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Bringing innovation to market: business models for battery storage

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Abstract

Power systems around the world have undergone significant transitions towards a decentralization and decarbonization with higher requirements on supply security and flexibility. Technology advancement helps to improve energy efficiency and bring down cost, which in turn promote the growth of battery storage internationally. Business models of battery storage remain vague given its early stages of development but it is clear that there is no universal business model for batteries given the breadth of applications. In this study, we review the main components of existing business models and highlight the areas to be strengthened in a novel business model. Business models should be distinguished at different scales (utility-scale; behind-the-meter application; community-island mode operation) addressing different needs (to replace existing system or to add new capacity). A successful business model of a battery storage system needs to take into account electricity system transition, market and regulatory barriers, among others. Last but not least, it is important to consider innovations in other technologies for the design of a business model.

Keywords: battery; business model; energy storage; innovation

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1. Introduction

Power systems have undergone significant transitions towards a decentralization and decarbonization with higher requirements on supply security and flexibility. Acknowledging the widespread environmental damage [1] existing unabated coal-fired power generation needs to shut down to achieve the central aim of the Paris Agreement, and no new unabated coal power plant should be built after 2017 [2]. At the same time, renewable energy has been growing fast. Comparing to fossil fuel-based generation coal, natural gas or even diesel oil used on islands [3], renewable energy has fewer environmental impacts during its life cycle [4]. It has also become less costly due to large-scale manufacturing, deployment and technology improvement. It is obvious that the penetration of renewable energy has driven the transition of the existing EU electricity system to a more sustainable and secure future [5-7]. However, the integration of large-scale renewable energy requires higher level of flexibility in the power system to allow for new forms of innovation to be used [8].

There are many ways to increase the flexibility of a power system. Nowadays, energy storage is becoming increasingly popular. It presents the most promising solution to address the variations of renewable energy outputs. Depending on the form of energy used, there are many different types of energy storage systems [9]. As one of the most promising storage technologies, batteries have become increasingly popular in recent years. Technology advancement helps to improve energy efficiency and bring down cost, which in turn promote the growth of battery storage. At utility level, battery storage can be used to provide grid services such as frequency control and energy arbitrage at various locations. In addition, battery storage presents a pathway to allow the uptake of intermittent renewable energy sources at micro-level (e.g. the behind-the-meter application), which is one of the core elements to achieve the emission reduction targets in the EU alongside energy efficiency improvements and energy savings [10].

Nevertheless, the business model of battery storage remains vague given its early stage of development and specificities of every application. Moreover, energy storage and decentralized energy challenge traditional utility scale approaches to energy supply [11,12]. In this study, we review the main components of existing business models and highlight the areas to be strengthened for a novel business model.

2. Business model

Definitions of business models are very diverse [13,14]. Nevertheless, they usually explicitly address several components that are important in a business model. For example, Chesbrough and Rosenbloom [15] address the significance of generating revenue in a business model. However, a business model is different from a financial model of a business. It covers the ways that the company satisfies customer needs, entices customers to pay for their product or service, and generates revenues from customer payment [16,17]. Alongside business models, companies employ strategies that enable them to position themselves in the market [18]. Apart from the costs and revenues, a business model also covers other factors such as customer segments, value propositions, channels to reach customers, partners etc. Osterwalder and Pigneur [16] indicate that a successful business model consists of nine building blocks, including customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure. The nine building blocks are the basics of a Business Model Canvas [17] which is widely used to design business models. In essence, it covers four key areas in a business: customers, suppliers, infrastructure and financial capabilities. In another study, Johnson et al. [19] introduce four main components in a successful business model: a customer value proposition, a profit formula, key resources and key processes. These components can explain how the company addresses customer needs through value proposition, which in turn generate revenues for delivering the product or service. It is also important to address key resources and processes, which are fundamentals for the company to deliver what customers need. In fact, the four main elements are very similar to the main elements in Osterwalder and Pigneur’s nine building blocks but are categorised into different groups. Shafer et al. [20] conduct a review on the components covered in business models. Given that differences among industries, over 40 different components are listed. These components vary from branding and strategy to economic logic and sustainability.

In addition, the design of a business model is closely linked to the potential of the innovation itself. The potential of an innovation is determined by five factors. Three factors are internal to the innovation, including market, function and adaptability; the other two factors are external to the innovation, including skilled management team and support

(Fig. 1). Nevertheless, for early innovations when a market does not exist or is too small to allow the penetration of a new product, a business model might require governmental support to succeed [21].

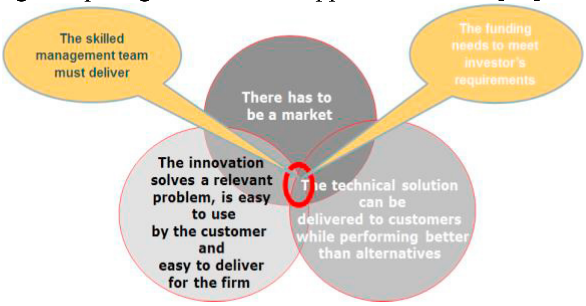

Fig. 1. Five factors that determine the potential of an innovation

3. Battery storage business models and their main components

Pollitt [22] address three main components in the business models of battery storage, including value proposition, value creation and value capture. Battery storage delivers tens of services. Each service is associated with one revenue stream (in other words the payments that providing these services could earn). The Rocky Mountain Institute describes thirteen services that batteries can provide at three-grid levels: behind the metre, distribution, and transmission [23]. It shows that battery storage that sited at the customer end can provide the most services to the power system but requires energy customers to be interested to engage beyond their regular ICT energy use [24]. In terms of value creation, the services of battery storage can provide value to different stakeholders. For example, with batteries installed at grid level, it can help the system operator to relieve grid congestion and improve grid management. It also reduces the need for new grid infrastructure. For batteries installed with a renewable energy plant, storage can help to shift renewable energy generation which makes the plant more flexible and is applicable at small community-scale [25,26] and large grid-scale systems [27]. For value capture, it depends on the services that batteries provide to the grid. Focus on single service provision is unlikely to offer a profitable model; therefore, services have to be combined. In the assessment of benefits, one of the main challenges is in benefits aggregation. These include operational conflicts, technical conflicts, regulatory barriers and multiple stakeholder benefits aggregation. First, battery storage services need operational compatibility. In other words, the provision of secondary services should not have operational conflicts with the provision of primary services. Eyer and Corey [28] create applications synergies matrix. It shows the compatibility of providing one primary service to all other services. For example, battery storage used for deferring T&D upgrade is not compatible to providing backup power to the system. Second, technical features of battery storage can restrict the services it can contribute. Some batteries cannot be used for frequent deep discharges, which can significantly shorten their lifespan. Third, regulations do not always provide sufficient support to the participation of some services that can be provided by battery storage.

3.1. Existing batteries application and their business models

One of the applications of Tesla's battery packs is the deployment of 52 MWh (13MW) lithium-ion battery system in association with Kauai Island Utility Cooperative (KIUC) [29]. The units are deployed near a solar farm which has a total generating capacity of 13 MW. According to the agreement, KIUC agrees to buy power from the battery system for 20 years at the rate of 13.9 cents per kilowatt-hour which is cheaper than purchasing power from the existing diesel power plants during evening peaks. The battery system addresses multiple energy needs of the island, which are to maximize the solar output potential, reduce the reliance on fossil fuel plants (less secure supply due to oil price fluctuation and higher emissions) and reduce costs during peak hours. In 2017, Tesla also installed a 20 MW 4-hour lithium-ion battery system at Southern California Edison's Mira Loma substation in Ontario [30]. The battery system is charged during the day time when solar production reaches its maximum and releases power during evening peaks. The project is part of an emergency response to the potential power shortage due to a huge leak from the Alison Canyon natural gas storage facility in 2015. In fact, the gas storage leakage has driven the growth of battery storage system in the last couple of years, since utilities have to look for alternatives in a very short period of time to provide secure supply during peak hours. Battery storage in the cases above is used to address specific needs in the energy system. First, there needs to be sufficient cheap energy production that can guarantee battery charging at minimum costs. This is usually the case when large-scale renewable energy sources are available (such as in California and Hawaii). Second, the costs of using battery storage are cheaper for specific services (providing peaking services) than any existing technology. Third, there is urgent need to replace the existing generators due to unexpected closure (the Alison Canyon gas storage facility leakage reduced gas availability). Therefore, costs were not the primary concern compared to security. Nevertheless, these experiments gradually improve the applications of batteries at different scales in different locations, which in turn provide valuable insights to the growth of battery systems in electricity markets.

Apart from the grid-scale application, others are considering the business models for behind-the-metre applications. For example, Sonnen is one of the leading energy storage system makers in Germany. The company experiments on a new concept called SonnenFlat in Australia, which allows owners of their battery system to participate in the market. Customers who also need to have roof solar system installed can pay a small monthly fee in exchange of an annual consumption allowance. The small monthly fee replaces conventional usage charge (e.g. $/kWh) and fixed supply charge (e.g. $/day), which is much lower than purchasing power from the grid. In return, Sonnet can use the capacity of their batteries by offering frequency services to the grid operator. The company claimed that a similar project in Germany has created an economic value of $550 per customer [31].

4. Battery storage business model innovation

Though battery storage has experienced rapid growth in the last few years, its application for power storage is still at the early stage of development and facing several constrains. Apart from the components discussed above, a successful business model needs to consider the following:

4.1. Electricity system in transition

The electricity market in the EU have been experiencing a structural change. The current regulation and market design is not sustainable due to stagnant demand growth, penetration of renewable energy, growing of demand side technologies, and associated policies on climate change and renewable energy subsidies. Nevertheless, the electricity market is still designed to reflect and optimize the cost structure of conventional power generation. Robinson [32] shows that the profitability of major EU electricity companies has fallen since 2008 due to falling revenues and raising costs. Revenues from wholesale market and ancillary services are both declining. At the same time, costs associated with tax payment, fossil fuel purchases and emission reduction are raising. The author argues that the change is structural but not cyclical, therefore a fundamental reform to the electricity market is needed. These ongoing changes seem to be able to facilitate the deployment of batteries in the near future. Nevertheless, there is still need to scrutiny the possible impacts of such changes to the deployment of batteries.

4.2. Market and regulatory barriers

Although battery cost is declining, it is often high comparing to alternatives that can provide identical services [33]. Even in some cases when costs are competitive (where costs of existing system or alternatives are high), market and regulatory barriers still exist. These barriers include the legitimacy of energy storage to participate or provide services to the grid and the lack of clarification on the functional classification of energy storage (e.g. whether they are classified as generation, transmission and distribution assets). Besides, existing revenue compensation mechanisms are designed to fit to the evaluation of traditional power system technologies. For example, in a liberalized market, the generation cost of the marginal unit is used as a benchmark for pricing. Such pricing structure is not appropriate for capital-intensive units such as energy storage. In addition, the complexity in understanding of economic performance of batteries due to their varied use functions has made developers or utilities unwilling to invest. These barriers have limited the use of storage for specific services and induced additional transaction costs, thus decreasing the profitability of batteries. Together with the barriers above, battery investments present significant uncertainties to potential investors.

4.3. The inclusion of externalities in the economic assessment

The use of battery can have many benefits to different stakeholders. Depending on its applications, it can reduce greenhouse gas emissions, improve system flexibility, avoid costs of upgrading existing infrastructure, and improve supply security. However, the economic assessment of batteries does not usually capture these benefits because they are not usually monetised under the existing pricing structure. For instance, batteries can help to improve supply security in remote areas, which cannot be sorted without the inclusion of these technology. At present, there is no agreed approach to evaluate supply security that can reflect the added value of batteries to the society.

Indeed, the inclusion of these externalities can potentially improve the economics of batteries [34]. For example, the rising costs of emissions can encourage the use of sustainable energy sources. Though batteries do not directly reduce emissions, they increase renewable energy integration.

4.4. Development of other innovations

Recent development of blockchain technology has enabled its use in the financial sector. The technology provides a platform for peer-to-peer transaction, which is similar to the recent transition in the energy system towards decentralized generation. It can facilitate energy trading from individual energy producers (rather than centralized producers) to consumers, therefore increase the use of decentralized energy sources such as batteries at households [35]. A number of trail projects were developed at different locations. Nevertheless, such application is dependent on the development of the technology, the regulatory settings as well as market responses [36].

5. Conclusion

Addressing a single business model for batteries is not possible as one size does not fit all. Battery business models should be distinguished at different scales (utility-scale vs. behind-the-meter application) addressing different needs (to replace existing system or adding new system). Before becoming cost-competitive, they should also target specific locations with different power requirements. A successful business model of a battery storage system needs to take into account electricity system transition, market and regulatory barriers, among others. It is also important to consider other innovations in the design of a business model.

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