Research on Business Mode of Energy Storage Station under Energy Internet Background

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Abstract. Energy storage technology is the key technology for the development and construction of energy Internet. At present, the development and application of energy storage technology in China have made initial progress and have possessed the industrialization foundation. In this paper, the business mode of energy storage station under energy Internet background was studied. Firstly, the investment modes of energy storage station were studied from the perspective of investors and investment approaches. Secondly, revenue sources of energy storage station were analysed, focusing on the revenue of peak and valley power price difference, revenue of promoting new energy consumption and revenue of reducing user distribution station capacity construction. Based on the above, the business mode of energy storage station was put forward, which provides reference to the development of the business application of energy storage station.

Keywords: Energy storage station; business mode; energy Internet; investment mode; revenue analysis.

1. Introduction
With the promotion of low-carbon and green energy strategies, the further construction of energy Internet and the implementation of supporting policies for the new round reform of power system, application value of energy storage has been recognized and it has become the key technology to advancing energy reform and energy restructuring in China. Under this background, accelerating the development of energy storage technology and industry is of great strategic significance to build a modern energy industry system which is "clean, low-carbon, safe and efficient", and to promote the transformation of energy production and utilization [1]. In 2016, Opinions of the State Council on Actively Promoting the "Internet +" Action issued by the National Development and Reform Commission points out that energy internet is an important strategic support to promote energy revolution in China and proposes the key tasks of coordinating and optimizing the operation of the energy storage system with new energy and power grids. It also puts forward the goal of mixed configuration, efficient management and friendly grid-connection of storage equipment. In 2017, Opinions on Promoting the Development of Energy Storage Technology and Industry issued by the
Ministry of Finance proposes that relevant work will be promoted in two phases in the next ten years. The first phase is to realize energy storage transferring from research and development demonstration to commercialization, while the second phase is to promote early commercialization to expand to large-scale development [2].

As the energy storage industry develops, technology and economy of energy storage is gradually raised, market mechanism and pricing system are improved and the application field of energy storage station is clearer, which explain that energy storage station is entering the early commercialization and building energy storage stations on the grid gradually appear [3,4]. Under energy Internet background, building energy storage station has many impacts on power grid, including delaying the upgrading and expansion of power transmission and distribution network, providing auxiliary services such as frequency modulation and reactive power support, and improving network safety and reliability. However, energy storage may also cause loss of power grid revenue. Therefore, it is necessary to study the business mode and cost-benefit of the energy storage station, in order to propose some relevant strategies for power grid company to deal with the development of energy storage station [5].

2. Analysis of energy storage station investment mode

2.1. Investors

Although the main investors of energy storage stations are energy storage equipment suppliers, with the expansion and development of energy storage market, investors tend to be diversified in future, including power generation company, power grid business, power user, energy storage equipment supplier and so on [6].

2.1.1. Power generation company. Energy storage station has advantage to balance the output of new energy, improve power quality and promote the consumption of new energy. At the same time, the energy storage station can also be used with traditional thermal power plants to participate in ancillary services such as peak shaving and frequency modulation and enhance the black-start capability of thermal power units. Therefore, power generation company can be the energy storage investors.

2.1.2. Power grid business. The energy storage station helps to stabilize the current and voltage in the power grid line and has the function of reactive power support to power grid. Meanwhile, it can also help delay the infrastructure construction of power grid, thus reduces the capital investment of power grid business and relieve the operating pressure. Therefore, the grid companies may also involve in investment in energy storage station.

2.1.3. Power user. Users can charge during low period and discharge during peak period by using energy storage station, which promote users to participate in demand side response and greatly reduce the electricity cost. Energy storage station can also be used as an emergency power supply to avoid power supply interruption. Above all, power user can also invest in energy storage station.

2.1.4. Energy storage equipment supplier. Energy storage equipment supplier should actively look for opportunities to invest in energy storage station to promote the installation and construction of energy storage station and strive for greater market share. So, they are still one of the main investors of energy storage station.

2.2. Investment approaches

At present, the energy storage station investment approaches being applied or proposed include setting up investment fund, setting up joint venture and government and social capital cooperation [7].

2.2.1. Set up investment fund. Investment fund is a kind of collective investment system with benefit sharing and risk sharing. The investment fund is the gathering of investors' capitals. Fund trustee
entrusts professional managers to manage the funds and engage in investment activities. Power grid business may seek cooperation with financial institutions such as banks or securities to set up energy storage station investment fund, using which to invest in energy storage station and entrust professional fund managers to manage.

2.2.2. Set up joint venture. Joint venture is generally set up by two companies who invest capital. They have a portion of their equity and share their profits, expenses, risks and control over the company. Power grid company can set up joint ventures with energy storage equipment suppliers, and invest in the construction of energy storage stations, by which it can take advantage of the experience of energy storage equipment suppliers and obtain investment profits.

2.2.3. Government and social capital cooperation. Government capital cooperation encourages private-owned company and private capital to cooperate with the government and participate in the projects’ investment and construction. Throughout the cooperation, the government and enterprises are full participation, they cooperate for a long time and achieve symmetrical information. Power grid companies may seek cooperate with local government and introduce government capitals to jointly invest in constructing energy storage stations. With governments’ support, the competitiveness of power grid company will be enhanced in investment in energy storage projects.

3. Analysis of energy storage station main revenue
The revenue of energy storage stations can be divided into direct revenue and indirect revenue. Direct revenue mainly refers to the revenue of peak and valley price difference, government subsidies and the basic electricity tariffs reduction for users under the capacity price system. Indirect revenue includes the revenue of delaying power grid upgrading, revenue of increasing user reliability, revenue of promoting new energy consumption, revenue of reducing conventional reserve capacity for new energy generation and revenue of reducing user distribution station capacity construction.

3.1. Revenue of peak and valley price difference
Revenue of peak and valley price difference gains from that energy storage device charges in valley load period when price is low, while discharges in peak load period when price is high. When using energy storage station to earn profits from peak and valley price difference, energy loss of energy storage system should be considered, assuming it is 95%, the same as the one-way conversion efficiency of current mainstream converter. Therefore, the annual revenue of peak and valley price difference can be expressed as:

$$I_1 = 365P_m \left( k(e_p h_1 + e_H h_2) - e_L h_3 / k \right)$$

$$P_m$$ is the rated power of energy storage system, $$k$$ is the charging and discharging efficiency of energy storage system, $$e_p$$, $$e_H$$, $$e_L$$ are electricity prices for peak, height and valley periods, respectively, $$h_1$$, $$h_2$$, $$h_3$$ are the charging and discharging hours for peak, height and valley periods, respectively.

3.2. Revenue of promoting new energy consumption
By configuring a percentage of energy storage system, wind energy that cannot be transmitted during the output peak hours is stored for releasing in output valley hours, so as to increase the wind power grid-connected rate and reduce wind and light abandonment. The electricity revenue generated by wind and light reduction is the energy storage system revenue.

Take the wind farm as an example, $$\Delta Q$$ is the reduced wind power by energy storage in annual, which can be calculated as follows:
\[
\Delta Q = \sum_{m=1}^{365} \sum_{n=1}^{1440} (P_1 - P_2) \cdot \Delta t \tag{2}
\]

\(P_1\) is the actual power of the wind farm with energy storage system, \(P_2\) is the actual power of the wind farm without energy storage system, \(\Delta t\) is the data recording interval of wind farm output. So, revenue of energy storage reducing wind abandonment can be calculated as follows:

\[I_z = \Delta Q \times e\tag{3}\]

e is the wind power tariff, accounting as benchmark price of ¥0.57/kWh.

3.3. Revenue of reducing user distribution station capacity construction

Large users will be equipped with a power distribution system with some redundancy according to their own electricity consumption. Energy storage system installed in low-voltage side of users can help to reduce distribution capacity, which saves the corresponding capacity investment. The annual revenue is expressed as follows:

\[
I_3 = \begin{cases} 
\gamma_d C_d k P_{max} & P_{max} \leq P_c \\
\gamma_d C_d k (2P_c - P_{max}) & P_{max} > P_c 
\end{cases}
\]  

(4)

\(P_{max}\) is the rated power of lithium ion battery, \(C_d\) is the unit cost of users’ distribution system; \(\gamma_d\) is the depreciation rate of fixed assets of distribution device, \(k\) is the charging and discharging efficiency of energy storage system, \(P_c\) is the difference between the peak value and the mean value of load.

4. Selection of energy storage station business mode

The business mode of energy storage station is that, in the commercialization process of energy storage, how will the relevant parties participate in the energy storage market and which ways will they take to achieve profit. The main business mode includes investment fund sharing mode, cooperation with government investment mode and mixed ownership investment mode.

4.1. Investment fund sharing mode

The investment fund sharing mode is a collective investment mode with benefit sharing and risk sharing. Power grid company can work with financial institutions such as bank and security to jointly set up energy storage station fund to support the construction and operation of its energy station projects. Since there haven’t been a mature business mode for reference, in order to avoid risk, the power grid company may choose the form of limited partnership which is a more conservative investment strategy. For example, the financial institution such as bank contributes a larger proportion of investment as the priority, while power grid company contributes smaller. The mode of energy storage investment fund needs some professional fund managers to manage, and divides profits each year according to a certain yield, as shown in figure 1.
4.2. Cooperation with the government investment mode
Such mode mainly takes the form that power grid companies cooperate with government departments, or the government sets up a project company with energy storage equipment manufacturers in form of government procurement and sign a cooperation agreement. The project company will coordinate the fund-raising and management of energy storage station. Specifically, government should have a complete policy framework, goal and implementation strategy for an energy storage project and guide and bind all participants in the process of project construction and operation. By signing a long-term agreement or contract with government, power grid company should coordinate the relationships among the project objective, the policy objective and the specific objective of government so that all parties involved can reach the scheduled goals as the project progresses. As figure 2 shows, project company is the executive of the target, who invests in and builds energy storage stations in order to achieve the objective of the cooperation agreement.

4.3. Mixed ownership investment mode
The proposal of mixed ownership investment mode is based on the practice of Dalian Hengliu Energy storage station Co., Ltd. Many companies are involved in the investment to set up a mixed ownership enterprise. Currently, the State Grid Corporation is vigorously promoting the construction of integrated energy service company to promote the transformation of the company. Therefore, the newly established integrated energy service company who is the dominator can co-find an energy storage partnership with the energy storage equipment manufacturers, big data and cloud computing companies as well as the Internet of things companies, as shown in figure 3.
Figure 3. Mixed ownership investment mode

5. Conclusion
At present, power market in China is experiencing a crucial period of deepening the reform, whose operation and development are facing a series of complicated new situations. After a decade’s development, the energy storage industry is at an important stage of transition from demonstration application to commercialization, with broad application prospects. However, the imperfections of technology and economy, market mechanisms and pricing system restricted the further commercial development of energy storage. Therefore, it is of practical significance for the power grid company to study the business mode and cost-benefit of energy storage station to deal with its development. In order to promote the commercial application and development of energy storage station, the following four aspects should be laid out:

Firstly, subsidy and billing method for energy storage stations should be specified, which is crucial to the establishment of its business mode. At present, there is no clear policy regulating energy storage stations how to participate in the electricity market, such as participation, billing standards, and subsidy standards.

Secondly, subsidy should be spent on the research and development of key technologies. When the energy storage market is relatively mature, government should gradually reduce the subsidy proportion until eventually cancelling subsidy, so as to promote the participation of energy storage station in market competition.

Thirdly, strict access rules on wind power and photovoltaic power quality should be formulated to promote the application of energy storage stations.

Fourthly, a diversified investment and financing system should be constructed, including formulating a financial policy that supports the development of energy storage station, and establishing a diversified financing channel which complements direct financing and indirect financing.

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References
[1] Hu Zechun, Ding Huajie, Song Yonghua, et al. Research Status and Prospect of Energy Storage Application under Energy Internet Background, J. Electric Power Construction, Vol. 37 (2016) No. 08, pp. 8-17.
[2] Ci Song, Li Hongjia, Chen Xin, et al. The Cornerstone of Energy Internet: Research and Practice of Distributed Energy Storage Technology, J. Scientia Sinica (Informationis), Vol. 44 (2014) No. 06, pp. 762-773.
[3] Li Jianlin, Tian Liting, Lai Xiaokang. Outlook of Electrical Energy Storage Technologies Under Energy Internet Background, J. Automation of Electric Power Systems, (2014) No. 23, pp. 15-25.

[4] Chen Yongchong, Li Aijing, Liu Dandan, et al. Application and Development of Energy Storage in Energy Internet System, J. Electrical & Energy Management Technology, (2015) No. 24, pp. 39-44.

[5] Kang Chongqing, Liu Jingkun, Zhang Ning. A New Form of Energy Storage in Power System: Cloud Energy Storage, J. Automation of Electric Power Systems, Vol. 41 (2017) No. 21, pp. 2-8.

[6] Li Jianlin, Tian Liting, Lai Xiaokang. Outlook of Electrical Energy Storage Technologies Under Energy Internet Background, J. Automation of Electric Power Systems, (2015) No. 23, pp. 15-25.

[7] Jing Ping, Xu Guizhi, Zhao Bo, et al. Large-scale Energy Storage Technology for Global Energy Internet, J. Smart Grid, (2015) No. 06, pp. 486-492.