in the market, the study can help the firm incorporate industry best-practices by identify gaps in the manufacturer's product design, reliability, manufacturing and installation and maintenance. They can also provide deeper visibility into the value chain for the lending community. Other groups can also benefit from bankability studies—particularly EPC (Engineering, Procurement, and Construction) firms who are increasingly being called upon to provide some level of performance insurance on the project.

3.3.4. Insurance

Insurance policies are increasingly important to the energy storage industry, and as the industry scales in both number and size of projects, many study participants believed the underlying requirements will impact storage. Project developers highlighted that typical project insurance (property, etc.) is increasingly available from different providers, but the variability in offers highlights the insurance industry's lack of experience with energy storage technology and market opportunities in general. Operation related insurance (default, business interruption) also was greatly impacted by the level of knowledge by the provider, with some study participants relating the hesitancy of insurers to get too involved with operational impacts without getting to know the market better. Performance insurance is increasingly being required to backstop the performance guarantee however, as the pool of providers for performance insurance is currently small with a large variability in offers.

The experience of insurers in the energy efficiency market highlights lender behavior, where according to an experienced insurer uncertainty kills 25% of all efficiency projects annually. Since the energy storage industry is far less structured and mature than the energy efficiency market, we can safely say that the number of energy storage projects killed annually from uncertainty is far higher.

Unfortunately, the lack of experience in the energy storage industry will not radically shift in the next few years simply due to the small number of projects. However, this is far more than what had been happening, and study participants felt that the insurance industry was on a strong learning curve that will help deepen the knowledge base. This is important, as there is no such thing as “energy storage” insurance. The degree to which these policies fit the energy storage project is based on the insurers knowing how to design an insurance policy tailored for an energy storage project operating in the power sector.

4. ROADMAP TO ACCELERATE MARKET GROWTH

The U.S. Department of Energy has been a critical catalyst in the early development of the energy storage industry; its opportunity now is to help establish a robust, sustainable, and competitive commercial market. What is lacking is not the further development of the technology or market applications, but enabling the financial industry to better understand the risks involved in energy storage project development, and help developers access cost effective capital to accelerate market growth sustainably.

The U.S. Department of Energy is uniquely positioned to drive this development. It is already trusted to provide the fundamental understanding of the technology and market applications. What is needed now are metrics and benchmarks grounded in this understanding to better judge and price the risk in systematic ways. Through these tools, the U.S. Department of Energy can expand access to capital by reducing the barriers to entry for new lenders.

The first part of this strategy is to coordinate a number of areas where the U.S. Department of Energy is already active and plays a key role, and extend these efforts to improve the environment for project development. These include:

- **Data & Analysis**: collecting, analyzing, and disseminating technical and economic information about energy storage technologies and projects.
- **Safety & Standards:** ensuring a safe design and operating environment for energy storage systems.
- **Demonstration Projects**: leveraging prior experience and outside support to showcase new commercial roles for energy storage systems.
- **Innovative Project Financing:** providing support to grow and deepen the financial industry's engagement with the energy storage industry.

The second part of this strategy builds on these existing efforts to to assist the financial industry in understanding the potential risks involved in energy storage project development, develop analytical framework to price that risk, and means to accommodate that risk through insurance and contracts. These include:

- **Performance Ratings:** support a broader effort to develop application specific performance metrics to allow the scoring based on the capability of different systems for commercial contracts.
- **Performance Guarantee:** enable a means for the performance ratings to be incorporated into operational contracts, and develop a means to allow energy storage OEMs to purchase cost effective insurance to they can provide performance guarantees in the market.
- **Energy Service Performance Contracts:** standardized, financeable contract tailored for Behind-the-Meter energy storage projects to enable "storage as a service".

4.1. Data & Analysis

The U.S. Department of Energy is uniquely positioned to provide objective, comprehensive, and reliable data and analysis for the energy storage industry. All survey participants stressed the need for more and better data to evaluate opportunities and gauge risk. The U.S. Department of Energy was universally singled out as the best and most trusted provider for the most fundamental data on energy storage technologies. As the industry moves into commercialization, private industry is looking to the U.S. Department of Energy to extend and enhance its analytical capabilities to also provide leadership in developing methods for reliably and fairly analyzing the different technical options, and supporting the establishment of industry standard operational cost, capability, and performance analysis.

4.1.1. Technical Reports

For many years, the U.S. Department of Energy has supported the production of technical reports covering technology, market analysis, and applications defining the energy storage market. These reports provide the public basis for technological description, capability, and usability in the industry, which is an essential role that the U.S. Department of Energy must continue to play as there is no other entity that industry participants have stated very clearly they will trust in this role.

The U.S. Department of Energy's Energy Storage Program publishes reports through a number of the National Laboratories. These include; Sandia National Laboratories (SNL), Pacific Northwest National Laboratory (PNNL), Oak Ridge National Laboratory (ORNL), and Lawrence Berkeley Laboratory (LBL). Each of these National Laboratories has specific areas of expertise, relating to energy storage. However, in addition to the individual reports published by the individual labs, the U.S. Department of Energy's and others have issued a number of reports viewed and mentioned widely by a number of study participants as essential. These include:

- **Grid Energy Storage Report**[16]
  This report is an overview of issues and challenges facing the energy storage industry, and how the U.S. Department of Energy is addressing them.

- **DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA**[17]
  This report is a how-to guide for utility and rural cooperative engineers, planners, and decision makers to plan and implement energy storage projects.

- **Quadrennial Technical Review**[18]
  This report examines the most promising research, development, demonstration, and deployment (RDD&D) opportunities across energy technologies to effectively address the nation's energy needs.

These reports are a crucial synthesis of industry knowledge, and provide a framework for technological and analysis programs concerning energy storage deployments. They are widely regarded by market participants as essential and an unbiased resource for groups looking to support the development of energy storage projects. Groups from across the industry continue to look to the U.S. Depart of Energy to continue providing this essential information.

4.1.2. Global Energy Storage Database

The U.S. Department of Energy Global Energy Storage Database[19] provides free, up-to-date information on grid-connected energy storage projects worldwide. Users can search the database by using a host of attributes, including region, technology, service territory, benefit stream, and other project statistics. As the database has grown, data visualization tools have been added to help users analyze the data. Competing project database offerings exist from different consulting firms, but the Global Energy Storage Database remains the most widely available resource to the public.

The U.S. Department of Energy's planned path forward for the Global Energy Storage Database is to continue to expand the number of projects included, deepen the level of information available on each project, and add additional analysis capabilities to make the database more usable and effective. Through this continuing effort, the Global Energy Storage Database will maintain its status as the primary basis for the analysis of energy storage projects.

Many survey participants stated it is critical for the continual expansion and development of the Global Energy Storage Database. As the industry matures, decision making is increasingly being based on the growing body of real-world knowledge that stems from the Global Energy Storage Database, not just estimates. Cost and performance benchmarking of existing projects—and their improving capability over time—will be the basis to provide lenders the confidence in to extend more and cost effective capital to this growing market.

4.1.3. Equipment Testing & Validation

The U.S. Department of Energy has a key role to play in both providing an easily accessible and comprehensive testing facility for energy storage systems, and in driving the harmonization and standardization of testing procedures to ensure comparable results.

Performance testing and validating of energy storage equipment is a fundamental step in the deployment of any piece of electrical equipment. Testing is a key part of the certification process, and it is critical for the safe and reliable interconnection and operation of energy storage systems. Energy storage equipment manufacturers typically have some testing capability in-house—both for product development and for pre-shipment verification—but many typically lack a testing facility capable of evaluating the energy storage unit at all component levels (cell, module, and system) and across all possible applications and operating environments due to the prohibitive costs of maintaining such a facility. Increasingly, it is this complete systems level testing that is gaining importance, both in the capability to do it, and to do it properly so as to replicate the full range of conditions that an energy storage system could be operated.

Many manufactures utilize 3rd party testing facilities to evaluate their equipment; not only does this typically save them significant costs, but it provides independent performance testing and validation results to provide to customers. The U.S. Department of Energy has long provided this capability to the industry at Sandia National Labs, and will continue to maintain and enhanced the testbed as needed by the industry. This need comes not just from OEMs as they develop new products, but project developers and financial groups needed a 3rd party validation of system's performance levels in order to ensure a bankable project.

As activity in the industry increases, the U.S. Department of Energy's role will also include ensuring the standardization of testing and validation procedures for private 3rd party's also providing test and validation services. The U.S. Department of Energy has led in this effort for years through such efforts as the report *Protocols for Uniformly Measuring and Expressing the Performance of Energy Storage Systems*[20]. The U.S. Department of Industry also provides assistance with standards bodies such as the IEEE as they develop standards for testing such as *IEEE P2030.3—Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications.* Those in the industry familiar with this component of the industry highlight the critical nature of maintaining harmony across all testing and verification efforts so that performance can be readily compared.

4.1.4. Project Analytics

One of the greatest new areas many industry participants suggest for the U.S. Department of Energy to contribute is the development of better analytical tools for energy storage project development analysis. The lending community in particular noted that when evaluating a project they are left many times having to evaluate difficult project models from developers as many do not typically support the modeling capability to fully capture the dynamic capabilities of energy storage systems. Although there was no stated implication of distrust in these models, the lenders nevertheless stated that they would prefer to have some type of standard, 3rd-party modeling framework to provide a check when analyzing the performance of energy storage systems.

Some cited the System Advisor Model (SAM) as an example of how the U.S. Department of Energy provides this capability for solar and wind projects. The System Advisor Model "makes performance predictions and cost of energy estimates for grid-connected power projects based on installation and operating costs and system design parameters that you specify as inputs to the model." To date, SAM has begun to incorporate energy storage assets within a renewable project, but not as a stand-alone wholesale asset.

Although some mentioned it might be possible to extend SAM to cover energy storage projects, many others with a deeper level of knowledge modeling energy storage projects mentioned that any proposed energy storage model needs to incorporate all of the dynamic performance capabilities of the different energy storage technologies in order to apply them supporting market applications at different levels of the electrical power system. That level of knowledge calls for the core analytical engine to be done in conjunction with the U.S. Department of Energy Storage program.

4.2. Safety & Standards

The U.S. Department of Energy was consistently mentioned by survey participants as the trusted actor to ensure the continued safe and effective design, manufacture, and operation of energy storage technologies and related systems. It was felt by many that these issues—although not normally prominent when discussing financing challenges—were fundamental to having energy storage projects be established as bankable assets.

4.2.1. Safety

The U.S. Department of Energy has been active in promoting the safe design, manufacturing, and operation of energy storage systems Strategic Plan for Energy Storage Safety (see *DOE Energy Storage Safety Strategic Plan*[21]) which many in the industry and a number of interviewees participated. This Program is designed to prevent both injury and property loss through better design, operation, and measurement and verification efforts.

Going forward, many simply desire the U.S. Department of Energy to continue executing on the U.S. Department of Energy Strategic Plan for Energy Storage Safety. In addition, the U.S. Department of Energy can extend its influence and impact by working with Standards groups in the development and promotion of safety issues into industry accepted standards such as the recently issued UL 9540–*Safety of Energy Storage Systems*.

4.2.1. Codes, Standards, & Regulations

The U.S. Department of Energy has long been a driving force in the development of Codes, Standards, and Regulation concerning the safe design, installation, and operation of energy storage technologies and system. These frameworks are essential for enabling the ease of integrating energy storage systems into existing power installations, and the interoperability of the subsystems and the overall system into the wider electric power network. CSRs also benefit manufacturers of complete systems and those that are responsible for assembling complete systems on site as they will be easier to site and commission. Going forward, many in the industry see the U.S. Department of Energy's role as maintaining a systematic standardization in development of these relevant guidelines as adherence by developers is a prerequisite when developing bankable energy storage projects.

4.3. Demonstration Projects

The energy storage industry is still in need of demonstration projects—not to prove that energy storage systems work, but to showcase the expanding ability of the different technologies to solve customer and market challenges.

Demonstration projects remain an essential component for propelling the energy storage market forward. Demonstration projects are still critical to highlight for lenders the significant market roles storage can successfully perform. The U.S. Department of Energy has played a key role for many years supporting energy storage demonstration projects, and it is important that the Department of Energy continues to support projects that are being conceived and designed to showcase these expanding roles.

Historically, as the energy storage industry has developed, the industry has been able to rely on the U.S. Department of Energy as the key financial and technical supporter for deploying energy storage projects. As the initial supporter of these early projects, the U.S. Department of Energy funded a large component of the project cost, which sometimes also included significant technology development or site-specific engineering work. As the energy storage industry has grown and matured, the U.S. Department of Energy has not had to provide as much financial and other support to drive the market forward. However, when showcasing new roles for even existing technologies, the U.S. Department of Energy can still act as a catalyst to initiate or sustain momentum in projects. An emerging role for the U.S. Department of Energy in this regard is to leverage its existing capability to provide project analysis or other in-kind support that is not available from any other source, and if need be, some limited financial support. In this way, local, and State governments can shoulder the majority of the cost for the project, but it benefits from the U.S. Department of Energy's deep capabilities and knowledge to support standardized monitoring and analysis, so that the results of these projects could be evaluated in a systematic way and compared with other projects to highlight the project. As we've seen, this data gathering and analysis role is crucial to the industry to provide a common set of performance metrics and testing procedures.

4.3.1. Examples—Market Applications

Through its ongoing work to showcase increasingly mature energy storage technologies in a number of market applications, including Frequency Regulation, Renewable Integration, and Resiliency.

4.3.1.1. Frequency Regulation

- **Beacon Power: Stephentown, NY:** The U.S. Department of Energy provided a $43 million loan guarantee (1705 Program) for Beacon Power's Stephentown, NY facility in 2011. This project demonstrated the use of flywheel energy storage to provide frequency regulation services in the NY ISO market. This plant has widely been highlighted as providing the basis for FERC to establish Pay for Play performance in FERC Order No. 755.

- **Duke Energy/Younicos (d.b.a. Xtreme Power**): Notrees, TX: The US Department of Energy provided a $22 million grant as part of the American Recovery and Reinvestment Act in 2013. This plant showcased remote operation, ramp control, smoothing, and frequency regulation in the ERCOT market, and was seen as providing a crucial pilot for EROCT in establishing Pay-for-Performance rate-making.

4.3.1.2. Renewable Integration

- **Southern California Edison/LG Chem: Tehachapai, CA**: The U.S. Department of Energy provided matching funds for the $50 million Southern California Edison/LG Chem facility. The 8MW/32MWh facility is designed for wind integration services at Tehachapi, CA. The facility was commissioned in 2014, and ABB was the integrator for the plant. The original energy storage technology provider was A123 Systems.

- **Public Service of New Mexico/East Penn Manufacturing:** Albuquerque, New Mexico: The PNM Prosperity Energy Storage Project was commissioned in 2011, and is composed of two elements: a 0.5MW Smoothing Battery utilizing Ultra Batteries and a 0.25MW/0.99MWhr Peak Shifting Battery utilizing Advanced Lead Acid Batteries, to create a firm, dispatchable, renewable generation resource that provides simultaneous voltage smoothing and peak shifting.

4.3.1.3. Resiliency

- **Washington State Clean Energy Fund:** The U.S. Department of Energy is providing funding and technical support for two key deployment programs. Both facilities will utilize UniEnergy Technology's (UET) vanadium, flow battery technology, matching funds for 2 projects: Snohomish PUD (2MW/6.4MWh) and Avista (1MW/3.2MWh). PNNL will be participating and providing siting analysis, benefit optimization and system testing.

4.3.2. Example—Stafford Hill Solar Farm

The Stafford Hill Solar Farm project in Rutland Vermont is a good example of the future type of demonstration project being supported by the U.S. Department of Energy—leveraging the investment of other groups to showcase new operating roles for energy storage. This solar plus storage project is designed to promote the integration of renewable energy into the grid by providing power and grid services to Green Mountain Power, and also support the adjacent emergency shelter at the Rutland High School. The project consists of 2.5MW of solar PV, 4MWh of battery capacity (lithium-ion and lead acid), and 2MW of inverters. The energy storage capacity is divided equally among the four Dynapower inverters that manage the output of the solar power to the grid, and allow for islanding of the emergency shelter so it can run independently in the event of local power outages. This program is also designed to help define how utilities value resiliency.

The U.S. Department of Energy's Electrical Energy Storage Demonstration Program worked in conjunction with the Vermont DPS Clean Energy Development Fund and the Energy Storage

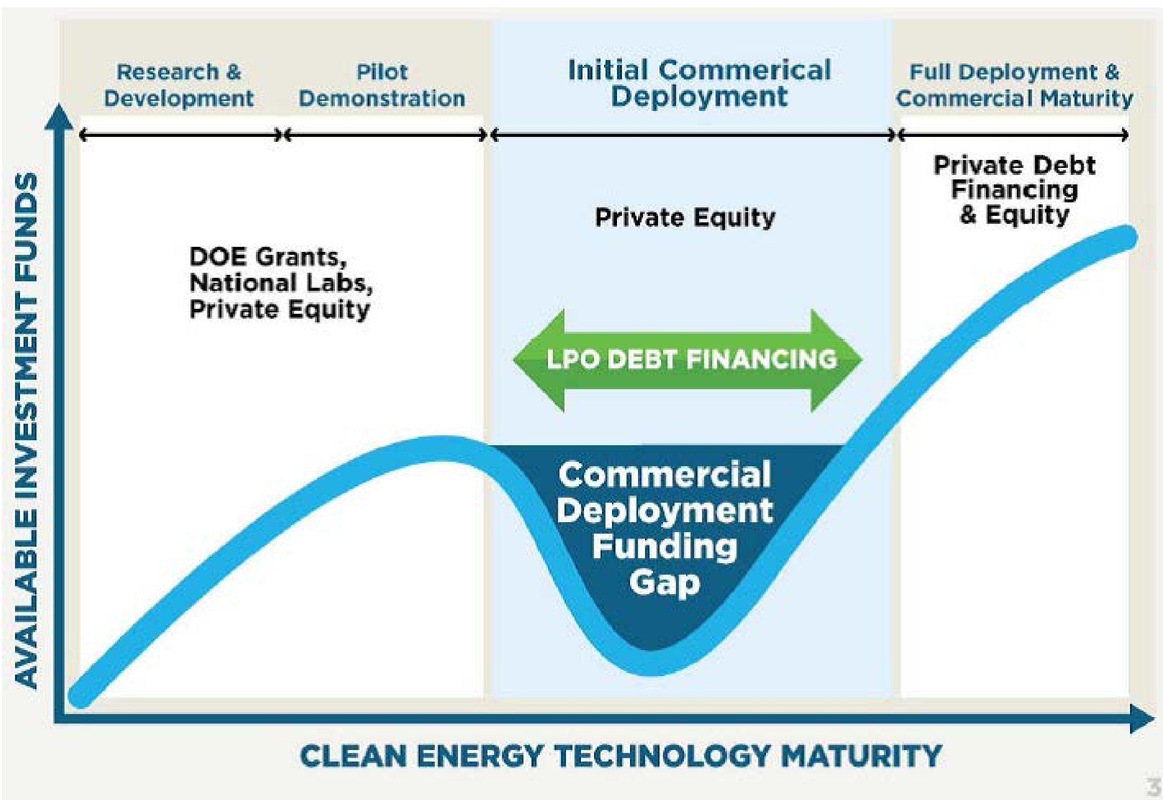
Demonstration Program (a state level program supporting resiliency run by Clean Energy Storages Alliance) to deploy this innovative project. Out of the project cost of $10 million, the U.S. Department of Energy contributed $250,000, while the State of Vermont contributed $50,000 and issued the solicitation, received and reviewed all proposals.

4.4. Innovative Project Financing

Developing innovative energy storage project financing methods is critical for the industry to grow as there are currently no typical means that lenders utilize due to the unknown risks involved. If a number of varied project financing options could be developed successfully, then lenders would have a number of real-world examples to use for comparison.

The U.S. Department of Energy established the Loan Programs Office to accelerate the deployment of innovative clean energy projects across the United States. The Loan Program Office traces its beginning to the Energy Policy Act of 2005, which included Title XVII (Incentives for Innovated Technologies) that created the Section 1703 loan program and the Loan Program Office. The Loan Program Office targets projects that improve the integration of renewable energy generation into the power grid by enhancing the capability for renewable energy variability, dispatchability, congestion, and control.

Figure 15 - Bridging the Gap



Source: U.S. DOE Loan Program Office

The Loan Program Office looks for ways to bridge the gap when private equity or other groups are not willing or ready to fund the early commercial development of market-ready innovative energy technologies. By helping to develop some of the first commercial projects of new energy technologies, the wider financial market (commercial lenders) is able to assess operating projects and thereby gain much needed comfort they need to be able to participate in the funding of such projects. The Loan Program Office will support these projects through co-lending, securitizations, and generally attracting new equity lenders and tax equity investors.

The U.S. Department of Energy's Loan Program Office follows four determinative factors in deciding the recipients of loan guarantees:

1. The technology is early stage, but commercially ready—meaning there are not three or more identical technologies operating commercially in the United States,

2. The technology is deployed at a site in the United States,

3. The operation of the technology effects a Green House Gas (GHG) reduction, and

4. There is a reasonable likelihood of repayment of the loan.

The Loan Programs Office has worked to include the opportunity for energy storage projects to be supported through its loan guarantee program. Currently, the Loan Programs Office has three open solicitations through which energy storage technologies could be supported:

1. ***Renewable Energy and Energy Efficiency**:* Under this $4 billion program, energy storage projects are directly qualified as stand-alone projects.

2. ***Clean Fossil Energy***: Under this $8 billion program, energy storage projects could be included as a portion of a clean fossil project if properly structured.

3. ***Advanced Technology Vehicle Manufacturing*** ("ATVM"): Under this $16 billion program, the U.S. Department of Energy is considering to include stationary energy storage projects as part of the vehicle charging infrastructure.

However, as of the date of publication this report, there have been no loan guarantees made for an energy storage project through the Section 1703 program. While some energy storage projects have been financed under the Section 1705 program, including the $43 million loan guarantee that was issued to Beacon Power, many of the study participants believed that the lack of funding using the load guarantee program is as a result of the structure of the program. First, the typical loan is not designed for energy storage projects, because the loan amount is on a much larger scale—$100 million+. While these are common in the wind and solar energy markets, it does not fit the energy storage market where the industry and technology is not as advanced. Further, the lack of a guaranteed revenue stream and a standardized, investment grade contracts makes it harder for energy storage projects to qualify for the Department of Energy Loan programs.

One of the most significant hurdles for energy storage projects qualifying for the loan guarantee program is the "first-three" limitation. (That limitation is that the technology is early stage, but commercially ready, and there are not three or more identical technologies operating commercially in the United States). While that criteria works for solar and wind projects, it does not work for energy storage, for several reasons. First, there are more than a dozen energy storage technologies that can be designed and operated. As such, the Department of Energy Loan Programs Office should view each of them as separate technologies and qualify them separately. Secondly, because of the flexible and interactive nature of energy storage technologies, the systems can be classified differently as transmission, distribution, and behind the meter, performing a wide range of different applications in the market. These market distinctions and opportunities are important. For example, an energy storage unit operating in the wholesale frequency regulation market is a very different business than an energy storage supporting peak load management for a behind the meter commercial customer, or a system that is providing system resiliency to a utility.

4.4.1. A New Approach

A number of study participants also suggested that the Loan Programs Office improve the financing opportunities for energy storage through two avenues: additional loans that would be more appropriate for the energy storage market, and expanding the current lending infrastructure to take into account the differences of energy storage technologies from solar and wind projects.

While the Department of Energy Loan Program Office has been working to extend the loan program for some time, to date, it has not been extended to fund energy storage projects. This is unfortunate because the industry continues to develop, yet the Loan Programs Office has not been able to assist the industry in the commercialization of new, innovative energy technologies, many of which were developed without such funding.

Recently, however, the Department of Energy Loan Programs Office has sought to make it easier for energy storage projects to be funded. It announced new funding opportunities to open loan guarantees to projects that aggregate many distributed energy resources (DERs) that will now constitute a single Project under Title XVII and the Section 1703 program because they are an integral component of a master business plan for a fleet of assets. This new funding is being managed by the Clean Fossil Energy[22] and the Renewable Energy and Energy Efficiency[23] programs. In its announcement, the Department of Energy Loan Programs Office recognized that DERs require financing that is different from structures that have been used for larger, centralized power projects. However, even though the new program’s funding is designed for more innovative and applicable to smaller system designs, applicants will still have strict financing and technology requirements in order to qualify. But, in order to assist groups interested in the funding opportunity, the DOE Loan Program Office developed three model structures for applicants to follow.

In its announcement, the Department of Energy Loan Programs Office provided three examples of differing ownership structure. The first type of ownership structure is for a traditional project developer who develops, owns, and operates the assets. This structure will support multiple installations of DERs at multiple sites, with direct control of the sites by a single entity. The second type of ownership structure applies to an aggregator of energy storage assets supporting behind the meter assets that would be backed by standardized equipment leases or Power Purchase Agreements with multiple host site owners. The third type of ownership structure envisions mobile or transportable technology “deriving revenues from its temporary set up and operation of such technology at multiple customer sites.” This is the least clearly defined option, though it largely sticks to the direct ownership structures of the first type.

Undoubtedly, the Department of Energy Loan Programs Office’s changes will present many more opportunities for developers of energy storage technologies. Specifically, reducing the fee structure to be cost effective with smaller projects will provide more near-term deployment opportunities for. Further, aggregating multiple units at multiple locations will enable smaller units (which otherwise would have been exclude) to qualify. It also would open up new and different business opportunities in a distributed energy network. Finally, since energy storage has the unique opportunity to be integrated with existing assets on the grid, the Loan Programs Office can rely on its previous funding and apply it to energy storage and classify it as an alternative energy source in the Clean Fossil Program.

4.4.2. Financing Infrastructure

In addition to improving the opportunities for obtaining a loan for energy storage projects, a number of survey participants suggested that the Department of Energy Loan Programs Office should lead the expansion of the financing infrastructure available for project developers.

The Loan Program Office can support the energy storage industry significantly by working with the financial community to educate it on the value proposition of energy storage. Through co-lending, or working with other lenders on the securitization of asset, the Loan Program’s office can leverage relatively small amounts of its financing ability to greatly expand the market.

In the end, many survey participants believe this the Department of Energy Loan Program can provide the greatest value by working with other lenders. Many in the financial industry realize financing energy storage project is a more complex undertaking than financing renewable energy projects, but once a critical mass of lenders have sufficient experience, many financial industry participants echoed one succinct interviewee: “if the market starts moving, we’ll figure it out.”

4.5. Performance Rating

Performance ratings have been instrumental in the development of the wind and solar markets, and will be critical to the commercial success of energy storage projects. Two approaches in particular will be important: performance scoring and benchmarking. Performance scoring defines how the energy storage asset operates against a market signal, whereas performance benchmarking defines how a particular energy storage asset operates as compared to other energy storage assets (or other resources). Both approaches provide insight into the operations of a particular energy storage asset, and thus can be a reliable metric to be used in compensating an energy storage system, or when comparing one asset vs another for purchase. As the confidence in a performance rating increases, the metric will become a more reliable and established input into ensuring the bankability of projects. Reliable performance ratings could then be used to define the compensation—and penalties for poor performance—in a lenders contract for project funding.

Unfortunately, a reliable, fair, and transparent performance rating covering all energy storage technologies in all possible markets is difficult if not impossible; as one interviewee noted, “If it were easy, we would have done it already.” The performance of an energy storage system is impacted by its design, and how and under what conditions it is operated. Most stated performance characteristics such as cycle-life and efficiency assume certain operating parameters such as the depth of discharge, charging/discharging rate, and the operating temperature. Unfortunately, performance measurements under lab-based steady-state conditions typically do not translate well into real-world conditions where dynamic activity is common, leaving many involved wanting performance metrics that would more closely correspond to what actually happens and be accepted by all parts of the industry.

The U.S. Department of Energy has a unique opportunity to play the pivotal role in the development and adoption of performance ratings to further the growth of the energy storage market. Rather than developing a universal performance metric for all energy storage applications, some interviewees suggested that the U.S. Department of Energy could take the lead in the development of separate performance ratings for different applications. The core of this effort would be the development of protocols and testing standards—with those becoming adopted also by private testing firms—that would provide a valid “Use Case” for the application, crafted from m variety of typical usage profiles for the application. These Use Cases would not try and simulate all possible application operating regimes, but rather could model a representative operational profile that would be acceptable placeholder for a typical usage profile in the application. Validation of these testing procedures would of course require significant input from the OEM and integrator community as they would need to be strong enough to be relied upon by financing contract. The key point would be that the testing and validation procedures would be based on the applications needs, not based on a technology’s performance on an OEM designed test. The U.S. Department of Energy has already taken requisite initial steps towards this development, as seen in the DOE report *Protocols for Uniformly Measuring and Expressing the Performance of Energy Storage Systems.*

Because of the sometimes very different design and operating characteristics, one option for a fair and impartial performance rating would be a synthetic construct including a variety of important characteristics and conditions for that particular application. This would help to avoid the most glaring issues of bias that would arise if the performance rating for an application is based on the capabilities of the technologies that are available, not on what would actually be the best performance measurement for the application.

Examples of performance ratings already in use in the market are instructive as to how performance ratings could be adopted in other settings to support the wider adoption of energy storage system based on their superior performance. A reliable performance rating would allow lenders to structure the funding for a project based on an agreed upon metric, significantly reducing their risk and thus helping to accelerate the number of lenders and the scale of their involvement in energy storage projects.

4.5.1. Performance Score—Frequency Regulation

Performance scoring is already a central factor used to determine payment for energy storage assets in the wholesale power markets at the ISO/RTO level. At the core of FERC Order No. 75's pay-for-performance based frequency regulation service is the performance score. All market assets providing frequency regulation services are measured through this process, so it has become an insightful measurement of how energy storage assets perform in a real and very competitive market. Individual ISO markets approach the performance score calculation differently depending on the structure of their market calculations, but generally have some type of hourly evaluation process where they score the resources providing frequency regulation services by weighting their operating performance with respect to delay, accuracy, and precision.

The performance score's usefulness is evident as it is used throughout these wholesale markets to determine resource qualification, offer evaluation, market clearing and settlement. By utilizing the performance score metric, the ISO/RTO is able to ensure that all assets providing the service to the market can perform at a minimum performance level to ensure adequate provisioning of the service to the market. Energy storage project developers in particular have leveraged the high performance scoring capabilities of their energy storage systems when developing projects serving the frequency regulation markets by guaranteeing a minimum performance score in the financing contract with the lender.

The U.S. Department of Energy can support the further expansion of energy storage assets into other wholesale power market roles through leveraging the experience of the frequency regulation market's performance score. By defining the qualification to provide market services to be one of performance rather than qualitatively specified (in the past some market roles were simply reserved base on the type of resource not their performance capability), energy storage systems that can provide superior services will be highlighted, and consumers will benefit from better services at a lower overall cost as has been seen in the frequency regulation markets.

4.5.2. Performance Benchmarking—Grid Star

Performance benchmarking could provide residential customers a desperately needed insight into their choices of energy storage systems. The energy storage options for residential customers is growing rapidly, and it is quickly becomes apparent that the average homeowner does not have the information nor ability to understand the different energy storage technologies, compare the lifetime costs and potential savings, and make an informed decision as to which system is the most cost effective. Unfortunately this task will become even more complex as additional energy storage systems—and of varying technologies—enter the market. Many providers of these residential energy storage solutions tout the low initial cost of the system, or some isolated performance metric, without giving the customer sufficient information with respect to overall costs and savings. By supporting the development of an integrated benchmark rating system, the U.S. Department of Energy could help customers more easily determine the cost effectiveness of a residential energy storage system. For working purposes, we will call this potential benchmark rating system for residential energy storage systems "Grid Star."

The proposed Grid Star program would be loosely based on the U.S. Government's existing "Energy Star" program. The ENERGY STAR™ rating is the leading international standard for energy efficient consumer products. The program was created in 1992 by the U.S. Department of Energy and U.S. Environmental Protection Agency. Equipment that showcases the Energy Star service mark typically 20% to 30% less energy than required by federal standards. The program is typically focused on consumer products, but commercial and industrial buildings are also included in a benchmarking rating, to provide a means for the energy efficiency of individual commercial buildings and industrial facilities against the energy efficiency performance of similar buildings.

The goal of the Grid Star program would be to consistently evaluate energy storage systems' ability to reduce a consumer's cost of service, and a means to compare the different systems. The first step would be to develop a standard design and operational profile for the residential application, with some key system assumptions fixed, such as a similar inverter (power) rating, no replacement of major equipment, specified operating temperature, etc. The most basic operating profile would be a simple peak shaving application, although more complex ones such as "solar/storage" could also be modeled. To anchor the commonality of the evaluation, a "usable energy" framework should be applied–meaning each unit would be responsible for providing the same amount of energy during a discharge cycle. Therefore the physical sizing of each unit would be dependent upon what would be required to reliably support the minimum discharge amount over the life of the unit. For instance, a particularly low cost battery may only be able to be discharged to 50% of the battery's energy capacity in order to support the desired lifespan, requiring a twice as many cells in order to support the required energy discharge capacity. Operating parameters such as the amount of energy needed for charging would be based on the specific technology provider's round-trip-efficiency, while the customer's tariff structure fixed on a State or specific utility to provide a more accurate estimate for the residential customer. Utilizing a similar discount rate would allow the results to be showcased to the potential residential customer as a levelized cost over the life of the unit. (Or, the analysis could be done on a payback period basis for instance.) Although the results of this analysis will obviously not be completely accurate for every individual consumer, the results would be helpful by easily showcasing the "all-in" costs of the different systems using only one cost metric for benchmarking purposes.

The success of any development like the Grid Star program would not rely on new programs, but rather an extension and acceleration of efforts already underway at Sandia National Laboratory's

Energy Storage Systems programs such as the development of application standards, system testing and verification, and performance analysis. As with other Standards efforts, the focus of the U.S. Department of Energy would be to work with private industry and lead the effort in establishing these protocols so that any accredited testing facility could provide the testing for verifying the storage system's adherence to the rating methodology. The Grid Star program could start with relatively simple applications such as residential energy storage systems, with other, more complex evaluations such as solar/storage and storage coupled with vehicle fast charging coming later.

4.6. Performance Guarantees

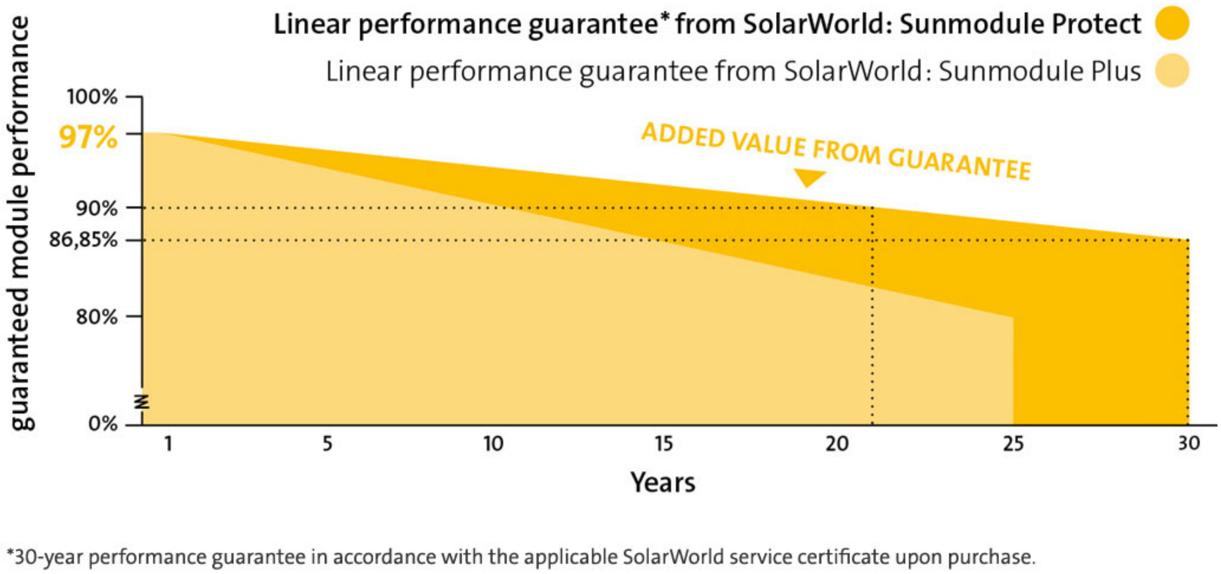
Many industry participants welcome the development of performance ratings, and want some aspect of them incorporated into project contracts as performance guarantees to ensure the project's ability to generate revenue. The inclusion of performance guarantees will benefit all involved by increasing visibility on this 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 they have limited experience with regards to energy storage projects. Project developers will also benefit by ensuring access to lower cost capital costs for the project through passing through the system performance risk to the OEM technology providers. Most OEMs will benefit—luckily, since OEMs are the ones ultimately on the hook for backstopping the performance guarantee. Those manufacturers able to either absorb the credit risk on their balance sheet or purchase 3rd party insurance will be able to utilize this capability to their advantage for marketing purposes. However, as the industry continues to transition to commercial status, those manufacturers that attempt to sell commercially unproven technology—even if it is technically superior—will be at a disadvantage; unfortunately, that is the nature of commercial markets.

When discussing performance guarantees, it is important to highlight the difference between product warranties and performance guarantees. Product warranties provide coverage for manufacturing defects, and are typically cover the first 2 years of operation, with subsequent coverage available for purchase on an annual basis. Product warranties do provide some level of assurance for operational capability, but generally only to the extent of a "spec sheet" level performance. Performance guarantees on the other hand, provide for a minimal operating performance taking into account multiple operational and environmental conditions.

4.6.1. Experience in Renewable Energy Markets

Performance guarantees have long been a part of other renewable energy markets. Historically, lenders working with projects in the solar and wind industries required cash reserves, if the lenders were not confident in the technology's performance capability and longevity, or if operational history was inadequate. So, while this type of financing gave these projects access to the market, it did so by greatly affecting the profitability of the project. In response, some solar panel manufacturers began providing a performance guarantees covering the efficiency of the solar panels throughout the life of the system instead of a bond, as seen in Figure 20. 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.

Figure 166 - Performance Guarantee in Solar



Source: SolarWorld

4.6.2. Energy Storage

As the energy storage industry begins to emulate the solar and wind commercial markets, customers and lenders are requiring assurances that energy storage systems perform as promised, especially over the full life of the system. The difference between energy storage and these other technologies however is that there are many more degradation factors involved in the operation of an energy storage system, making the definition of the application extremely important, but also highly dependent upon the assumptions made as the different degradation factors interact with each other. For instance, critical performance metrics (efficiency, cycle-life, etc.) greatly depends on how the system is operated (depth of discharge, charge/discharge rate, etc.), and under what conditions it is operated (temperature, etc.), which leaves performance guarantee difficult to define for a realistic operating range for a customer's needs to respond to variable market conditions. This challenge is magnified when trying to not induce bias as separate energy storage technologies operated differently.

Many leading energy storage OEMs are confident that their technology is able to meet the desire for ever-improving performance targets as this is increasingly a key market differentiator among OEMs. Over time, they are raising the minimal operating performance guarantees—albeit within a specific operating range—as they gain more operational experience in commercial settings. Although lenders were clear of the need for performance guarantees from energy storage providers, many admit they did not understand the technical challenges involved, and thus the risk level they were requiring the OEMs to take on. The question then remains, how close are these OEM guarantees to ones the lenders and customer's actual want? Matching and coordinating the performance metrics that OEMs want to back with what lenders want in the contract remains the crux of this critical issue.

A number of insurance companies have begun to explore the energy storage market to determine how they can provide a bridge between what lender's want, and what OEMs feel they can provide. Insurance companies have been active in the energy storage market providing coverage to some for warranty contracts, especially for smaller firms; expanding the coverage to performance guarantees is just seen as the next logical step. However, insurance industry study participants voice concern that it will be difficult to price a universal performance guarantee product for energy storage manufacturers and developers, because of the wide variety of technologies, their operational maturities, and the point that the technology is still changing. Some energy storage technologies vendors have begun to provide an expanded performance guarantee to customers for an additional annual fee, both to cover the cost of provisioning the service, and the cost of insurance for that service. While this is not a problem for the larger energy storage OEMs who are able to self-insure, it is harder for smaller and medium size developers, leaving them at a distinct disadvantage and potentially greatly curtailing their opportunities. At the worst—some are even priced out of the market totally.

One solution to level the playing field is for the U.S. Department of Energy to help provide a means so that even small manufacturers and developers can afford insurance policies to provide performance guarantees for their energy storage products and/or projects. The first part of this undertaking would be to develop some industry-wide accepted operating performance levels and associated testing regimens for various applications. This builds off the ongoing work the U.S. Department of Energy is doing to establish application definitions, but extending this to focus on the performance levels when performing the application. Once a standard testing regime is established, it could be performed by third party private testing firms, or possibly at a U.S. Department of Energy Laboratory, depending on the availability of an acceptable testing infrastructure.

The second part of this undertaking would be for the U.S. Department of Energy to support the development of widely available and affordable insurance to back up performance guarantees by OEMs. The idea is not for the U.S. Department of Energy to provide this insurance, but help develop an "insurance pool" for companies to purchase basic insurance coverage through—once they've passed the performance test. Here, the expertise of the Loan Programs Office could be brought to bear on this problem by bringing insurance firms interested in participating in the energy storage market to work together to provide the insurance through the pool, and gain invaluable experience—although there may very well be the need for the U.S. Department of Energy to be the backstop to the insurance pool overall to keep the premium cost low. Given time and experience, these insurance companies would then be free to issue their own policies provider better coverage without the backing of the federal government. By developing the insurance pool, more medium and small energy storage OEMs and developers would be able to enter the industry, and gain a more even footing with their larger competitors.

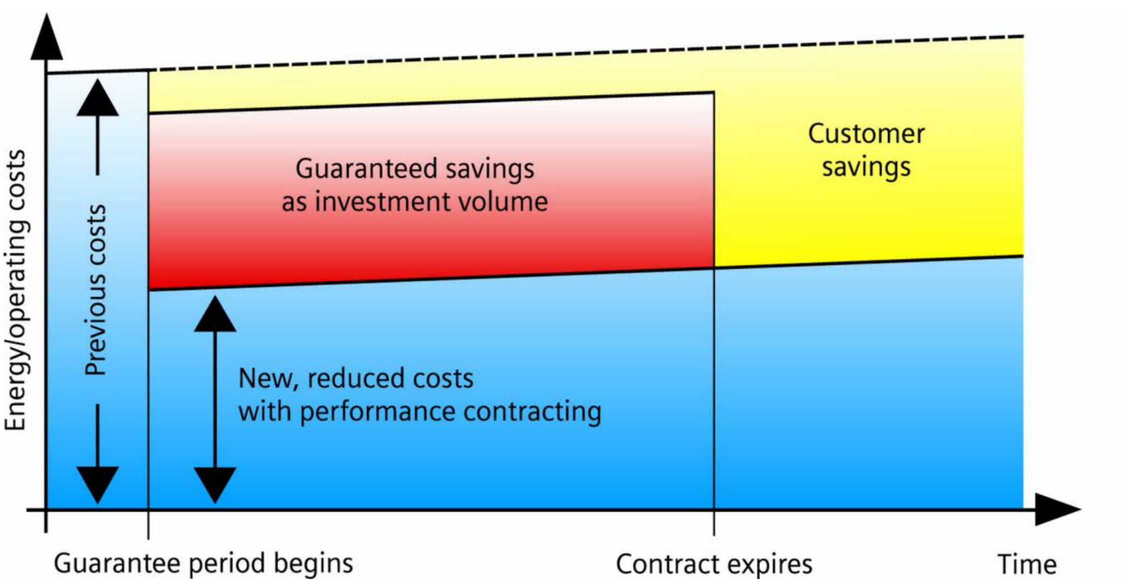
4.7. Energy Savings Performance Contracts

Project developers and customers alike need a standardized, financeable contract to accelerate the market for bankable Behind-the-Meter energy storage projects. A number of developers active in the market are developing their own proprietary contracts to support their own commercial development. The U.S. Department of Energy could prove instrumental in supporting the development of a more open and transferable industry standard contract.

The existing Energy Savings Performance Contract (ESPC) used widely in the energy efficiency market could be adapted for use in the energy storage market. An ESPC for Behind-the-Meter energy storage projects is akin to a PPA in front of the meter energy storage projects, as both contracts clearly define the terms and conditions for their respective project. The PPA is well suited for the wholesale market as it deals with the sale of energy or grid services, whereas an ESPC is well suited for the Behind-the-Meter market as it deals with the reduction in customers' energy bill. The ESPC framework has been widely used in the energy efficiency market to enable customers pay for energy efficiency upgrades to their facility by using a portion of the cost savings, thus eliminating the customer's to pay up-front for the desired project. An ESPC designed for the energy storage market could both ensure that energy storage project developers will be able to work with lenders on a level playing field, and ensure that commercial customers could benefit from the subsequent savings without the large outlays of capital.

Typically, project developers in the energy efficiency market that offer ESPCs to customers arrange financing from a third party financing company and the contract usually is in the form of an operating lease. In this way, the EPSC contract defines a turnkey service for the scope of work desired by the client and meets the investment criteria of the lender. The contract provides for guarantees that the savings produced will be sufficient to finance the full cost of the project. The operation of the project is then monitored to verify the savings, and to provide data on operational performance and requisite maintenance.

Figure 17 - Energy Savings Performance Contract



Source: Building Owners and Managers Association

The experience in the energy efficiency industry provides a guide for how these types of contracts could be applied to the energy storage market. Initially, developers in the energy efficiency industry developed their own proprietary contracts, and while this led to innovation in the market, it resulted in many different and somewhat unique contracts that were not easily comparable. As such, customers and lenders had to sift through different programs and decide among different service providers based on incomplete comparative information.

In order to accelerate market growth and improve competition, the Building Owners and Managers Associations (BOMA) developed a standard energy performance contracts to execute energy efficiency retrofit programs for buildings. The *BOMA ENERGY PERFORMANCE CONTRACTING MODEL (BEPC)*[24] was designed to provide an easier way for private building owners or managers to develop and execute investment-grade energy efficiency retrofits. Essentially, by developing an industry-sponsored standard contracting model, building owners and energy service providers have a better starting point from which to tailor an energy performance contract for a customer, while still providing the core operational similarity in structure. The model provides transparency on pricing and performance expectations and to give building owners a high degree of confidence that the project will meet the stated goals in a competitive manner.

ESPCs are well suited for the Behind-the-Meter commercial and industrial energy storage market. Commercial and industrial customers are increasingly exposed to higher and more volatile electricity rates, as utilities shift more of the service charge from a commodity (kWh) basis to a demand (kW) basis, through rising demand charges in their tariffs. Of course, while commercial and industrial customers are interested in lowering their energy service costs, they are reluctant to sign procurement agreements with private energy service firms that cannot guarantee savings. In the energy efficiency market, lighting and HVAC upgrades allow the energy service firm a means by which they can lower the overall usage, but cannot selectively control the timing of the reduction—outside of all of the time. Here, an energy storage system enables the user to target reduction of load, without affecting the operational profile of the facility. The benefit here is that the scale of the load reduction by using the energy storage device can easily be greater than that provided by the energy efficiency program, thus providing a greater reduction in the demand charges. By coupling the ESPC with the energy storage asset (and provide the necessary guarantee), together, the customer and the energy service provider can enter into an agreement whereby cost savings from demand charge reductions can be guaranteed. Including the capital cost of the battery equipment in the contract would allow the customer to enter into an operating lease agreement, which would provide guaranteed cost reductions, especially targeting the ever rising demand charges. Some service providers that provide such energy storage projects have called this “storage as a service”.

The U.S. Department of Energy is well suited to provide a number of key supporting roles in the development of such an industry standard contract. Two key roles would be to ensure that the contract’s development was open and transparent with wide industry involvement, with another being the development of standardized measurement and verification processes to accurately determine estimates for savings, costs, and to account for operational issues that could impact the results. The U.S. Department of Energy’s involvement would help lenders and other financial industry participants trust both the structure and outcome of an energy storage ESPC, alleviating much of the uncertainty of financing the project.

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APPENDIX A: STUDY INTERVIEWEES

	First	Last	Title	Company
1	Doug	Alderton	Director, Marketing & Sales	Vionx Energy
2	Norm	Allen	Operating Partner	Potomac Energy Fund
3	Ali	Amirali	Senior Vice President	Starwood Energy Group
4	Sean	Becker	President	Sparkplug Power, Inc.
5	Ben	Block	Partner	Ardsley Partners
6	Dale	Bradshaw	President	Electrivation
7	Barry	Britts	President & CEO	Beacon Power
8	Richard	Brody	VP Business Development & Sales	Primus Power
9	Jake	Brown	CEO	Cubed, LLC
10	Dan	Cass	Vice President	G Cube Insurance Services
11	William	Christensen	Vice President, Business Development	AltaLink
12	Mark	Cox	Partner & CIO	New Energy Fund
13	Vani	Dantum	VP Business Development	Landis & Gyr
14	Farid	Dibachi	Founder & CEO	JLM Finance
15	Kevin	Dillon	Director of Sales & Marketing, N.A.	FIAMM
16	James	Falsetti	Director	BQ Energy
17	John	Fernandez	Director, Policy & Market Development	RES Americas
18	Reyad	Fezzani	Chairman & CEO	Regenerate Power
19	Bob	Fleishman	Senior Of Counsel	Morrison Foerster
20	Ryan	Franks	Senior Program Manager	NEMA
21	Dan	Gabaldon	Founding Partner	Enovation Partners
22	Charles	Gassenheimer	President	Carnegie Hudson Resources
23	Jeff	Gates	VP Sales	Alevo Group
24	Patrick	Gengoux	Associate	Seacoast Capital
25	Larry	Goldberg	Regional Sales Manager	EnSync Energy Systems
26	Katherine	Hamilton	Principal	38 North Solutions
27	Spencer	Hanes	Managing Director, Business Development	Duke Energy
28	Pat	Hayes	Business Development Manager	ABB, Inc.
29	Darrell	Hayslip	President & Founder	Narrow Gate Energy
30	Steve	Hellman	Chairman of the Board	EOS Energy Storage
31	Udi	Helman	President	Helman Analytics
32	Bill	Holmes	Partner	K&L Gates
33	Craig	Horne	Chief Strategy Officer & Co-Founder	Enervault
34	Eric	Hsieh	Office Director, Energy Policy Systems Analysis	U.S. Department of Energy
35	Salley	Jacqumin	Microgrid Business Manager	Siemens

	First	Last	Title	Company
36	Andrew	Kaplan	Partner	Pierce Atwood LLP
37	Praveen	Kathpal	Vice President	AES Energy Storage
38	Michael	Kearney	Corporate Development Principal	AMBRI
39	Curt	Kirkeby	Fellow Electrical Engineer - Technology Strategy	Avista Utilities
40	Matthew	Koening	Director of Sales, Eastern Region	Princeton Power Systems
41	Chris	Kuhn	Christopher Kuhl	Northern Power Systems
42	Bob	Lane	Manager, Compliance: Energy Risk Management	San Diego Gas & Electric
43	Matt	Lazarewicz	President	Helix Power
44	Dann	Lee	Director of Engineering	Celestica
45	James	Levy	Managing Director	Warburg Pincus
46	Roger	Lin	Director, Product Marketing	NEC Solutions
47	Mark	MacCracken	CEO	CALMAC
48	Mark	Manley	Manager, Consulting	Black & Veatch
49	Taite	McDonald	Sr. Advisor	Wilson Sonsini Goodrich and Rosati
50	Jim	McDowall	Business Development Manager	SAFT America
51	Troy	Miller	Director, Grid Solutions	S&C Electric
52	Mir	Mustafa	Executive Director of Business Development	National Electrical Contractors Association
53	Matthew	Nordan	Co-Founder & Managing Partner	MNL Partners
54	Ali	Nourai	Director	DNV GL
55	Hisham	Othman	Advanced Solutions Leader	SunEdison
56	John	Petersen	Executive Vice President & CFO	ePower Systems
57	Michael	Quinn	Vice President & CTO	Oncor
58	Ross	Reida	VP, National Accounts	TIP Capital
59	Matt	Roberts	Executive Director	Energy Storage Association
60	Brad	Rockwell	Production Manager	Kaua'i Island Utility Cooperative
61	Ben	Rogers	Partner	Broadscale Group
62	Jack	Rubinstein	General Partner	Dica Partners
63	Chris	Russo	Vice President, Energy	Charles River Associates
64	Vijay	Somandepalli	Managing Engineer	Exponent
65	Bic	Stevens	Principal	Stephens Capital Advisors
66	Mike	Stosser	Of Counsel	Sutherland, Asbill & Brennan LLP
67	Chris	Thompson	Grid Power, Business Unit Manager	Eaton
68	Russ	Weed	VP Business Development & General Counsel	UniEnergy Technologies
69	Jon	Wellinghoff	Partner	Stoel Rives LLP
70	Leon	Zhang	Senior Business Development Manager	BYD America

APPENDIX B: 2014 ENERGY STORAGE FINANCING SUMMIT

Energy Storage Financing Summit

On December 16, 2014, the U.S. Department of Energy, Sutherland Asbill & Brennan LLP, Mustang Prairie Energy, and the Energy Storage Association jointly presented a one-day financial summit at Sutherland's New York office in Manhattan.

The summit was the kickoff for a new U.S. Department of Energy study "*Energy Storage Financing: A Roadmap for Accelerating Market Growth*," to identify the risks and challenges of financing energy storage projects, and to determine a roadmap to accelerate the development of, and investment in, the energy storage industry.

The study is being conducted by Mustang Prairie Energy and will be based on interviews of leaders in the energy storage, renewable energy and financial communities to determine what lessons can be learned from the early growth stage of other markets, as well as how this knowledge can be adapted for use by the energy storage industry.

Matt Roberts, the Executive Director of the Energy Storage Association, also used this landmark event to launch a Financial Task Force to further the ESA's outreach to the financial community.

The summit began with speakers from the U.S. Department of Energy. Peter Davidson, the Executive Director of the DOE Loan Programs Office, provided the first keynote address on how the federal government is supporting early deployments of innovative energy technologies, and how energy storage projects can benefit from the government's flexible approach. Imre Gyuk, the Program Manager of the DOE Energy Storage Program, gave an overview of federal support for energy storage technology development, and explained how that support is extending into the commercialization of these systems.

The first panel of the day focused on underlying challenges to project financing, such as project bankability, insurance and operating experience, and discussed how these issues will shape the industry going forward.

The second panel of the day focused on project financing. The panelists reviewed current financing models and considered which ones would emerge in the future, and discussed whether lessons could be learned and adapted from the solar, wind and energy efficiency industries.

The summit closed with a keynote address from Alfred Griffin, the President of the NY Green Bank. His presentation showcased the efforts of the NY Green Bank in addressing current financing gaps and barriers for clean energy projects in New York State, and how that support can benefit energy storage projects.

2014 Energy Storage Summit Attendees

	First	Last	Title	Company
1	J Norm	Allen	Operating Partner	Potomac Energy Fund
2	Ali	Amirali	Senior Vice President	Starwood Energy Group
3	Richard	Baxter	President	Mustang Prairie Energy
4	Sean	Becker	President	Sparkplug Power, Inc.
5	Edward	Bossange	Vice President	Morgan Stanley
6	Kevin	Bryant	President, KLT, Inc.	Kansas City Power & Light
7	Vaughn	Buck	EVP	Santander Bank N.A.
8	Goodloe	Byrob	Managing Director	Potomac Energy Fund
9	Dan	Cass	Vice President	G Cube Insurance Services
10	Matt	Cheney	CEO	CleanPath Ventures LLC
11	Christopher	Cioni	Principal	C2 Energy
12	Lara	Cooley	Business Development Manager	Sutherland Asbill & Brennan LLP
13	Nikka	Copeland	VP Strategy & Technology	National Grid
14	Alan	Cordova	Business Development Manager	NRG Energy
15	Alan	Dash	Sr Vice President	Starwood Energy Group Global, LLC
16	Peter	Davidson	Executive Director	U.S. DOE - Loan Programs Office
17	Sarah	Davidson	External Affairs	NY Green Bank
18	James	Dixon	Vice President	ConEdison Development
19	Michael	Donnelly	Business Development - M&A/Strategy	GE Energy
20	Jack	Doueck	Principal	Advanced Energy Capital
21	Niko	Elmaleh	Exec VP	World-Wide Holdings Corp.
22	Mark	Friedland	EVP Finance and Legal	K Road DG LLC
23	Daniel	Gabaldon	Partner	Enovation Partners
24	Alberto	Garcia	Vice President	Santander Global Banking & Markets
25	Charles	Gassenheimer	President	Carnegie Hudson Resources
26	Dan	Girard	Director: Business Development	S&C Electric
27	Glen	Grayeb	US Power & Gas Trading and Origination	BTG Pactual Commodities US LLC
28	Alfred	Griffin	President	NY Green Bank
29	Imre	Gyuk	Energy Storage Program Director	U.S. DOE - Energy Storage Program
30	Kristian	Hanelt	SVP, Renewable Capital Markets	Clean Power Finance
31	Sean	Hearne	Manager - Energy Storage Group	Sandia National Laboratories
32	Lifton	Jay	Chairman	Cella Energy
33	Matt	Lazarewicz	President	Helix Power
34	James	Levy	Managing Director	Warburg Pincus

2014 Energy Storage Summit Attendees (Continued)

	First	Last	Title	Company
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36	Charles	Long	Sr. Vice President	William Gallagher Associates
37	Mark	MacCracken	CEO	CALMAC
38	Mark	Manley	Manager, Consulting	Black & Veatch
39	Ian	Marcus	Origination and Structuring	Morgan Stanley
40	Glen	Matsumoto	Partner	EQT Partners Inc.
41	David	McCullough	Associate	Sutherland Asbill & Brennan LLP
42	Yulia	Michael	AVP Underwriter	Aspen Insurance
43	Troy	Miller	Manager, BD and Marketing	S&C Electric
44	Dan	More	President	DBM Capital LLC
45	Chris	Moscardelli	Director	Societe Generale
46	Gerrit	Nicholas	President	K Road DG
47	Eiji	Okada	Senior Executive VP & COO	Marubeni America Corporation
48	Renwick	Paige	Managing Partner	Energy Infrastructure Partners
49	Gregory	Petzold	Managing Director	Maroon Capital Group
50	Matt	Roberts	Executive Director	Energy Storage Association
51	Ben	Rogers	Managing Partner	Broadscale Group
52	Ralph	Romero	Director	Black & Veatch
53	Jack	Rubinstein	Partner	Dica Partners
54	Dana	Sands	Director	TAG Energy Partners
55	Rich	Sberlati	Senior Advisor	TPG Special Situations Infrastructure Partners
56	Douglas	Sherman	Director	Freepoint Commodities
57	Harry	Singh	Vice President	Goldman Sachs
58	Alex	Sorokin	CEO	Cella Energy
59	Pankaj	Srivastav	Analyst	UBS
60	Michael	Stosser	Of Counsel	Sutherland Asbill & Brennan LLP
61	Jason	Strominger	Managing Director	Ardour Capital Investments, LLC
62	Russ	Weed	VP Business Development & GC	UniEnergy Technologies
63	Gary	Yang	CEO	UniEnergy Technologies
64	Bassil	Youakim	Director	Bank of America Merrill Lynch
65	Robert	Zabors	CEO	Enovation Partners

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