Comparative Analysis on Energy Storage Policies at Home and Abroad and Its Enlightenment

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Abstract. In this paper, current development of energy storage(ES) in China and the United States is introduced firstly. Then, the typical ES policies of China and the United States are enumerated from the perspectives of general policies and multi-angle policies, which is consists of the generation side, the grid side and the user side. Through the analysis of the policies, the paper expounds the promoting effect of various ES policies on its development and makes a comparison of ES policies in China and the United States. Finally, according to the policies mentioned in this paper, combined with the current national conditions in China, the enlightenment and suggestions on policy formulation of ES are given due to the current national conditions in China.

1. Introduction

As the development of technology, the proportion of renewable resources in power generation is gradually increasing. As the mainstream trend of energy development in the future, for one thing, renewable energy has advantages of clean and low cost, for another thing, its characteristic of fluctuation has a certain impact on the stability of power grid. Energy storage(ES) technology, as a bidirectional energy flow carrier, provides a new idea for better absorption of renewable energy. Taking the distributed photovoltaic generator for an example, there is a time difference between the peak of photovoltaic power generation and the peak of power consumption. Through ES technology, electricity generated by solar energy can be stored before the day and sent to the grid, so as to ease the load peak in the evening. At present, ES has been regarded as an important measure to assist the integration of renewable energy. In order to promote the application of ES, countries have formulated corresponding policies and measures in accordance with the existing development situation.

2. Development status of energy storage

2.1Current status of energy storage in the United States

The United States is an early adopter of ES. It currently has nearly half of the world's demonstration projects, and several commercialized ES projects have emerged. According to the U.S. department of energy, the total capacity of ES batteries in U.S. will increase to nearly 1GW by 2019.

From the perspective of application mode, the large-scale deployment of the U.S. grid-level ES projects in 2016 covered different fields, such as grid-connection of renewable energy, regulation and

power transmission[1]. In addition, behind-the-meter market, represented by industrial and commercial ES and family photovoltaic ES, is also moving rapidly towards commercialization. Since the fourth quarter of 2017, the deployment scale of behind-the-meter ES has exceeded that of front-the-meter ES.

From the perspective of geographical distribution, California has the largest share of ES, accounting for 88% of the whole installed capacity. The gas-leak incident of Aliso Canyon lead to the emergency purchase of ES by the California government and urged the utilities to complete the project within a short period of time. Based on the experience of California, Oregon, Massachusetts and New York all started the deployment of ES projects on a utility scale by setting ES procurement targets or proposing procurement requirements, and adjusted the focus of ES application based on their respective energy structure and supply-demand characteristics.

2.2Current status of energy storage in China

Development of ES in China started in 2011 and has been growing rapidly in recent years. According to the statistical report of CNESA, in the first half of 2018, the installed capacity of new electrochemical ES projects putting into operation in China was 100.4MW, which has a 26% increase compared with the end of 2017.

From the perspective of application modes[2], ES is mainly used in distributed generation and micro-grid energy storage systems, accounting for 56% of the total installed capacity. In the field of centralized renewable energy generation, ES is mainly used to solve wind and solar power curtailment, smooth output and provide ancillary services.

From the perspective of geographical distribution, Jiangsu province has the largest installed capacity of new projects, accounting for 25%. In addition, solar and wind energy resources are concentrated in northwest China and ES has become an important solution to the consumption of renewable energy. By the end of 2017, about 100MW of electrochemical energy storage projects have been put into operation in northwest China.

3. Comparison on Chinese and American Energy Storage Policies

ES cannot develop without the support of policies. In the early stage of ES development, it is necessary to give a clear definition, increase the diversity of profit models and expand the application scope of ES through policies, which will be the foundation for mature business model formation at a later stage.

3.1General policies

In the U.S. electricity market, FERC 841[3] gives a definition of ES formally. And the order also requires each RTO and ISO to revise their tariff to establish a participation model consisting of market rules that, recognizing the physical and operational characteristics of ES resources within 270 days.

In China, the guideline on promoting ES technology and industrial development is the first guiding policy on ES technology and its application. The guideline points out that ES will be promoted in two stages in the next 10 years. The first stage is the transition from demonstration to commercialization and then to large-scale commercialization on the second stage. Under the opportunity of electricity market reform, the demonstration project of ES should be continuously increased based on technological innovation. Meanwhile, it needs to be combined with the Energy Internet to improve the level of informatization and control.

The reason why some of the wholesale markets do not include ES is the absence of rules and regulations. The order of FERC can remove barriers to fair competition for ES in the wholesale power market, help ES gain benefits in more markets, and standardize the participation in different markets operated by RTO and ISO. The aim of domestic guideline is also to create a better environment for ES. The pilot construction of electricity market in China is still in the primary stage. Instead of the formulation of specific rules in each provincial electricity market, the policy makes it clear that ES development needs to attract investment through early-stage demonstration projects and technological innovation, supplemented by government compensation policies and tax incentives.

3.2Multi-angle policies

3.2.1Generation-side policy. The application modes of ES in generation side[4] can be divided into two kinds. One kind is the combination with renewable energy, helping smooth the output of renewable energy, and effectively reducing the rate of renewable energy curtailment. Another kind is participating in ancillary services, which uses its characteristics of fast response and high accuracy.

Various states in the United States have issued different laws to promote the combination of ES and renewable energy. Oregon's legislature passed 2193-b[5], which requires some power companies to purchase qualified ES systems by January 1, 2020. Similar to Oregon, three investor-owned utility companies (IOUs) in California are required to complete the ES purchase goal by 2020 under AB2514[6]. Both of the bills promote the installation and purchase of ES on the generation side through mandatory means.

In China, the official notice issued by national energy administration is about pilot work of the compensation mechanism in northeast, northern and northwest part, which aims at promoting ES to participate in ancillary services. The document stipulates that ES facilities on the generation side can participate in peak and frequency modulation jointly with the unit or as an independent subject. Among them, electrical ES facilities, which participate in peak regulation as independent subjects, should have the charging power more than 10 megawatts and continuous charging time more than 4 hours. Meanwhile, power discharged by electrical ES is equivalent to power generation of plants, and shall be settled in accordance with relevant contract price of plants.

With the rapid development of renewable energy in the United States, there is an urgent need for ES to help the integration of renewable energy into the Internet. State governments promote the combination of ES and renewable energy mainly through mandatory ES installation act or compensation mechanism. Relying on the liberalized power market, the application of ES in ancillary services market of the United States has been relatively mature, while the construction of the ancillary services market of China is still in the pilot stage, so the basic rules should be established for the participation of ES. The policy established the status of electric ES as an independent market entity for the first time. It also clarified the technical requirements and settlement rules for ES participation in the peak and frequency modulation markets, which clears the obstacles for the extensive participation of energy storage in ancillary services.

3.2.2Grid-side policy. On the grid side, ES can be used as an alternative to the investment and upgrading of the transmission network, improving the transmission capacity and alleviating congestion. In addition, ES can also provide ancillary services on the grid side to improve the safety of network operation.

In the United States, FERC 755 requires ISO to take response speed and modulation accuracy into account when paying for ancillary services. This act mainly considers the advantages of ES over conventional generation technology in frequency modulation. Furthermore, in order to facilitate the access of ES system and distributed energy. The Department of Public Utilities in Massachusetts issued a decree authorizing significant investments and upgrades to the power grid[7]. The modernization reform of power grid mentioned in the decree will enable mechanical equipment to automate command and control and is aimed at creating a self-healing power grid.

The official notice on the compensation mechanism in northeast, northern and northwest part in China also clearly stipulates the ES participation and settlement rules of grid-side ancillary services. Moreover, in order to help the power grid in consumption of renewable energy, China has issued the notice on construction of transformation projects. And 12 ultra-high voltage transmission projects are approved to expand the transmission capacity and create space for renewable energy access due this year and next.

Both China and the United States have clear access and compensation rules for ES on grid-side ancillary services, which standardizes the participation of ES and provides visible economic benefits. The policy of U.S. also takes the advantages of ES into consideration when formulating the

compensation rules, which will lead to a further increase of ES installation on grid-side. In addition, the U.S. grid modernization act provides technical support for ES. The upgrading and transformation of the power grid have enhanced the adaptability with ES, making the process from connection to metering more convenient, and also facilitated centralized control of distributed devices. The development of ES in China is still in the early stage, so the transformation of the power grid has not been refined to the technical level of ES access, but focuses on the expansion of the grid scale. The construction of high-capacity transmission lines increases the access amount of renewable energy, and indirectly promotes the installation demand of ES.

3.2.3User-side policy. With the increase of user-side distributed energy, ES can be combined with it to reduce its fluctuation. Furthermore, users can also realize energy arbitrage by storing low-cost electricity during periods of low net demand and releasing back to the grid during periods of high net demand.

In 2017, the New York State Public Service Commission announced the law[8] on compensation mechanisms for solar and other distributed power sources, establishing a reasonable price mechanism for the value created by distributed energy. In order to promote the integration of ES and distributed energy, the Internal Revenue Service has issued the tax credit policy of investment[9], with 30% of the tax credit used to transform the ES of existing photovoltaic systems. Meanwhile, SB 18-009 was signed into law, which ensures the right of Colorado residents to install and use ES systems without discrimination.

In order to guide users to install ES and promote the commercialization of ES by means of price arbitrage, ministries in China issued the guidance of promoting power substitution. One of the focus mentioned in guidance is widening the price gap between valley and peak. The most elastic part of energy substitution is the ES sector, and widening the peak-valley spread provides a business model for ES.

ES has a tight link with distributed energy, which helps the distributed energy play a good role in the market. Therefore, state governments in U.S. provide subsidies for ES installation, and encourage users to use ES systems by ensuring fairness in installation and charging while developing the distributed energy. At present, the profit mode of ES on the user side in China mainly comes from arbitrage, so the gap between peak and valley is the decisive factor affecting its return years. Compared with foreign countries, the price difference between peak and valley in China is still small, especially the decline of industrial electricity price further reduces the profit space of user side ES. Therefore, the policy increases the sustainability of the user-side business model by further widening the peak-valley price gap and attracts more installation of ES equipments.

Table 1. Energy storage policies of China and the United States

Nation / **Kind of policy**		United States	China
General policies		standardize the ES participation in markets	two-stage development of ES
Multi-angle policies	Generation-side	mandatory ES installation act	technical and settlement rules for ES participation in ancillary services
	Grid-side	**1.**grid modernization reform **2.**compensation rules on ES participation in ancillary services	**1.**expand the transmission capacity **2.**settlement rules for ES participation in ancillary services
	User-side	**1.**compensation mechanisms for distributed sources **2.**tax credit policy of investment **3.** ensures the right of ES installation	widen the peak-valley spread

4. Enlightenment to the development of energy storage in China

The development of ES in China started late and there is still a long way to go before large-scale commercial application. Compared with foreign policies, China has an obvious lack of clear planning, implementation rules, subsidies and other incentive policies. Policy guidance in the early stage is crucial to the development of ES. In the process of policy formulation, it is necessary to take the

commerciality of ES into consideration while establishing rules and technical norms, which will promote the establishment and development of ES business model. By referring to the achievements abroad and the comparison of policies between China and the United States, following suggestions are given:

4.1Improvement of the price mechanism

Long-term development of ES depends on the incentive of economic value. Comparing with the policies in China, the United States has relatively complete and detailed laws and regulations for the compensation mechanism of distributed resources, which facilitates the reasonable value evaluation of ES and distributed generation, and attracts the investment of ES through considerable interest prospect. In addition to the direct incentive, the introduction of the net metering in the United States and its subsequent revisions also determine a more reasonable mechanism for the measurement and pricing of ES. In China, there are policies to clarify the threshold and settlement rules of ES participation in ancillary services, but there is also a lack of corresponding price mechanism to reflect the advantages of ES. Compared with traditional thermal power units, ES can be involved in frequency and peak modulation with fast invocation speed, good effect and strong flexibility. Therefore, compensation fees can be considered according to the effect when formulating rules. It is worth noting that market demand should be taken into account when formulating price compensation and incentive policies to avoid the interference with resource allocation.

4.2Formulation of technical standards.

The access of ES depends on the instruction of technical rules. ES is still in the stage of technological development, especially the access of household ES should take safety into consideration. For example, the permitting and interconnection guidelines for outdoor lithium-ion storage in New York has made clear specifications on its fire safety and installation requirements. On the grid side, there is also a lack of policies on operation safety and construction safety supervision of ES power stations. It is necessary to clarify the operation responsibility of ES power stations to ensure the safe and stable operation of power grids. In addition, clear standards and application procedures will facilitate the application of ES projects, which encourages generators or users to build ES power stations or install ES equipment to some extent. Therefore, China needs to formulate technical industry standards and grid-connection standards for ES as soon as possible, to indicate the direction of technological development.

4.3Promotion of the demonstration and application.

As mentioned in the guideline, the first stage of ES development in China is to accelerate the construction of key demonstration projects. For one thing, the demonstration project can explore the way for commercialization of ES, try to find the defects in the existing mechanism, and feed back to the policy-making and technology innovation. For another thing, the benign operation of demonstration projects can also attract investment for large-scale application. In the United States, due to the outstanding performance of utility San Diego Gas & Electric in ES construction during the Aliso canyon gas leak, California Public Utilities Commission approved the company's application for the deployment of five ES projects in 2018. Also because of the good application of ES, the unique California model has become a reference for other states in America. China can also promote the demonstration projects through specific fund policy, improvement of technical level and reduction of the technical cost. At the same time, government can provide management and guidance for the business model of ES and support the industrialization of ES technology.

5. Conclusion

With the development of technology and its value excavation, ES will inevitably experience the transition to large-scale and commercial applications. In order to facilitate the process of development, policy assistance is essential. In this paper, ES policies of China and the United States are introduced

and compared in combination with the current status of the two countries. After the analysis of specific roles of different policies in pushing ES development, enlightenments are given in terms of price mechanism improvement, technical standards formulation and demonstration projects promotion. In the future, as the deepening of China's electricity market reform, it is also necessary to keep track of the changes in the domestic and international environment and continuously optimize the policy formulation for ES development.

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