Beyond Renewable Integration:

The Energy Storage Value Proposition

November 2016

ACORE
American Council On Renewable Energy

scottmadden
MANAGEMENT CONSULTANTS

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INTRODUCTION

Energy storage has the potential to transform the power system and fundamentally change the way we think about energy. However, it is a hybrid asset, neither fish nor fowl, and does not neatly fit into our established grid categories. The technology's value lies in its ability to provide grid flexibility and shift electricity supply to times of peak load, as well as providing a wide range of services to the power system as a generation, transmission and distribution (T&D), and behind-the-meter resource. Despite these capabilities, the potential value of storage is only partially recognized in today's markets

The cost of energy storage systems (ESSs) continues to fall, placing more individual applications of energy storage "in the money." As costs decrease, the value proposition for all types of applications will continue to improve.

The full value of storage lies in its ability to provide services across a variety of applications—often at the same time. However, barriers exist that limit the ability to capture the full value of energy storage and allocate it across multiple stakeholders: system and non-energy benefits of storage are often excluded in cost-benefit analyses; paths to revenue are often unclear; regulatory frameworks inadvertently limit energy storage; and new business models are still in their infancy.

Nevertheless, in many parts of the country, progress addressing these barriers is being made. Select markets are working to incorporate storage; projects are being conducted across the country to demonstrate the value of various storage applications; new business models are being developed to take advantage of value streams; and regulators at the state and federal levels are working to identify and address barriers to energy storage adoption.

This paper will provide an overview of the market to bring context and understanding to energy storage in an effort to synthesize seemingly complex issues and provide a construct for understanding the current state and readiness for growth, including questions related to:

- What are the specific applications for energy storage?
- How do those applications provide benefit?
- What are some real examples of these applications in practice?
- How can energy storage benefits best be valued and monetized to accelerate adoption?

Energy storage will play a key role in transforming the grid by allowing for a more flexible and efficient electricity system. In order to achieve this transformation, policymakers and industry stakeholders should improve their understanding of the potential full value of storage and how it can be quantified and monetized to drive adoption.

The views and opinions expressed in this report are those of the authors and do not necessarily reflect the views of ACORE.

THE ENERGY STORAGE MARKET TODAY

Recent analysis estimates that U.S. energy storage capacity will grow from just 300 MWs in 2016 to more than 2.1 GWs in 2021, with more than half of new capacity from behind-the-meter applications.[1]

Storage sited throughout the power system is beginning to demonstrate clear economic value to utilities and end users alike. As applications are becoming better understood, industry attention is shifting from addressing technical challenges to identifying models that appropriately value the benefits of energy storage and fully realize its potential.

Existing applications are primarily concentrated in areas where energy storage can provide a direct benefit to the system and where markets or rate structures exist that have clear mechanisms to monetize those benefits.

Two markets accounted for 82% of the U.S. annual installed energy storage capacity in 2015: the frequency regulation[2] market in PJM and the demand charge management[3] market in California.[4] Each market employs a distinct approach.

PJM's RegD market provides frequency regulation services in response to price signals for fast-responding resources. Resources are compensated for the speed and accuracy of their response to control signals (vs. simply the capacity of the resource)—traits that many ESSs possess. As a result, the frequency regulation

What's Driving Energy Storage?

The concept of storing energy for later use is not new. Pumped hydro storage has been widespread since the 1930s and still constitutes the overwhelming majority of the global energy storage capacity. However, in recent years several trends have encouraged renewed interest in new energy storage technologies:

- Advances in energy storage technology, in particular battery duration and efficiency
- Increasing penetration of renewable generation and distributed energy resources (DERs) and the resultant need to integrate increasing numbers of variable resources into the grid
- Growing constraints on the development of new transmission combined with Increased need for new transmission to manage increasing congestion and integration of DERs
- Declining load growth leading to reduced investment in new capacity and/or transmission
- Rapidly declining cost of energy storage systems

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[1] U.S. Energy Storage Monitor: Q3 2016 Executive Summary, GTM Research/Energy Storage Association

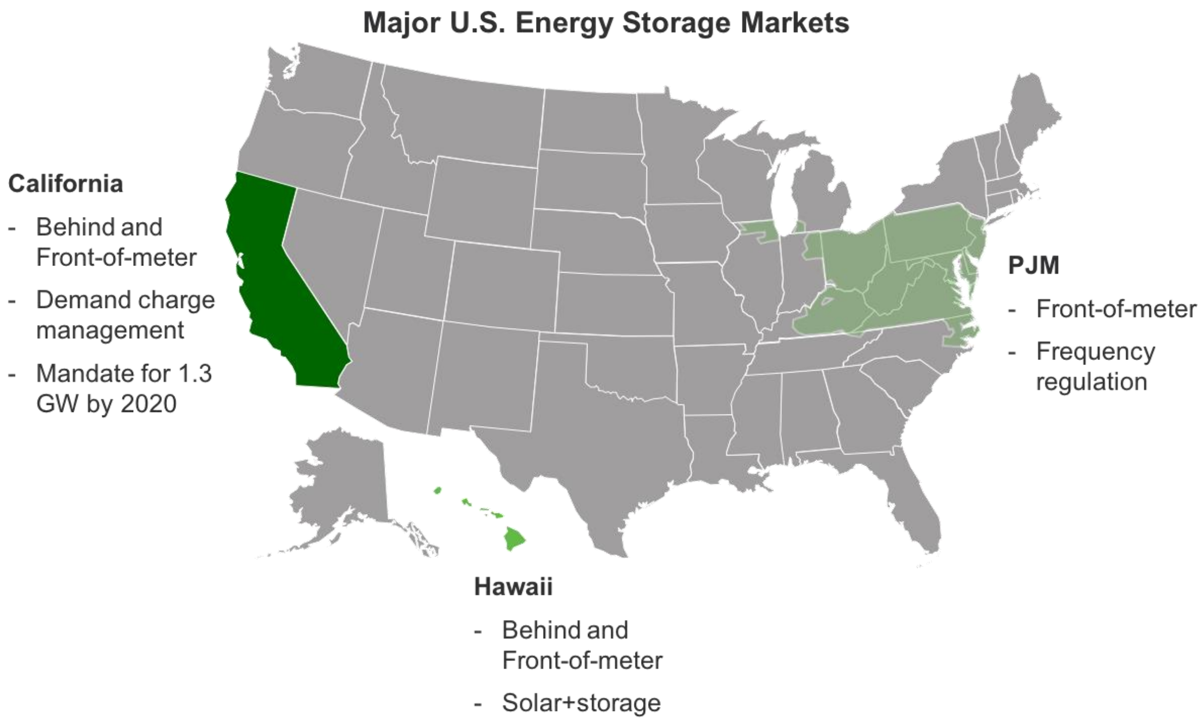
[2] Frequency regulation refers to the need to react to short-term changes to supply and demand to maintain the frequency of the grid to within operational limits

[3] Demand charge management seeks to minimize the peak demand over a given billing cycle by storing energy at times of low usage and using that energy at times of higher use

[4] U.S. Energy Storage Monitor: Q3 2016 Executive Summary, GTM Research/Energy Storage Association

market in PJM accounts for 85% of all utility-scale installations and nearly 75% of total energy storage capacity added nationwide during the last three years.[5]

In California, the demand charge management market developed organically to help commercial and industrial (C&I) customers manage demand charges incurred when peak use exceeds preset levels during a billing cycle. By storing energy and using it later to avoid consuming power from the grid, customers can shave their peak demand and avoid excess charges.



In these two very different cases, PJM's and California's distinct approaches helped to unlock the value of storage by monetizing existing applications of energy storage through markets or rate structures. So what can be made of the direction of storage when the two largest markets are so different in applications and business models?

This paper will highlight the benefits of approaches that hold promise in encouraging new deployment. It will also review how and where energy storage applications provide benefits to the grid and the steps necessary to realize the full value of storage.

[5] U.S. Energy Storage Monitor: Q3 2016 Executive Summary, GTM Research/Energy Storage Association

Applications for Energy Storage

Energy storage can provide value to the grid across a wide variety of applications. As a generation resource, storage enhances the system by providing additional, flexible capacity; as a grid resource, it brings operational flexibility and enhances reliability of the T&D system; and as a customer resource deployed behind the meter, it improves efficiency and reduces costs. However, the full value of storage is in its potential to provide each of these services via a single resource through the stacking of multiple applications.

While many new energy storage technologies have recently emerged, we will focus on reviewing the primary applications where storage can best provide value.

Generation Services

As a generation resource, energy storage can absorb energy during charging cycles and release that energy back into the grid later when it is needed or more beneficial. Long-term resources[6], such as flow batteries or pumped hydro, can act as additional capacity that provides energy back to the grid when needed to match load or augment existing generation.

Energy Time Shifting/Generation Arbitrage

Energy time-shifting works by generating or purchasing electricity at times when rates are low and storing that electricity until it can be used or sold later. This creates arbitrage opportunities for producers who wish to sell electricity at the time when rates are the highest, thus reducing costs and/or maximizing revenues.

Electric Supply Capacity and Peak Demand Management

Energy storage can be used to support peak capacity requirements by storing energy during times of low demand and by acting as a peaking resource when demand is high. Used in this way, storage can reduce, defer, or eliminate the need to build additional generation capacity (or, to a degree, transmission and distribution capacity).

Renewable Capacity Firming/Smoothing

Energy storage systems store unneeded energy during times of high renewable resource availability and discharge when resources are low, maximizing the availability of renewable energy on the grid. This

[6] Definitions of short vs. long-term duration vary. For the purposes of this paper, we consider short term to be less than four hours and medium and long term to be anything greater than four hours.

reduces the risk of curtailment and reduces the need for other, potentially more expensive resources, such as natural gas peaking plants, to provide these services.

Lastly, in some areas, system planners require reserve capacity to back up renewable generation. Energy storage can reduce or eliminate these requirements by firming renewable capacity allowing for greater renewables as a proportion of the supply stack. An example of renewable capacity firming can be seen in the Cedartown case study (page 10) where a 1 MW/2 MWh lithium-ion battery is being used to integrate utility-scale solar resources.

Grid Services

As a grid resource, storage provides value to T&D systems by allowing T&D owners to defer upgrades; mitigating congestion; and providing ancillary services such as frequency regulation, voltage support, and reserve power to help stabilize the grid.

T&D Upgrade Deferral

In cases where existing infrastructure is nearing peak capacity, energy storage can be used to delay (or, in some cases, defer altogether) costly upgrades that would otherwise be needed in order to maintain the system's ability to meet load requirements.[7] Rather than replacing or reconductoring lines, storage can act as a buffer, releasing energy when lines are near capacity limits, thereby reducing the amount of energy needed to flow through the line itself.

Beyond the immediate cost savings of delaying upgrades, waiting to make significant investments in the grid allows planners to get better clarity regarding future load growth, which reduces risk and enhances the effectiveness of the future grid investments.[8]

Transmission Congestion Relief

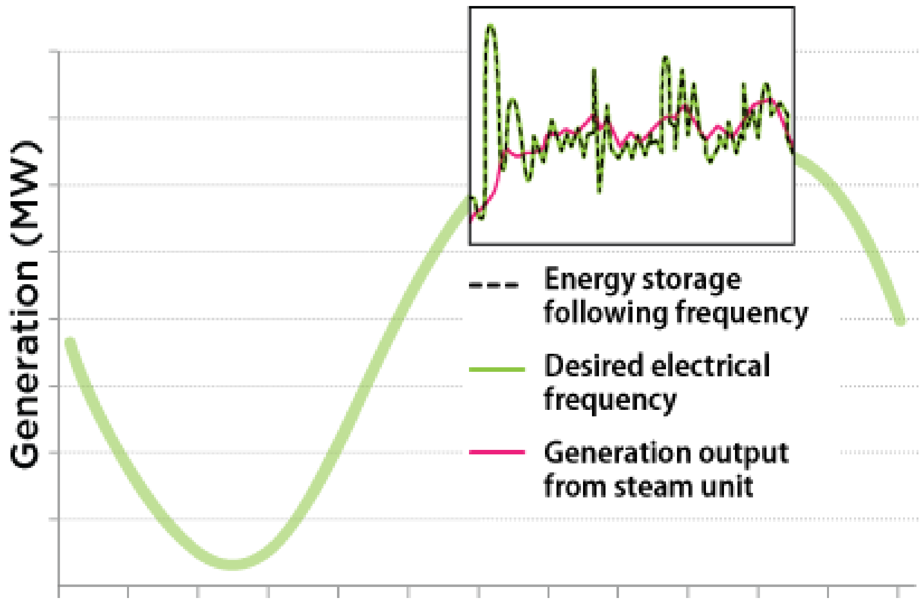
Due to difficulties in siting transmission right-of-ways, the transmission system in some parts of the country has become congested, leading to higher transmission access fees and congestion charges at times when the grid is in highest demand.

Energy storage can be used by transmission owners to mitigate the impacts of transmission congestion by placing storage assets downstream of choke points to store electricity at times of lower consumption for release at peak times. This reduces the need for excess power to flow through the congested line, minimizing transmission capacity requirements and potential congestion charges.

[7] DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA, February 2015
[8] Benefit-Cost Analysis for Distributed Energy Resources, Synapse Energy Economics, 2014

Ancillary Services

Ancillary services provide necessary support for the transmission of electric power from seller to purchaser to maintain reliable operations of the interconnected transmission system.[9] Examples include frequency regulation, voltage control, reserves, and load-following services.



Source: PJM

Frequency regulation refers to the need to react to short-term changes to supply and demand to maintain the frequency of the grid within its operational limits. Maintaining the frequency of the electricity on the grid is essential to ensure that it remains within the narrow range necessary to maintain system stability. System frequency that becomes too high or low can damage equipment and lead to blackouts or other grid failures.

ESSs such as batteries and flywheels are able to respond to frequency needs within seconds and with a considerably higher degree of accuracy than many traditional generation sources. These characteristics form the basis of the RegD market for fast-responding resources in PJM's frequency regulation market.

Load following refers to generation capacity that changes power output (as often as every few minutes) in response to changes in load, in order to manage changes in supply and demand. Similar to frequency regulation, load following acts on a longer timeframe with the goal of matching generation to load rather than maintaining grid frequency.

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[9] FERC Guide to Market Oversight – Glossary, https://www.ferc.gov/market-oversight/guide/glossary.asp

Energy storage provides load-following services by releasing energy into the system when load increases. However, when load decreases, storage can follow load down and act in one of two ways: either by ceasing to release energy into the system (similar to a traditional resource) or by taking in excess generation while in a charge mode. By acting as load, energy storage allows conventional generators to operate at maximum efficiency.

The electric grid relies on backup reserves to provide capacity in the event that regular supply resources unexpectedly become unavailable. Energy storage can be used as all types of reserve capacity, again reducing, deferring, or eliminating altogether the need for additional generation.

Rather than needing to be online, operational, and synchronized with the grid, energy storage simply needs to be charged and available. Additionally, because of storage's fast ramp rate, it can react almost immediately to control signals and does not need to come up to speed as non-spinning resources do.

Voltage control refers to assets that supply reactive power to the grid to maintain grid voltage within a specified range. Just as the frequency of the grid must be regulated to ensure it remains within a narrow band, the voltage of the grid must also be controlled to ensure it remains as close to the nominal voltage as possible.

Storage again plays an important role in serving as an additional capacity for providing reactive power to the grid when needed. The Cedartown and Panasonic projects (pages 10 and 18, respectively) each seek to evaluate the benefits of storage to provide voltage control services.

Behind-the-Meter

In addition to providing services at the utility scale, ESSs can be deployed behind-the-meter to provide a variety of services directly to energy end users. From backup power to demand shifting, behind-the-meter energy storage can provide significant value and is expected to grow from 25% of energy storage installations in 2016 to more than 50% in 2021.[10] Furthermore, behind-the-meter storage systems can potentially be aggregated to provide additional value as capacity or grid resources.

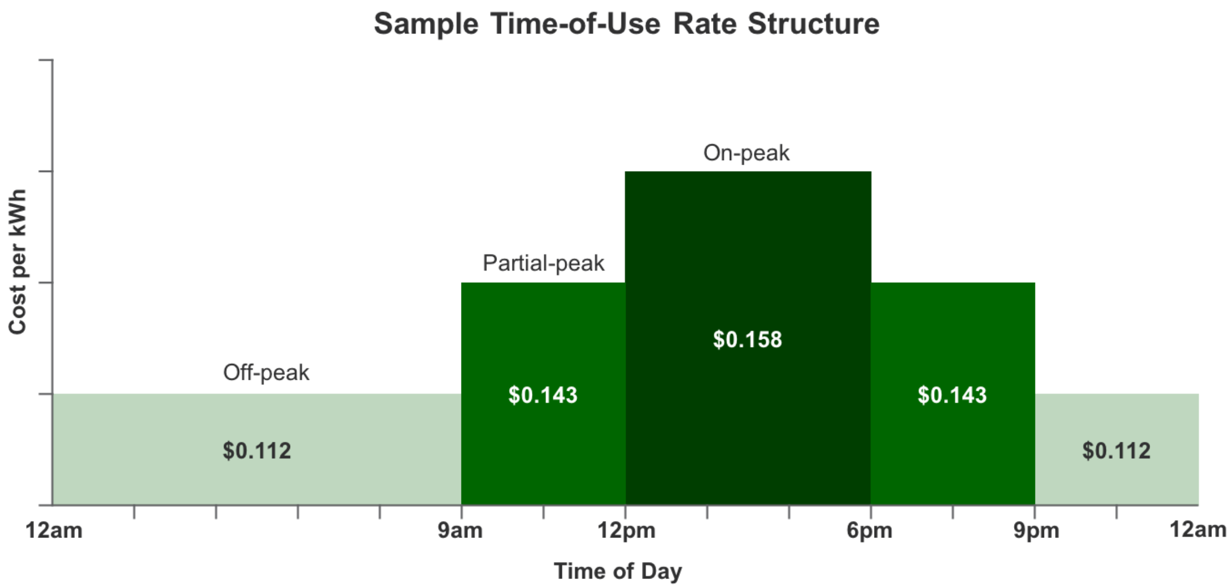
Backup Power

Energy storage can provide backup power during unexpected outages or disaster recovery scenarios. For some commercial and industrial customers, backup power is essential. Critical, must-run facilities such as hospitals require power to ensure life-saving services can continue to be provided to patients. Additionally, for some electronic manufacturers, a loss of power would be harmful to sensitive electronic equipment. In such cases, maintaining a backup power system provides a benefit by reducing the risk of a loss of power.

[10] U.S. Energy Storage Monitor: Q3 2016 Executive Summary, GTM Research/Energy Storage Association

Retail Electric Time Shifting and Solar Self-Consumption

Retail electric time shifting is a strategy used by customers to reduce their overall electricity bill by shifting consumption to times when rates are low. Using energy storage, customers can buy electricity when time-of-use (TOU) rates are the lowest (e.g., overnight), store it behind the meter, and then use it later during peak times when prices are greater, thus avoiding higher rates.



Customers in areas with high rates may choose to couple behind-the-meter energy storage with rooftop solar to reduce the amount of energy they must purchase from the utility altogether. Pairing solar + storage allows customers to generate their own electricity and store the excess for later consumption, thus reducing their overall use from the grid and lowering their electricity bill.

In states such as Hawaii, where there is high penetration of rooftop solar coupled with high electricity rates, solar + storage has been an effective strategy to manage electricity bills and has driven growth in behind-the-meter storage installations.[11]

Demand Charge Management

Commercial customers are typically charged for their peak demand (kW) in addition to the volume of energy (kWh) they consume over a billing period. In some areas, such as California and New York, demand charges can add up to as much as half of a commercial customer's monthly electricity bill.[12]

[11] U.S. Energy Storage Monitor: Q3 2016 Executive Summary, GTM Research/Energy Storage Association
[12] Energy Storage and Electricity Markets, Clean Energy Group, 2015

Demand charge management seeks to minimize peak demand over a given period by storing energy behind the meter at times of low usage and using that energy at times of higher use, thus acting to reduce the average peak load (also referred to as peak shaving) and minimizing the demand charges faced by the customer.

Microgrids

Many microgrids are designed to leverage renewables for some, if not all, of their generation needs. As the grid achieves higher levels of renewable penetration, there is a greater need to provide an additional source of power to maintain stability. In the bulk power system, this function is performed by the utility, but in a microgrid operating in an islanded configuration, the intermittency of renewable resources would require additional generation or risk instability caused by voltage or frequency variation.[13]

Energy storage can support microgrids by storing energy and using it to provide voltage and frequency support. In addition, storage can provide benefits, including smoothing variable generation and time-shifting solar and wind to meet peak demand. Finally, storage supports integration when connected to the grid.[14] This case is illustrated by Panasonic's use of energy storage at their Enterprise Solutions Headquarters in Denver (see page 10). The ability to island the facility's microgrid is one of the primary focus areas of the project as well as other stacked applications.

Conclusion

The variety of applications that energy storage can support is broad. As a generation resource, storage can provide capacity support services similar to traditional capacity resources, such as providing needed reserve capacity. As a grid resource, storage can enhance system efficiency by relieving transmission congestion and enhance operational flexibility. Finally, as a behind-the-meter asset, storage can provide a variety of services to energy end users such as backup power or bill management.

Still, there are larger questions surrounding the true value of energy storage, such as the overall value that storage provides to the grid, energy producers, and consumers; how to define the value of storage; and how to monetize the value in a way that benefits stakeholders and drives adoption.

[13] "Microgrids with 50 Percent Solar Do Not Need Storage," Greentech Media, http://www.greentechmedia.com/articles/read/microgrids-with-50-percent-solar-do-not-need-storage
[14] "Energy Storage Is a Key Ingredient for All Microgrids," Troy Miller, Renewable Energy World, 2015, http://www.renewableenergyworld.com/articles/2015/10/energy-storage-is-a-key-ingredient-for-all-microgrids.html

Case Study

Cedartown Battery Energy Storage Demonstration Project

OVERVIEW

WGL Holdings, Inc. (NYSE: WGL), through its subsidiary, WGL Energy Systems, formed a partnership with Southern Company and the Electric Power Research Institute (EPRI) to test and evaluate a battery storage system at a 1 megawatt (MW) solar array in Cedartown, GA.

OBJECTIVE

The purpose of this initiative is to analyze a 1 MW / 2 MWh lithium ion battery energy storage system and establish a technical and economic foundation for future grid deployments, with a specific focus on renewable integration. The research will facilitate:

- Development of a technology track record for lithium-ion battery systems
- Better understanding of the effectiveness of ESSs to support grid applications
- Hands-on experience in the installation and operation of a large ESS
- Increased knowledge of how battery ESSs can create value for customers

INTERVIEW WITH WGL: PROJECT DEVELOPER

The continued research and evaluation of battery storage is paramount to increasing the feasibility of solar energy for individuals, businesses, and municipalities.

An energy storage system is much more than just deploying a battery; there are many components that must all work together to become a functional system. Just like with any new installation, there have been unforeseen hurdles, many of which have been serendipitous in the sense that they have allowed Southern Company

Project Summary

Project Name:
- Cedartown Battery Energy Storage Demonstration Project

Location:
- Cedartown, GA

Technology:
- Lithium-ion battery
- Solar PV

Applications:
- Peak load management
- Renewable integration
- Voltage support

Owner:
- Southern Company

Development Partners:
- WGL Energy
- LG Chem
- EPRI

Key Dates:
- Entered into operation in September 2015
- Project duration: 3 years

to work through many potential issues before widespread deployments of ESSs. The integration aspects of Cedartown have required more attention than was originally expected. Southern Company has improved controls, protections, and communications schemes with the aid of EPRI.

The Cedartown Demonstration to date has accomplished much of the original goals outlined prior to project launch. Demonstrations like this project are necessary to establish models, frameworks, and economics and to enable renewable energy integration. It has allowed our joint team to gain hands on experience in the installation and operation of utility scale ESSs; and to understand the ability and effectiveness of energy storage to meet grid objectives and create value. Finally, Cedartown has allowed Southern Company to understand the total cost of ownership of an ESS of that scale and to work out potential problems that could arise in the deployment of future more energy storage assets.

Currently, the system is operational and testing has begun on some of its intended applications. Ultimately, the system's ability to peak shave, provide ancillary services, and integrate intermittent renewable assets will be tested and thus provide valuable insight for research and development purposes. To date, the facility is operating as expected and the main benefit is the continued educational opportunities that result from such a pilot program.[15]

ABOUT WGL ENERGY

WGL Energy is a leader in efficient and environmentally-friendly energy technology solutions to residential, government, commercial and industrial customers. WGL Energy delivers a full spectrum of energy solutions, including electricity, natural gas, renewable energy, carbon reduction, distributed generation and energy efficiency provided by WGL Energy Services, Inc. and WGL Energy Systems, Inc. WGL Energy's portfolio includes distributed generation projects in 19 states totaling over 205 MW.

Nate Greenberg, who joined WGL Energy as Business Development Manager in March 2010, provided the interview. In his role, he is responsible for the acquisition and development of solar assets within WGL Energy's Commercial Solar Investment program.

[15] Greenberg, Nate. Business Development Manager, WGL Energy.

Interview

FLEX

Alejandro Schnakofsky, Director of Applications Engineering for Flex Energy

Flex is an American supply chain solutions company with over 200,000 dedicated innovators, working across 30 countries to create a smarter, more connected world. Flex enables companies to go to market by augmenting their development and technical resources to advance new technologies and product offerings.

Q: As a leader in the development of energy storage balance of system components, how much do you see standards in energy storage driving the growth of the industry?

AS: This is actually very important. If you look at electrical power components—switch gears, protective relays, fuses—they are products where we have had industry standards for a long time; several decades ago that was not the case.

The first step for industry standards is standardization of use cases and ratings. I think that we are seeing that already. It is clear that the industry is clustering around grid support applications, which are high power from a battery perspective. From a hardware perspective, that follows our definition and has allowed us, as a systems integrator, to come up with a platform that centers around specific use cases.

Q: Use cases for energy storage are frequently defined in terms of long-term or short-term applications. How does that categorization enable manufacturers to design systems on that basis?

AS: We have found long-duration applications to be much easier to standardize than short-duration applications. For short-duration applications, utilities are typically very specific in regards to their technical requirements, and the cost structures of such systems support higher levels of customization. Whereas for energy applications, products have started to become generic, and we are actually starting to see consolidation and commoditization in those types of product solutions.

Q: Are there any areas where Flex sees dramatic cost reductions or technological improvements in the energy storage systems in the next two to five years?

AS: The biggest cost reduction in front of us is the dramatic decrease in the cost of bidirectional inverters. I predict that within one to five years we will see 10 to 12 cents per watt on the power conversion, which is going to be a significant reduction from what we see today, which is anywhere between 25 and 40 cents per watt.

Q: What applications or use cases does Flex find particularly interesting?

AS: Storage is interesting to us for two reasons. One is software innovation, which will ultimately give you the value of the hardware. That is the clear driver of value in the industry. The second is the financial innovation, financial engineering, or ownership models that these companies will need to come up with to make the systems viable not just in California or Hawaii, but other regions in the country and around the world.

Q: What no-regrets actions can be taken by the industry today?

AS: We are seeing a lot of interest in the commercial and industrial market for backup power. Essentially, there are all sorts of issues with stationary diesel tanks—from degradation of fuel to clogging of filters. They require a significant amount of maintenance to make sure that when the generators need to operate, they are actually working. We are not just looking at it from the perspective of emissions reduction, but maintenance and simplification. That is a key component and a key item for the true value that can be provided. If you take into consideration the design of a structure with storage in mind, then the cost structure is totally different than doing it via brownfield retrofitting, which is what is happening now.

Alejandro Schnakofsky*, Director of Applications Engineering for Flextronics Energy segment, is responsible for supporting business development personnel and other functions in technical matters related to electric power transmission and distribution and the energy storage markets. He also serves as the primary interface into the CTO Office to develop strategies to leverage Open Innovation & identify new technical capabilities needed to drive business growth.*

VALUING ENERGY STORAGE

The full range of benefits provided by energy storage includes economic, system, and non-energy benefits.[16] Storage benefits the grid economically in the form of increased efficiency and by reducing system costs. Storage also provides system benefits in the form of increased reliability and flexibility. Lastly, storage also provides non-energy benefits such as emissions reductions and helping to achieve clean energy goals.

Additionally, many ESSs can provide additional services beyond their primary applications which add significantly to the potential value of the system. As a result of the diverse nature of energy storage benefits, fully understanding the value of storage has proven to be a challenge.

UNDERSTANDING ENERGY STORAGE BENEFITS

Economic Benefits

Economic benefits are provided in the form of incremental revenue or cost savings. Incremental revenue can be earned either through the sale of energy storage services or through participation in wholesale markets, such as assets that are bid into capacity markets to support reserve requirements, ancillary services markets, or even directly into real-time and day-ahead energy markets.

In markets with high-demand charges, behind-the-meter energy storage companies earn revenues by assisting commercial and industrial clients in managing their energy use, producing revenues for energy storage companies as well as cost savings for their clients.

Whether participating in wholesale markets or providing behind-the-meter services, market conditions have to be conducive to storage in order to allow value capture, whether it be through structures that allow storage to participate in the market or rate structures that provide other pathways to monetization. Where such market and rate structures exist today, business models have emerged to monetize the value of energy storage.

Energy storage also provides economic benefits through cost savings. Avoided costs provide a simple method to quantify the value of energy storage by putting a dollar figure to the avoided costs themselves. Measuring avoided costs does not require changes to rate or market structures, although identifying which costs are actually avoided can be subjective and controversial.

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[16] World Energy Council, World Energy Resources Report 2016, E-storage: Shifting from Cost to Value 2016 – Wind and Solar Applications

For instance, in the case of an ESS used to mitigate transmission congestion charges, the value provided to the system would be, in part, the total of the avoided congestion charges over the presumed lifetime of the asset. Similarly, for some C&I customers that require stable power flows for the manufacturing of sensitive electronics, the value of voltage control services provided by energy storage can be valued according to the avoided cost of poor power quality on their operations.

In both cases, energy storage provides tangible benefits in terms of generating incremental revenues or reducing costs for system owners.

System Benefits

As penetration of renewable energy accelerates, grid operators need to be able to call up fast ramping supply resources to provide capacity support when renewable resources are scarce or, in the case of storage, to dispatch load when conditions allow renewables to operate at, or near, peak capacity.

By acting as both capacity and load, energy storage offers greater flexibility in helping the system respond to unanticipated changes, reducing risk to the system through increased resource optionality.[17] ESSs also enhance resiliency and serve to reduce risks from outages or other unexpected system events.[18]

Energy storage supports the grid by providing distributed capacity, frequency, and voltage support, as well as fast ramping resources that allow the grid to avoid system bottlenecks, improve power quality, and more easily respond to sudden changes in supply and demand. These services improve system efficiency and reduce system costs, providing benefit to system operators and users.

Non-energy Benefits

The value of storage is not limited to the delivery of energy. As an enabling technology, storage can increase the amount of renewable energy that is delivered to consumers and reduce dependence on more carbon-intensive generation. This in turn lowers carbon emissions and, in some cases, may even reduce potential compliance costs for generation owners and system operators.

In the case of load following generation or spinning reserves, traditional generators are required to operate at less than optimum levels while waiting to be called upon to provide services. Energy storage enhances the efficiency of other grid assets and can help avoid the need to place other systems on standby when supply exceeds demand, which can be costly and may reduce environmental benefits.[19]

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[17] World Energy Council, World Energy Resources Report 2016, E-storage: Shifting from Cost to Value 2016 – Wind and Solar Applications
[18] Benefit-Cost Analysis for Distributed Energy Resources, Synapse Energy Economics, 2014
[19] DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA, February 2015

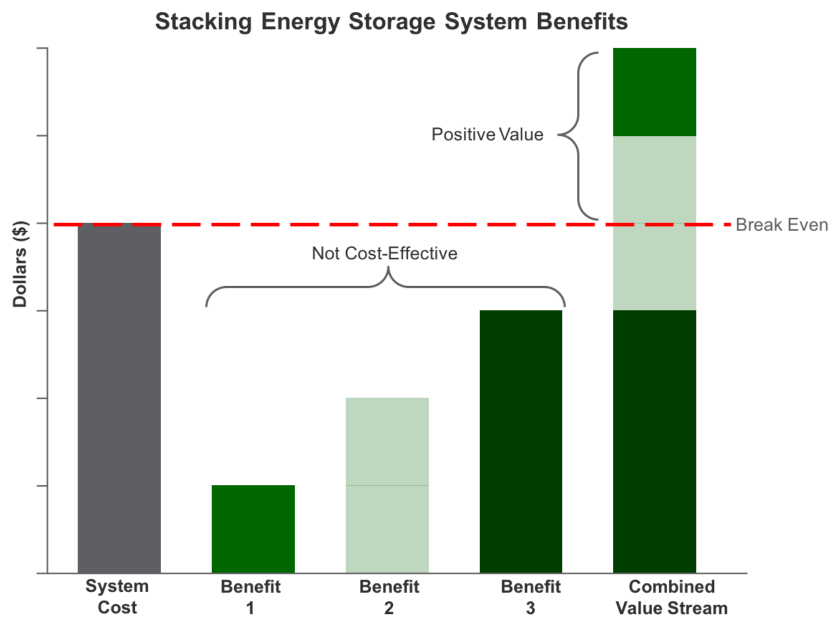
Energy storage can provide these services more efficiently without the risk of higher emissions. Moreover, a single energy storage asset could perform the role of both load-following generation and spinning reserves, providing even greater value to the system owner.

The value of non-energy benefits is hard to quantify, as discussed in a later section. However, it remains important to be aware of non-energy benefits and understand their impact when valuing energy storage applications.

BENEFITS STACKING

A crucial component of the value of storage is its ability to support multiple applications—and thus value streams—at the same time. In many energy storage applications, the delivery of the primary service may only take up to half of the storage system's capacity.[20] Using the remaining capacity in other applications allows the system to provide multiple, stacked services that create additive value for the system.[21]

A compelling case for benefits stacking is the application of energy storage to defer transmission or distribution system upgrades. In a deferral application, an ESS is only required a few times a year when peak demand on the system exceeds existing capacity. In a single application environment, the rest of the time the system would be idle.



[20] The Economics of Battery Energy Storage, Rocky Mountain Institute, 2015, http://www.rmi.org/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport
[21] Ibid

However, by providing other services during times when the primary application is not required, the system can maximize its utility and add significant value both economically and to the system. In this case, depending on the characteristics of the system, the storage system may also be able to provide load following or reserve capacity, or help meet resource adequacy requirements—all of which would add significant value to the asset.

The same can be seen in the behind-the-meter storage market in California, which is driven largely by demand charge management for commercial and industrial customers. In these applications, ESSs may only be utilized 5% to 50% of the time.[22]

The California Independent System Operator (CAISO), in recognizing the potential of these assets, is working to allow behind-the-meter storage to provide demand charge management services up to 50% of the time, while being aggregated and bid into the CAISO wholesale market as supply side resources for the other half of the time. This has the potential to significantly improve the economics for the systems involved.

While not every storage system is equally suited to support multiple applications, stacking benefits distributes the cost of energy storage across multiple revenue streams, greatly enhancing its cost effectiveness. However, each application is unique, depending on the context in which it is utilized and the market and regulatory frameworks present.

When assessing the value of energy storage, effort must be made to understand the full range of economic, system, and non-energy benefits that a storage system can provide. Doing so is necessary to understanding the full value of storage relative to its cost. Consequently, in order to drive adoption of energy storage, existing barriers to its adoption must be addressed.

But how do we capture and realize energy storage benefits once we understand their value? What issues need to be addressed to increase the value proposition for stakeholders and drive energy storage adoption?

[22] The Economics of Battery Energy Storage, Rocky Mountain Institute, 2015, http://www.rmi.org/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport

Case Study

PEÑA STATION SOLAR PLUS STORAGE MICROGRID PROJECT

OVERVIEW

The project is a battery storage demonstration project, connected to the Xcel Energy power grid, designed to help understand system-wide benefits of energy storage and what benefits go to each owner of the storage system. The objective is to develop a better awareness as to how the economics can work for all participants.

OBJECTIVE

The goal of the project is to quantify and demonstrate, in a real world environment with customer participation, the multiple stacked benefits that can come from a single storage resource and how those benefits accrue to different combinations of the stakeholders. In this case, the expected benefits include voltage regulation, grid peak demand reduction, passive energy arbitrage, and regulation services, in addition to providing backup power to the host facility.

INTERVIEW WITH PANASONIC: PROJECT DEVELOPER AND OFFTAKER

The project is sited adjacent to Panasonic's new Denver operations hub, anchor for the broader Peña Station NEXT development, a 400 acre smart and sustainable transit oriented development near the Denver International Airport. It features a 1 MW / 2 MWh lithium-ion battery system, owned and operated by Xcel Energy, that is coupled with a 1.6 MWDC solar PV carport system owned by Xcel Energy installed on carport structureowned by the Denver International Airport, and a 259 kWDC rooftop solar array on Panasonic's facility. Younicos storage control software is designed to provide multi-mode operating capability to enable Panasonic, Xcel Energy, and future tenants derive maximum benefits from battery storage and high penetration of PV solar.

Project Summary

Project Name:
- Panasonic Enterprise Solutions Peña Station Solar Plus Storage Microgrid Project

Location:
- Denver, CO

Technology:
- Lithium-ion Battery
- Solar PV

Applications:
- Distribution voltage regulation
- Grid peak demand load reduction
- Microgrid/resiliency
- Regulation services

Owner:
- Public Service Company of Colorado

Development Partners:
- Panasonic Energy Solutions
- Younicos

Key Dates:
- Expected to enter into service in the spring of 2017

Rather than thinking of the singular benefit or use-case storage can provide, the objective of this project is to value the real benefit of the battery, which is its flexibility. The benefits of the system will go to both the host Panasonic in terms of islanding potential for its network operations center, as well as to Xcel Energy. The pilot project will determine the optimal battery operating parameters and the best ways to optimize the battery asset to maximize the overall benefits for all stakeholders.[23]

ABOUT PANASONIC

Panasonic Energy Solutions Group, a unit company of Panasonic Corporation of North America, develops, installs, and maintains large-scale energy solutions for utility, business, government, and institutional customers. Janet Lin is the group's Strategy Director.

[23] Lin, Janet. Senior Manager, Strategic Planning, Panasonic USA. (2016, September 27). Telephone interview.

Interview

Starwood Energy and Vionx Energy

Alan Dash, Director, Vionx Energy
Patrick Verdonck, Principal, Starwood Energy

Starwood Energy Group Global, LLC ("Starwood Energy") specializes in energy infrastructure investments, with a focus on natural gas and renewable power generation, and transmission assets. Through its general opportunity funds (Starwood Energy Infrastructure Fund I and II, and other affiliated investment vehicles), Starwood Energy manages total equity commitments in excess of $2 billion, and has executed transactions totaling more than $5 billion in enterprise value. The Starwood Energy team brings extensive development, construction, operations, acquisition and financing expertise to its investments.

Vionx Energy Corp. ("Vionx Energy"), a Starwood Energy portfolio company, is a battery storage technology company that has developed a 6-10 hour vanadium redox flow battery using technology pioneered by United Technology Corp. Vionx Energy has strong technology and financial partners through its affiliation with Jabil Circuit, Inc. and VantagePoint Capital Partners, L.P. Vionx Energy had deployed batteries in several operational projects including one with the U.S. Army.

Q: Starwood Energy has, to date, primarily invested in large energy infrastructure investments, such as utility-scale power plants and transmission assets. With that in mind, how is Starwood Energy looking at energy storage and what investments have you made in storage?

Patrick Verdonck: Starwood Energy Group has divided the storage market into short-duration energy applications and long-duration energy applications. On the short end, there are peak shaving applications, ancillary services and continued power requirements. On the long duration side, there is renewable energy integration and, more importantly, transmission and distribution support, mostly congestion relief and the ability defer or avoid transmission and distribution system capex.

Five years ago, we had the opportunity to invest in a flow battery company with United Technologies and brought that company to a full commercial product, Vionx Energy. On the short duration side, we have agreed to provide up to $100 million dollars of project-level financing to Stem, a leading developer of distributed batteries.

Q: Is there one particular value stream you look at when evaluating potential investments?

Alan Dash: Energy storage is a flexible resource and can, depending on the market, create several different value streams including:

Short-duration Applications: In California, putting two-hour batteries at commercial and industrial sites saves the customer a lot of money by not hitting demand ratchets and provides the utility with local capacity in often constrained load areas. Participating in the wholesale markets for ancillary services and energy could become an incremental value stream for these projects. There is a great ability to capture and monetize these streams whether under contract or merchant market.

Long-duration Applications: It is very expensive to supply islands, like Hawaii, with fuel. Consequently, putting solar and long duration battery-systems onto the island grid has a fast payback period. The local utility can offer lower rates, which benefits consumers, and investors can earn a reasonable return on their investment.

Another long-duration storage application example is the New York-Brooklyn-Queens Demand Management program. Parts of Brooklyn and Queens are seeing significant population growth that is leading to increased power demand, which, in turn, is threatening to overload local distribution circuits, particularly on hot summer days. This overload could reach up to 70 MW. Rather than build a $1.2 billion substation, a combination of batteries and other demand-side measures provides the same congestion relief at significant savings to the ratepayer. Similar situations are true for many metropolitan areas such as the Los Angeles and San Diego basins.

More broadly, studies indicate that the transmission system has approximately a 30% capacity factor. Since utilities simply cannot afford to redesign the whole distribution system, batteries can solve many congestion and reliability problems at a lower cost than adding generation or transmission and distribution capacity to the grid.

Q: How do you see market and rate structures changing over the next two to five years?

AD: Utility-scale batteries are perhaps best known for providing ancillary services. That is a small niche market that provides reasonable revenues for now but that will soon be saturated. However, all the other applications of storage are evolving, especially on the long-duration side.

A few of the projects Vionx is working on are a wind integration project, which will open up in a few weeks, and solar-peaker plants, in Hawaii and Massachusetts, that will open up market opportunities for renewable integration.

PV: In addition, we see indications that in extremely sunny areas, particularly deserts in the Southwest, there is a terrific opportunity to solar+storage, which can displace peakers. As a result, you see the ability to integrate renewable resources into the grid with batteries in a much more effective way than we have seen in the recent past.

We will continue to see, demand charge management and power quality support, primarily in California, New York and increasingly Oregon and Massachusetts, and we will see great growth in behind the meter, renewable integration and congestion relief applications.

Alan Dash *is a Director on the board of Vionx Energy, a portfolio company of Starwood Energy. Vionx Energy holds the global, exclusive license to a vanadium redox flow battery developed by United Technologies Research Corporation. In his role as Director, Mr. Dash is responsible for the formation of strategic relationships, the global sourcing of vanadium, arranging the manufacturers performance warranty insurance critical for project finance, and raising corporate and project capital.*

Patrick Verdonck *is a Principal with Starwood Energy and is responsible for making principal investments in the power sector. He was actively involved in the acquisition of Quail Run and Berlin Station. Most recently, he led the structuring of Starwood Energy's battery storage finance program with Stem. In addition, Mr. Verdonck held an observer role on the board of Nautilus Solar Energy.*

MONETIZING THE VALUE OF ENERGY STORAGE

Monetizing the value of storage continues to face challenges that go beyond just understanding its applications. Benefits that do not result in direct value streams are hard to quantify and often left out of cost-benefit analyses. In some regions, existing market structures inadvertently limit participation of energy storage. In others, a lack of clarity about whether storage should be classified as a generation or transmission asset prevents storage from participating in the market. Lastly, not all benefits are distributed to all stakeholders, which may limit investment and cloud understanding of an asset's full value.

COMPREHENSIVE BENEFIT VALUATION

In order to fully realize the value of energy storage, cost-benefit analyses need to take into account all benefits, including system and non-energy benefits, where possible. System benefits, such as increased reliability, while difficult to quantify, are one of the key benefits provided by storage and should be included in storage valuation. While challenging, quantifying the value of system benefits has been accomplished for other energy resources, such as demand response and energy efficiency programs.[24]

System benefits can be quantified according to agreed-upon proxies or valuation techniques that recognize the benefit being provided. One approach is the value of lost load, which seeks to value the reliability benefit that storage assets provide in terms of avoiding the cost-of-service outages.[25] Alternatively, the Department of Energy developed the interruption cost estimate calculator tool for system planners to use in estimating the benefits associated with reliability improvements made to the grid.[26,27] Each of these approaches provide a framework around which a basis can be formed for valuing the reliability benefit of ESSs to the grid.

Non-energy benefits such as emissions reductions or clean energy goals can also be approximated. The Environmental Protection Agency's social cost of carbon tool is a starting point for an approach to value the environmental benefits that result from increased renewable generation and emissions reduction. While not a direct value, the social cost of carbon is useful in shedding light on the benefit provided by storage's ability to enable large-scale renewable generation and other environmental benefits.[28]

[24] Benefit-Cost Analysis for Distributed Energy Resources, Synapse Energy Economics, 2014

[25] Value of Lost Load: An Efficient Economic Indicator for Power Supply Security? A Literature Review, Schröder T. and Kuckshinrichs W., Front. Energy Res. 3:55. doi: 10.3389/fenrg.2015.00055 (2015)

[26] Interruption Cost Estimate Calculator, U.S. Department of Energy, http://www.icecalculator.com/

[27] Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States, Michael J. Sullivan, Josh Schellenberg, and Marshall Blundell, Nexant, Inc. 2015

[28] Environmental Protection Agency, Social Cost of Carbon, https://www3.epa.gov/climatechange/EPAactivities/economics/scc.html

While direct valuation is preferred, estimating the impact of system and non-energy benefits of energy storage provides a better option than leaving out these attributes entirely. By estimating these benefits, it is possible to avoid unintentionally undervaluing storage assets.

MARKET PARTICIPATION

In markets where pathways to monetization are clearly defined, known applications of energy storage are monetizable through markets or rate structures that allow the value of energy storage to be realized. This is most evident in PJM, where due to its frequency regulation market for fast-responding resources, the energy storage market has flourished.[29]

Other RTOs/ISOs also allow storage to participate in wholesale markets, but current market structures were written for traditional resources and unduly limit storage participation. For instance, restrictions on resource size, duration of output, or market eligibility (ancillary services vs. capacity markets) unintentionally bar participation by storage assets.

The Federal Energy Regulatory Commission has recognized these issues and is leading efforts to identify barriers to participation of energy storage in wholesale markets through its AD16-20 proceeding. Removing barriers that exist, such as restrictions on minimum capacity and duration, will allow additional resources to participate in existing markets.[30]

ASSET CLASSIFICATION

Another potential barrier to participation in organized markets is the classification of energy storage assets. Storage is a hybrid asset and does not easily fit into traditional definitions of generation, transmission, or distribution—the categories which define traditional benefits assessment and monetization.

Today, only a few RTO/ISOs recognize storage as a unique asset class, and existing regulatory structures are not sufficient to address assets that either fall in between, or span, operational categories. As a result, classifying resources under current wholesale constructs has been problematic for energy storage adoption.[31]

How a storage resource is classified affects how it is compensated and valued. For example, short-term storage (flywheel, battery) for frequency regulation, black start, and reactive supply and voltage control has qualified under MISO's tariff since 2009; but under current rules, medium-term storage (battery,

[29] Energy Storage and Electricity Markets, Clean Energy Group, 2015
[30] Federal Energy Regulatory Commission Docket No. AD16-20-000, April 2016
[31] ScottMadden, Energy Industry Update, Volume 16, Issue 1, 2016

thermal storage) that can provide more than four hours of power does not qualify as capacity, energy, or reserves.[32]

In extreme cases, some current regulatory frameworks may even serve to inhibit storage investment. In Texas for instance, T&D service providers are prohibited from owning generation and operate solely as wires companies. Under the current regulations, an ESS designed to provide transmission congestion relief cannot also participate as a generation resource in the wholesale market. This limits benefit stacking opportunities and potentially leaves money on the table. In this case, a regulatory framework would need to be provided that would clarify ownership and application of energy storage assets on the grid that have the capability to provide capacity-related services.[33]

Distribution of Energy Storage Benefits

Due to the wide variety of benefits and the ability for an ESS to provide multiple services, accounting for and allocating storage benefits to stakeholders is a challenge that can hinder investment.
Key to driving investment in energy storage is the need to develop models that account for all of the benefits provided by the system to all stakeholders. Partnerships between utilities, developers, C&I customers, etc. will need to become more common in order to better capture and allocate the benefits of storage systems. For example, in the Panasonic case, multiple stakeholders, including owners and customers, are partnering to better understand, in part, these types of questions.

Incentives or alternative compensation mechanisms can also be used to realize indirect energy storage benefits. In other segments of the power system, incentive rates of return on equity have been used to drive investment in transmission infrastructure. Because not all benefits of increased transmission, such as reduced congestion and greater system reliability, go to the investor, there is a need to incentivize transmission development. While the developer or transmission owner is able to directly monetize some benefits, system-wide benefits accrue to customers and utilities through increased reliability. A higher rate of return, in part, compensates investors and transmission owners for these benefits.

In wholesale markets, this can be done through the development of market product specifications and prices that reward energy storage for the system-wide benefits it contributes to the system. Similarly, regulators have the ability to build appropriate incentives into rates or market structures that serve to allocate benefits across customers, utilities, and developers.

As the link between electricity systems and customers, utilities have a unique opportunity to aggregate energy storage benefits and redistribute them to their customers. By realizing the benefits of improved operations, increased efficiency, and reduced system costs, these benefits can then be quantified and passed on to customers through lower rates and improved service.

[32] ScottMadden, Energy Industry Update, Volume 16, Issue 1, 2016
[33] The Value of Distributed Electricity Storage in Texas, The Brattle Group, 2014

Interview

DNV GL

Dr. Davion Hill, Energy Storage Leader, Americas

DNV GL provides classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas and energy industries. In the energy sector, DNV GL provides independent engineering services to support renewable energy project development In the energy storage area, DNV GL is providing performance and safety testing, technology reviews and due diligence, and economic use case modeling for customers.

Q: DNV GL has done quite a bit of work on New York's Reforming the Energy Vision (REV). Could you give us some specific examples where you see storage providing value? What are some of the big issues in capturing benefits in terms of rate-design?

Davion Hill: In New York City demand management is a major technical challenge. The markets therefore need to adequately value this service; the value of avoiding the peak, distribution system upgrades, and responsiveness and reliability of the solution. There are precedents for this across the US, but New York has the unique challenge of bringing these together simultaneously. New York is presently challenged to structure electricity tariffs with great detail to capture these revenue streams, however the effort to do so will delay the implementation of the market until this is done.

Q: Which storage functions do you see as the most valuable and which are the most difficult to accommodate?

DH: The NYBEST 2016 Energy Storage Roadmap for New York's Electric Grid cites NewYork's challenges: improving efficiency and capacity factor of the grid, integrating renewables, and increasing resiliency. According to the New York Public Service Commission, the peak 100 hours of demand cost rate payers $1.2-$1.7 billion. Adequately valuing services for the long term that reduce demand cost is the first necessary step.

Q: DNV GL has also done a substantial amount of work in California around rolling out the energy storage mandate, which is very different from REV. What are the biggest differences in the ways each market looks at valuing storage?

DH: California's higher penetration of renewables increases the need and demand for frequency support. New York has congestion issues, lower solar, and greater diversity regionally that makes their case unique. In California, the demand charge business model is already clear. In New York, once these prices are settled, the market will have the information it needs to move.

Q: The differences in regional markets are critical in determining the true value proposition of energy storage. How do you see

other state and regional markets evolving to better capture these benefits?

DH: A state needs to take several steps to seriously adopt both renewables and storage. First, the renewable portfolio standard (RPS) needs to have teeth, i.e. the public utilities commission needs to hold its utilities accountable to meet it. Second, the rate structures need to be set and then left alone, i.e. demand charges need to be approved and implemented, and this may also require hand-holding between municipalities, utilities, and the local ISO. Third, the local ISO needs to have pay-for-performance markets. Energy storage can be interesting on stacked revenue streams with demand charges and frequency regulation alone. Remember that these address both behind the meter and utility markets; behind the meter storage *is a utility solution*. Fourth, bringing it back to the state RPS, the federal tax equity play with the ITC is helping the market, and even though that’s a big window right now, it is really only about 3 years to get this done and get projects in the ground. If states can get those right and drive it through the PUC and the utilities, and do it in the next 12-24 months, they can create stable markets for storage and will likely find that they are addressing congestion, peak generation constraints, and economic development goals by doing so.

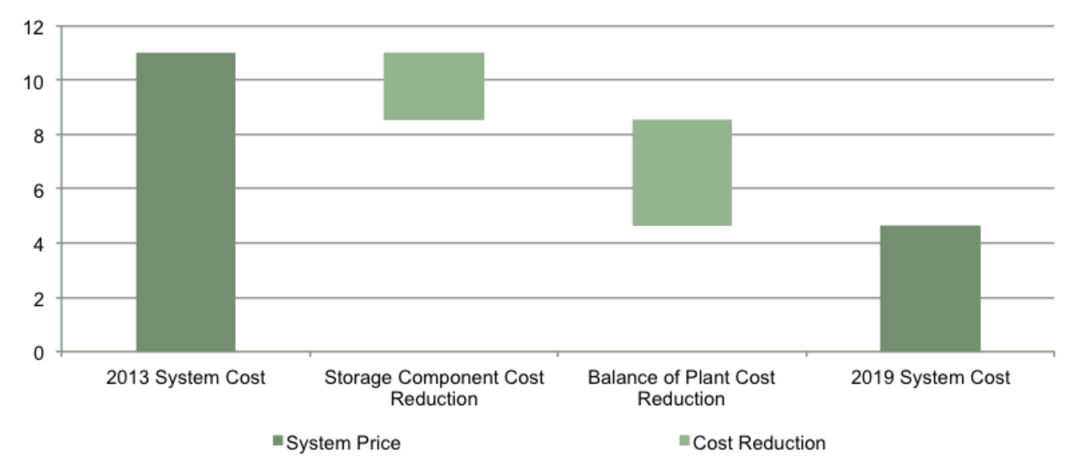
***Dr. Davion Hill** is DNV GL’s Energy Storage Leader for the Americas region and is the 2016 Chairman for NAATBatt International.*

CONCLUSION AND RECOMMENDATIONS

Energy storage has the potential to change the very nature of our relationship with the electricity system. By decoupling the generation of energy from its consumption, storage opens up a world of opportunities for better managing the grid, optimizing existing resources, and integrating large-scale renewable resources.

As costs decline, more applications will become competitive and deployments are expected to increase. Overall price-reduction estimates range between 12% and 15% per year, with the cost of some technologies dropping by up to 50% within the next five years.[34,35] Pilots and demonstration projects are transitioning from focusing on proving storage technologies to proving storage economics and identifying successful business models.

Forecast Installed Price Reduction of a 10 MW / 5 MWh Battery Storage System ($ million)



Notes: Based on typical 10 MW / 5 MWh Li-ion energy storage system
Source: IHS

© 2015 IHS

Even as costs are falling, the full value of energy storage often remains elusive. Many attempts at evaluating the cost-benefits of storage leave out all but the most immediate benefits and fail to account for the potential for most storage systems to provide multiple value streams. As the cost of storage technologies continues to decline, cost-benefit analyses can be better framed to account for broader benefits and multiple value streams. As this happens, storage will move from select applications in limited areas to more fully realize its broader potential.

[34] U.S. Energy Storage Monitor: 2015 Year in Review, GTM Research/Energy Storage Association
[35] "IHS: Grid-scale lithium-ion battery storage prices will decline by half by 2019", Utility Dive, November 2015, http://www.utilitydive.com/news/ihs-grid-scale-lithium-ion-battery-storage-prices-will-decline-by-half-by/409822/

By stacking benefits, the cost-to-benefit ratio of energy storage can be much higher than for individual applications, and the number of potential markets can be expanded beyond those where storage is prevalent today. Recognizing the system and non-energy benefits that exist in addition to stacking adds to the value proposition of storage.

Nevertheless, there are challenges to realizing this potential. Not all energy storage benefits are easy to quantify, making valuation of storage difficult. Stacking of benefits is still largely conceptual and requires advances in energy storage software systems to better understand how to economically dispatch stacked applications. System and non-energy benefits accrue across a large pool of beneficiaries, requiring new models to be developed that allocate storage benefits to all stakeholders. And lastly, there are significant regulatory barriers with respect to asset classification and the achievement of clear market mechanisms that reward storage for the benefits it brings to the system.

As state regulators make efforts to incentivize energy storage development, mandates and programs are beginning to emerge as a means to drive investment. Most notable is California's 1.3 GW by 2020 mandate for storage and a recently passed mandate in Massachusetts that is expected to be established by the end of 2016.[36]

There is little doubt that energy storage has the potential to be a transformative technology, changing everything from how we manage the grid, to how we power our homes. However, there are challenges to realizing the full value of storage that will need to be addressed. To recognize this value in a way that will drive investment in energy storage, the following areas need further exploration:

1. **Adopting cost-benefit frameworks that go beyond immediate system costs and benefits to take into account the full spectrum of economic, system, and non-energy benefits across stacked storage applications**

   Models should be developed that take into account system, stacked, and non-energy benefits in order to best understand the full potential value provided by a proposed ESS. Economic benefits can continue to be the primary consideration, but stacked benefits should also be considered according to expected use. In addition, system benefits, such as increased flexibility and reliability, and non-energy benefits, such as emissions reduction, should be estimated to the closest value possible and included in cost-benefit analyses, whenever possible. While not the optimal solution, ignoring these benefits altogether undervalues storage and should be avoided.

[36] "An Energy Storage Mandate Could Be Coming Soon to Massachusetts," Greentech Media, 2016, http://www.greentechmedia.com/articles/read/an-energy-storage-mandate-could-be-coming-soon-to-massachusetts

2. **Clarifying paths to revenue to facilitate the development of energy storage business models**

   Market and regulatory structures need to be developed that provide clarity around the revenue opportunities for energy storage. In areas where clear pathways to monetization exist today, energy storage has flourished and business models have developed to leverage the capabilities of storage to provide benefits across the full range of stakeholders.

3. **Improving regulatory clarity around asset classification and developing agreed-upon valuations for system and non-energy benefits**

   In many areas, market participation requirements, such as capacity and duration minimums, inadvertently limit participation of energy storage in markets where it may otherwise have the ability to provide benefits to the electricity system.

   How energy storage assets are classified can inhibit growth and warrants consideration for how to embrace hybrid resources, like storage. Market rules need to be developed that allow for storage participation in energy markets, and limitations or asset classification rules that hinder growth should be revised in a way that allows storage to meet the needs of the system.

4. **Distributing system benefits to the full range of stakeholders**

   Energy storage provides a wide range of benefits that accrue to a large pool of stakeholders. However, current models may not distribute all benefits, such as system or non-energy benefits, to all stakeholders, potentially limiting energy storage investment and development. Recognition of the full range of stakeholders and beneficiaries of ESSs is needed in order to facilitate investment and guarantee returns for risk takers. New and creative models are needed that will recognize risk-takers and allocate benefits accordingly.

Energy storage is increasingly recognized for the benefits it can provide to the system and the potential value streams it can create. As the value of energy storage becomes fully realized, adoption of storage will grow, playing a key role in enabling the transformation of the grid into a more flexible and efficient electricity system.

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