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A review of energy storage financing—Learning from and partnering with the renewable energy industry

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ABSTRACT

The energy storage industry has made great progress in developing technology, standards, and market policies and is poised to offer solutions to rapidly changing energy markets. Currently, energy storage as a solution is more inhibited by project financing than by the technology itself. High capital costs and a lack of financing options and incentives make it difficult for large scale energy storage to be realized. These same challenges were faced by the renewable energy sector a decade ago and have since been largely overcome through a decrease in costs and in perceived risk, innovative financing mechanisms, incentives and subsidies, and renewable portfolio standards. However, it will not be as simple as transposing the incentives and mechanisms that worked for renewables to the energy storage industry. This research will evaluate which elements and mechanisms of renewable energy financing can be applied or adapted to fit the energy storage industry and which cannot.

As renewable energy makes up more of the supply mix, the need for storage will be greater. Most states and provinces are planning for increased renewables, however, without also providing adequate incentives for storage, there will likely be disconnects between long-term planning and market designs. As technologies matures, prices are likely to decrease, however, as has been seen in the renewable industry, market rules and regulations can have strong influence on whether energy storage is economically feasible. New project finance models and a favourable regulatory environment will be key to transforming and unlocking the energy storage market.

Innovative financing mechanisms such as corporate power purchase agreements (PPAs), hybrid bonds, cooperatives, and flip-models have played a pivotal role in financing the development of renewable energy projects. Some elements of these mechanisms can apply to energy storage as well however, energy storage PPAs will be more complex than renewable energy PPAs due to the multifunctional capability of an energy storage facility. Energy storage developers can look to renewable energy as a guide for how nascent technologies can compete against established energy technologies in the market. The industry is in need of case studies, not to showcase that the technologies perform, but to demonstrate different mechanisms that projects can implement to achieve successful commercialization.

1. Introduction

Energy storage is central to enabling broad renewable energy adoption and has been identified as the ultimate solution for allowing intermittent sources, such as wind and solar, to meet utility base load demands [1]. Managing the variability and intermittency of renewable energy is a major challenge to achieving higher grid penetration. Energy storage can address this challenge by increasing the flexibility of grid operations in an economical and environmentally friendly way. Although energy storage still remains a relatively small market, as was the case with renewables a decade ago, growth is on the horizon. GTM Research expects the U.S. energy storage market to grow from 221 MW in 2016 to roughly 2.6 GW in 2022, with cumulative 2017–2022 storage market revenues expected to be over $11 billion [2,3].

Currently, energy storage as a solution is more inhibited by project financing than by the technology itself. High capital costs and a lack of financing options and incentives make it difficult for large scale energy storage to be realized. These same challenges were faced by the renewable energy sector a decade ago and have since been largely overcome through a decrease in costs and in perceived risk, innovative financing mechanisms, incentives and subsidies, and renewable portfolio standards. Some of the lessons learned by the renewable energy industry can be considered as the energy storage industry looks to overcome similar barriers. However, there are also some distinct

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differences between the industries and it will not be as simple as transposing the incentives and mechanisms that worked for renewables to the energy storage industry.

This paper provides discussion on the pathway that the energy storage industry can take to improve financing options for project development. The first consideration is for the benefits of energy storage to be well defined and quantified. It is now clear that energy storage systems (ESSs) can provide valuable services to the grid. For systems to be deployed, however, the value of the services that they provide must exceed the costs of the system over its lifetime. This introduces the first challenge surrounding energy storage financing – quantifying the benefits of an ESS. The next consideration is for the energy storage industry to evaluate the policies and financing models that have allowed the renewable energy industry to expand over the last decade and to replicate what worked well and improve on the identified shortcomings. This leads into what will likely be a major driver of economical project development which is the development of incentives as a means of lowering the costs of ESSs and allowing them to compete with generation.

Recently, contracts have been awarded that include both renewable energy and energy storage such as the solar plus storage power purchase agreements (PPA)s executed in Hawaii and Arizona [4,5]. In these innovative contracts the cost of energy, including demand charges, are used as the basis of the PPA price. These allow for developers to have better control over when electricity is generated and could lead to better PPA terms. These are another opportunity for the energy storage sector to partner with renewables in order to obtain financing. Lastly, an innovative financing model for storage is highlighted to encourage developers to consider creative solutions to enabling storage deployments.

2. Quantifying the benefits of an energy storage system

A myriad of promising technologies are being developed to address the need for storage to support electrical grids that can meet demand increases through integration of low emitting energy sources. One challenge surrounding commercialization of energy storage is the difficulty in quantifying the economic benefits that ESSs can provide. While it is easier to quantify benefits from renewables such as solar and wind because they generate kWh, it is a bigger challenge to value storage. Further complicating the economics is that the organizations paying for the ESSs are not the ones receiving most of the benefits.

There are several ways in which energy storage systems provide real value to an energy system. The first way in which this can be quantified is through capacity value. For example, a 1 MW system can offset the equivalent of a peaking combustion turbine. The value of capacity is contingent on the system actually requiring additional capacity to meet additional demand or to replace a retiring asset. This makes is challenging to assign value as there will be a large range depending on location and markets. Annualized values for capacity in the PJM market for 2011–2013 ranged from \$40/kW-yr to \$90/kW-yr [6]. Where capacity values have been estimated, it has been implied that capacity value from ESSs are greater than operational benefits [7].

Arbitrage is another quantifiable benefit of energy storage – systems can be charged during low-price periods and discharged during high price periods. In Massachusetts for example, with respect to hourly pricing, the top 10% of hours accounted for 40% of the electricity costs in 2013–2015 [8]. The ability to use energy generated during low cost periods to serve load during peak periods is unique to ESSs and can improve the overall economics of the grid. A recent study demonstrated this value with an optimization approach to obtaining bidding strategies for wind energy and energy storage in a day-ahead electricity market [9]. The wind plus storage combination lead to increased economic performance through the use of energy arbitrage. Quantifiable arbitrage benefits will vary depending on the system characteristics and efficiency. Previous reports have suggested values ranging from \$46–\$115/kW [10,11]. A more recent study on European markets reported arbitrage revenues ranging from \$EUR5–\$EUR40/MWh [12]. These studies demonstrate that arbitrage values alone are unlikely to support new project developments, however, in combination with frequency regulation, the ability to provide or reduce generation on demand, the benefits increase substantially. A 2010–2011 study of California markets reported combined benefits of arbitrage plus regulation ranging from \$117–\$161/kW [13].

Energy storage can also mitigate or defer the need to construct new generation to meet increasing demands. The avoidance or deferral of costs provides a quantifiable value attributable to the system. Another quantifiable benefit is curtailment recapture. When renewables are curtailed by the utility during periods of excess production on the grid, storage systems allow for energy to be generated and stored for later deployment. A recent study in California demonstrated a decrease in curtailment of solar PV from 17% to 5% [14]. Assigning a value to curtailment recapture is a challenge because due to number of factors that value would be driven by, including local grid conditions, underlying contractual agreements with suppliers, production tax credits, and other regulatory issues [13]. ESSs are also assumed to provide value through avoided line losses compared to centralized generation and through balancing services.

Lastly, energy storage systems can provide resiliency which can reduce or eliminate outages. When called upon in an emergency, the value of resiliency is clearly demonstrated through businesses and critical facilities remaining open and residents being able to power their homes, however quantifying the economic benefits is challenging due to the unpredictability of outage events. A recent NREL study concluded that valuing avoided losses could make the difference between a system being a sound fiscal investment or not [15]. This was demonstrated with a case study that illustrated at 160% boost in net present value of the ESS economics of a large office building when the cost of avoided outages was accounted for [15].

Table 1 summarizes the potentially quantifiable benefits that ESSs can provide. A major challenge to valuating energy storage benefits is how variable these will be depending on technology, market dynamics, demand charges, location, and other factors. Currently, each project requires specific evaluation in order to attempt to quantify savings.

Table 1
Quantifiable benefits of energy storage systems.

Benefit	Description	Estimated Value(s)
Capacity Value	Storage provides firm system capacity.	\$1697/kW [16] \$40/kW-yr–\$90/kW-yr [6]
Arbitrage	Price differential between charging off peak and discharging on peak.	\$46/kW [11] \$60–\$115/kW [10]
Arbitrage plus frequency regulation	Arbitrage combined with the ability to provide or reduce generation on demand	\$117–\$161/kW [13]
Curtailment recapture	Storage of energy that would have otherwise been curtailed	Reduction in curtailment of ~12% [14]
Avoidance or deferral of capital costs	Mitigation or deferral of the need to construct new generation to meet increasing demands	Dependent on cost of generation avoided
Resiliency / Elimination of outages	Ability to store energy can eliminate costly and potentially catastrophic outages	Value could sway the NPV of a project [15].