‘Renewable Energy + Energy Storage’ Business Model Innovation -- An Emerging Sustainable Business Model Innovation

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Abstract. Recent reforms in the power industry include the promotion of 'dual carbon' targets, the development of large-scale and high-penetration, renewable energy and grid-connected consumption, and deep integration of digital technology and power services. The ‘renewable energy+energy storage’ combined innovation is the important direction of business model innovation for energy power enterprises. The data-driven, intelligent empowerment, green and low-carbon are all interesting items. This paper analyzed smart green business model innovation for the motivation, essential connotation and basic structure of ‘renewable energy+energy storage’. Combining application scenarios, analyzing typical cases and practical effects of sustainable business model innovation were analyzed. the mechanism of digital technology empowering smart green energy business model innovation is explored. Finally, the general rules of sustainable business model innovation of smart green energy are summarized. The study will help power enterprises to promote the green and low-carbon transformation of energy and help to provide actionable guidance for achieving the goal of 'double carbon'.

1. Introduction

'Notice on Encouraging Renewable Energy Power Generation Enterprises to Build or Purchase Peak Shaving Capacity to Increase the Scale of Grid Connection' was issued by the National Development and Reform Commission and the National Energy Administration on August 10, 2021. It clearly stated that power generation enterprises should build peak shaving resources. That means power generation enterprises should build a wholly owned proportion of pumped storage, electrochemical energy storage, gas and electricity, thermal power station or carry out coal flexibility. The introduction of the policy has raised the development of energy storage to an unprecedented height at the national level. At the same time, with the acceleration of the ‘dual carbon’ work in the power industry, the scale of renewable energy installation and power generation is expanding rapidly. The large-scale and high-proportion renewable energy grid-connected consumption brings great challenges to the safe and stable operation of the power system [1]. By 2025, China's non-fossil energy consumption is expected to reach about 20%, energy consumption per unit of GDP will be 13.5% lower than that in 2020, and carbon dioxide emissions per unit of GDP will be 18% lower than that in 2020. By 2030, it is expected that the proportion of non-fossil energy consumption will reach about 25%, and the carbon dioxide emissions per unit of GDP will be reduced by more than 65% compared with 2005, to achieve the goal of carbon peak by 2030. Energy storage can smooth the output of renewable energy power generation and improve the utilization rate of renewable energy development. Energy storage is a technological innovation and an indispensable component of building a new power system. Energy storage is accelerating to gain market and capital support [2, 3]. ‘renewable energy + energy storage’ combined innovation will become an important development direction, and become the energy supply side business model innovation [4]. How to strengthen the coordinated development of renewable energy power generation and energy storage, and how to maximize value creation and value acquisition, has become a hot topic in the industry and academia [5].

2. The motivation of ‘renewable energy+energy storage’ business model

During the ‘14th Five-Years’ period, China’s electricity market reform continued to advance. Also, renewable energy power evolved to a new level. During the "Fourteenth Five Year Plan" period, it is estimated that China's annual renewable energy installed capacity will far exceed 60 million kilowatts, reaching the scale of 100 million kilowatts. At the same time, the energy storage technology, represented by lithium-ion batteries, is becoming more and more mature. The unit energy storage cost is decreasing year by year. The further combination optimization of energy storage in renewable energy stations faces new business opportunities and opens up new value space [6].

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2.1. The accelerated release of diversified market demand

Through the 'renewable energy+energy storage' model innovation, energy storage accelerates access to the power market and can participate in the auxiliary services of grid peaking and frequency modulation. Relying on energy storage with energy storage, rapid regulation and control functions, it can provide capacity reserve in remote areas. In that power supply scenario, the innovation improves power supply reliability. The construction of energy storage in the user-side distributed, power supply can be optimized by participating in the power market transaction.

2.2. Technological breakthroughs reduce costs and expand application space

With the continuous breakthrough of energy storage technology, the price of electrochemical energy storage has dropped rapidly. 'Renewable energy+energy storage' can give full play to the advantages of rapid response and is suitable for occasions with high power requirements, such as frequency modulation, emergency power support and other fields. In the future, a variety of energy storage methods can be used in combination. When the pumped storage power station is faced with the problem of peak regulation in the renewable energy power generation gathering area where the local grid structure is blocked and the conventional peak regulation resources are scarce, the electrochemical energy storage can be configured to play its ' leverage' role and replace the large-scale power grid transformation or peak regulation power supply investment with less investment.

3. The connotation and structure of 'renewable energy+energy storage' business model innovation

Based on the existing research results of business model innovation such as the business model canvas model, this study deconstructs the connotation structure of 'renewable energy+energy storage' business model innovation from three aspects: customer value proposition, business activity system and value realization mode. Among them, the proposition of new customer value is of guiding significance to the innovation of the 'renewable energy+energy storage' business model; reshaping the business activity system to fully tap the potential application value of energy storage technology in the field of renewable energy; design new ways to realize the value to help obtain economic value and achieve sustainable value cycle [7].

Specifically, from the perspective of customer value proposition, the innovation of the 'renewable energy+energy storage' model can solve the randomness and volatility of renewable energy power generation to a large extent. Hence, intermittent and low-density renewable clean energy can be widely and effectively developed and utilized. Meanwhile, the energy structure can be transformed from high-carbon to low-carbon. From the overall architecture of the business activity system, there are four forms. They have shared energy storage architecture, rental energy storage architecture, energy integrated system architecture and community energy storage architecture respectively. In terms of value realization methods, the addition of energy storage can make renewable energy a grid-friendly high-quality power supply. It can obtain a variety of values, including meeting the rigid requirements of the power grid, smoothing the renewable energy output curve, providing auxiliary services and other market demands. Specifically, the commercial value of 'renewable energy+energy storage' can be realized by meeting the requirements of grid frequency regulation. The regulation refers to possessing priority grid-connected qualifications, participating in power auxiliary services, participating in power spot market trading arbitrage and other ways [8].

Compared with the traditional renewable energy power generation mode, the 'renewable energy+energy storage' business model innovation has distinct characteristics such as a long value chain, large global optimization space, and deep integration of energy flow and information flow. This business model innovation needs the application of digital technology. Through digital technology, it can open up multiple links in the value chain and information islands. This model enables optimal resource allocation on a larger scale, led by a fast, lightweight information flow. Also, it may optimize the renewable energy flow and create a synergistic effect between renewable energy generation and renewable energy consumption [9-11].

4. Practical application and effect of business model innovation

At present, China 's 'renewable energy+energy storage' business model innovation practice is mainly an energy storage demonstration project led by power grid companies and power generation companies. Since 2016, the provinces (autonomous regions and municipalities) in the 'three north' region of China have selected electric energy storage facilities to participate in the pilot project of compensation (market) mechanism for auxiliary services of power peak regulation and frequency modulation. Under the guarantee of the safe operation of the power system, the existing policies are used to give full play to the advantages of electric energy storage technology. Research on peak and frequency regulation function of electric energy storage in power system operation and its commercial application is then explored. The long-term mechanism to promote renewable energy consumption is established [12-14].

The business model innovation of 'renewable energy+energy storage' strengthens the connection between the power generation side and the demand side in the power system. On the one hand, it optimizes the power transmission and transformation project of the power grid and reduces the consumption of resources such as land, and specially cultivated land area. On the other hand, it can alleviate the problems of abandoning wind, water and light and limiting power, as well as improve the utilization rate of power generation. Based on 1.065 kg CO_2 emission reduction per kWh saved, a 10 MW/20 MWh energy storage power station can help renewable energy generation consume 20,000 kWh of electricity per day. If 120 days of a

year are used to consume renewable energy, it can consume 2.4 million kWh of electricity and reduce carbon emissions by 2,556 tons per year [15-16].

The ‘renewable energy+energy storage’ business model innovation significantly improves the overall operation quality of the power system, which is manifested in: (1) improving the output characteristics of the power system. To a certain extent, the energy storage system has the operating characteristics of traditional units, such as adjustment ability, the moment of inertia, etc., to ensure the safe and stable operation of the power system; (2) reduce the pressure of power system peak. ‘Renewable energy+energy storage’ can realize the adjustment and reduction of the overall output of renewable energy and reduce the peak-valley difference through the coordination of energy storage. (3) enhance the emergency capability of power system. When ‘renewable energy+energy storage’ is deployed on a larger scale, a safe power supply can be guaranteed in extreme weather.

5. Inspiration

In terms of technology, the innovation of the 'renewable energy+energy storage' mode helps to adjust the volatility, intermittence and randomness of renewable energy power generation. This improves the peaking capacity of the power system and solves the universal problem of large-scale high-proportion renewable energy grid-connected consumption. In terms of economy, although renewable energy storage will raise the overall cost of power generation, with the progress of power generation as well as energy storage and control, 'renewable energy+energy storage' overall cost will continue to decline. The wind and light abandonment phenomenon in renewable energy power generation will also continue to improve. This will significantly improve the efficiency and output of energy generation. As a result, economic profitability is enhanced.

Generally, the ‘renewable energy+energy storage’ business model innovation has become a sustainable business model innovation. By giving full play to the advantages of digital technology and fully tapping the value potential of green low-carbon renewable energy, it not only creates environmental benefits, but also creates social and economic benefits. Meanwhile, it realizes the compatible balance of economic, social and environmental values. Sustainable business model innovation has some common characteristics and rules, mainly reflected in three aspects including scene traction, data-driven and platform support.

5.1. Scene traction: Driven by the construction of application scenarios

‘Renewable energy+energy storage’ business model innovation will occur in the household, industrial, commercial and other diversified scenarios. The energy storage systems will be further integrated with all aspects of power system development. 'Renewable energy+energy storage' is the key link of the new generation power grid reliability construction. Through deep coordination with the power supply side, grid side, and user side systems, it can play a variety of roles. This includes a 'buffer pad' between the power generation side and the power consumption side. This mode can also play the role of 'buffer path', including reducing power abandonment, peak shaving, power grid frequency modulation, smooth output, etc. It can deal with the randomness, volatility and fragmentation of renewable energy power generation, solve the problem of renewable energy power consumption, and ensure the safe and stable operation of the power grid. This innovation mode can also achieve multi-station integration. The means it employed include substation resource construction, operating data center stations, building communication base stations, building foundation enhancement stations for Beidou satellites, building charging piles, and building energy storage stations. It can support strong smart grid business internally and expand energy service channels externally to better value.

5.2. Data-driven: optimization of energy flow guided by data flow accuracy

The amount of power grid data has grown exponentially along with the accelerated deployment and grid-connected access of massive distributed renewable energy, configured energy storage and other power terminals at the social level. Technologies for processing massive power data include the Internet of Things, big data, cloud computing, blockchain, and artificial intelligence. The application of these new generations of information technologies in the 'renewable energy+energy storage' business model can improve management precision and optimize energy resource allocation. The new generation of information technology can digitally map the physical elements in the energy storage system and visually present the operation status of the energy storage system in a three-dimensional visualization way. The countermeasures for potential risks include a safety intelligent protection system, energy storage safety visualization system and battery health examination system of energy storage. Data-driven may achieve a comprehensive observation of the power generation side operation. Its accurate measure and control can be accomplished simultaneously. Data-driven helps the grid side form a cloud-side coordinated control system. Data-driven can form a virtual power plant to promote effective aggregation of the power side.

5.3. Platform support: platform aggregation technology data and knowledge forming the intelligent brain

Building the infrastructure of digital technologies is a key step in platform construction. The key to the success of the energy internet platform is its application within the power industry. With the help of various information networks, power grid services can be interconnected. This includes all aspects of the value chain, the production and operation of commercial entities, and management. Aggregation of massive multivariate heterogeneous data can both improve operational quality and efficiency, and improve the level of productivity. The applied technologies include big data

analysis, information extraction, precipitation knowledge, digital, networked and intelligent upgrading of operation and management of the whole power industry chain. The business model innovation of 'renewable energy+energy storage' based on a digital platform will break through the time limit and support the following applications. It includes distributed renewable energy and distributed energy storage. Applications will enter homes, commercial buildings, factories, parks and power grids. The business model innovation of course may enhance the reliability of renewable energy power generation. Efficient use of energy storage resources will become a bridge and hub. Source-storage complementary coordination will meet the personalized, diversified and market-oriented power demand. The matching of power supply and demand is naturally achieved in the 'renewable energy+energy storage' business model innovation.

6. Conclusions

The business model innovation of 'renewable energy+energy storage' is a typical 'digital and Watt' deep integration, which solves the problem of renewable energy consumption, and is compatible with a variety of value creation of smart green energy model innovation. It is a deep excavation of the value of green low-carbon renewable energy. This innovation effectively balances economic, social and environmental interests. It supports the development and utilization of renewable energy to the greatest extent. Certainly, it provides a strong impetus for the green and low-carbon transformation of energy and the realization of the national " double carbon " goal.

In terms of the market, the 'renewable energy+energy storage' business model innovation conforms to the following industry development trends. This includes further optimization of the energy storage layout, solving the increasingly prominent contradiction between renewable energy development and consumption. The innovation improves the efficiency of renewable energy development and reasonably arranges the configuration of renewable energy storage according to the benefits of different configuration energy storage methods. As a supplementary measure for peak regulation of renewable energy power generation, this model further promotes renewable energy parity.

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