Energy storage development trends and key issues for future energy system modeling

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Abstract. In the future, the penetration rate of new energy in the energy system will continue to increase. To improve the safe and stable operation of the energy system, energy storage and other equipment will become indispensable measures. How to consider new energy and energy storage in conventional energy system modeling is a key issue facing future energy systems. This paper focuses on the trend of energy storage in the future based on the current status of energy storage and analyzes possible key issues to provide ideas for the modeling of subsequent energy systems.

1. Introduction
The development of energy in the world today is continually advancing in the direction of clean, low-carbon, safe, and efficient, showing the general trend of accelerated transformation, cross-border integration, and active innovation. It has become a common choice for all countries in the world to gradually build an energy system with renewable energy as the main body, and to deeply integrate new energy technologies to solve new challenges[1-3]. In order to promote the absorption of new energy and enhance the flexibility of the power system, energy storage is widely used in the power generation, transmission, distribution, and use of various links[4-6]. However, at present, energy storage has problems such as low technical economy, independent dispersion of locations, low utilization rate, and cost mediation methods, and limited profitability. In order to better promote the development of energy storage, we should closely integrate the characteristics of energy transformation and clarify the internal logic of energy storage development, the challenges faced, and the required industrial environment[7].

2. Energy storage development trend
2.1. "renewable energy + energy storage" mode will emerge
The development of energy is going through the use of high energy density such as coal and oil to the use of low energy density such as scenery, and this change is also the process of indirect use of solar energy to direct use. The direct use of solar energy saves many intermediate conversion links, and realizes the large-scale development and utilization of energy "what you see is what you get". To achieve high-quality utilization of low-energy-density energy, energy storage will play the role of energy "compressor, modulator", to achieve high-density, controllable utilization of low-density, fluctuating energy, to achieve the effect of "class conventional power supply" Therefore, in the energy
transition, "new energy + energy storage" will become an important form of energy use and infrastructure.

2.2. Diverse technologies lead to increasingly rich application scenarios
The market demand orientation will greatly affect the development of energy storage. The current industry regards the economics of energy storage as a key judging factor to measure whether energy storage development can achieve breakthroughs, leading to the simplification of energy storage technology development. Only the development of batteries and lithium batteries fast. As the penetration rate of new energy sources continues to increase and energy security constraints become increasingly prominent, from a system perspective, energy storage will become a rigid demand for the system.

According to the characteristics and application scenarios of different energy storage technologies, different types of energy storage can jointly solve the problem of supply-side and demand-side balance of energy and power systems in different time scales and spatial ranges. They complement each other and complement each other. Energy storage economy is no longer a limiting factor for energy storage development. Taking pumped energy storage and electrochemical energy storage as examples, pumped energy storage mainly solves the problem of system peak-shaving balance on a large time scale and in a large area, and is suitable for the development of centralized new energy; while battery energy storage more solves small time The system power balance of scale and the local area is suitable for the development of distributed new energy; the two are not a complete replacement relationship. Simply benchmarking battery energy storage and pumped energy storage for technical and economic benchmarking can easily lead to misjudgment in decision-making.

2.3. “Primary energy” storage will be more economical than electricity storage
Energy storage in a broad sense can be divided into primary energy storage, intermediate energy storage, and terminal energy storage according to the shape of the storage medium, and the storage difficulty, duration, and cost of terminal energy are greater, shorter, and more than direct energy storage expensive. Electrochemical energy storage is much higher than the primary energy stored directly, so its large-scale application will inevitably lead to a substantial increase in cost; and hydrogen storage, pumped storage, compressed air energy storage, heat storage, etc. In the form of storage, the storage cost is lower, and it is easier to achieve large-scale development. Therefore, in the future, cheap and large-scale energy storage will exist in the form of raw material storage, and those with higher energy quality requirements will mainly exist in the form of terminal energy storage such as electricity storage. To make better use of advanced energy forms such as electricity storage, energy storage cloud, and other models can be used to implement energy storage cluster scheduling to achieve large-scale applications.

2.4. The development of the energy storage industry is closely related to other energy industries
Current energy storage products have the problem of "path dependence" that follows the power battery manufacturing system. If the energy storage is only considered to be an extension of the battery industry and continue the battery industry's "production-use-recycling" perspective of the energy storage industry, then relevant practitioners It will be impossible to break through the identity recognition of general battery suppliers, product innovation and business model innovation are restricted, and the business chain is difficult to extend downstream.

In the future, the real competitive pressure of the energy storage industry will come from the squeeze of market space brought about by the progress of other energy and power technologies. It is not just a technical route competition or capacity competition between industries. The real value space in the entire industry ecological chain.
2.5. *The improvement in energy storage economy lies in open source and savings*

The current "new energy+energy storage" is not as economical as traditional fossil energy is a key factor limiting the further development of energy storage. To promote energy transformation, it is necessary to achieve energy storage economy through "open source" and "throttling". Continuous improvement.

In terms of throttling, the purpose of reducing the cost of energy storage is mainly achieved by improving the technical economics of the entire life cycle of energy storage. The technical and economic improvement of the entire life cycle of energy storage can be achieved by means of increasing the life cycle of energy storage, developing new and cheap alternative materials, standardized production processes, cascade utilization of energy storage resources, and recycling. For example, the cycle life of lithium batteries is more than 10,000 times at 80% charge and discharge depth; research and development of new battery technologies that replace precious metal nickel and cobalt electrodes; expand the use of energy storage ladders, and at the same time achieve the best use of technology and reduce as much as possible Remaining capacity when energy storage is decommissioned (for example, the original 80% of the remaining capacity, that is, the retired battery is improved to 60% of the remaining capacity, and then retired), delaying the decommissioning of the battery from the source; through the development of standards at the battery production end Standardized and unified screening, disassembly, matching and other processes.

In terms of open source, it is necessary to diversify energy storage application scenarios and enrich business models to realize value mining under the multifunctional reuse of energy storage. Besides, new energy technologies are used to further stimulate the value of energy storage. Energy storage is a very flexible regulation resource, which has power value, capacity value, and energy value. It can be used in single or multiple types in different links and scenarios Function combinations play different roles. At present, due to imperfect market mechanisms, inadequate energy storage value assessment methods, difficult to identify beneficiaries, and the principle of value allocation among various stakeholders is not clear, etc. It has been brought into full play, and its value has not been fully quantified and compensated. Therefore, the economic improvement of energy storage has been promoted from the following two aspects.
Figure 3. Comprehensive value of energy storage based on multi-functional reuse

3. Key issues in the development of energy storage

The safety[8], standardization[9-10] and evaluation mechanism[11-12] of energy storage will be the three key factors restricting the development of energy storage. In terms of security, the security of the energy storage ontology and its interaction with the energy and power system is a key constraint factor affecting the development of energy storage. In terms of standardization, standardization covers the standardization of energy storage technology (energy storage ontology technology, integrated application, operation and maintenance technology, echelon utilization and recovery technology, etc.). In terms of the standardization of energy storage database. The evaluation mechanism should include energy storage modeling and simulation platform evaluation, energy storage feasibility evaluation, energy storage value evaluation, etc.

Table 1. Three key constraints on the development of energy storage

| Problems   | Response                                                                                                                                                                                                                                                                                                                                 |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Security   | The security of the energy storage ontology and its interaction with the energy and power system is the key restricting factor affecting the development of energy storage. The following problems should be solved:  
  · Breakthrough in battery body safety technology and key technologies of BMS safety management system;  
  · Breakthrough was made in the energy management system EMS for the interaction between the energy storage system and energy and power.                                                                                      |
| Standardized | Standardization covers the standardization of energy storage technology (energy storage ontology technology, integrated application, operation and maintenance technology, echelon utilization and recovery technology, etc.), as well as the standardization of energy storage database and modeling and simulation platform. The following measures can be taken:  
  (1) Energy storage technology standardization  
    · Ontology technology: it can standardize the specifications and models of power batteries and energy storage batteries according to different specifications of application scenarios, to guide the large-scale production of domestic battery products, strengthen the whole life cycle management of batteries, and promote the sustainable development of the battery industry;  
    · Integrated application: establish standards for energy storage system integration, installation, access, and regulation;  
    · Operation and maintenance technology: gradually form routine work sorting, event management standardization and process formulation, daily work standardization and process implementation, and promote automated cloud diagnosis;  
    · Echelon utilization and recovery technology: first, formulate special guidelines for battery recovery and utilization, and determine key tasks such as research and development of battery recovery and utilization technology, construction of recovery network and construction of support system. Second, accelerate the research and development of key generic technologies such as retired battery residual. |

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value assessment technology, single battery automatic disassembly, and material sorting technology. Third, we will select key areas for the development of new energy vehicles and carry out pilot and demonstration programs for recycling power batteries.

(2) Standardization of energy storage database

· Energy storage database: the database of energy storage life cycle is established to facilitate energy storage control and subsequent recovery and classification.

| Evaluation mechanism | The energy storage evaluation mechanism should include the evaluation of a modeling and simulation platform, energy storage feasibility evaluation, energy storage value evaluation, etc. |
|----------------------|------------------------------------------------------------------------------------------------------------------|
|                      | · Evaluation of modeling and Simulation Platform: form a set of energy storage modeling and simulation analysis tools, which can evaluate energy storage performance evaluation, simulation analysis, control strategy formulation, etc., and evaluate the rationality and accuracy of the simulation platform itself; |
|                      | · Energy storage feasibility evaluation: the energy storage feasibility evaluation focuses on the evaluation of the feasibility of energy storage technology selection, site selection, fixed capacity, and control strategy, such as selecting appropriate energy storage technology through comprehensive evaluation for a given application scenario, evaluating the rationality of energy storage site selection, fixed capacity, and control strategy under different schemes, and evaluating the risk of project investment; |
|                      | · Energy storage value evaluation: through the energy storage modeling and simulation platform combined with specific application scenarios, the direct value and indirect value of energy storage under the whole life cycle of energy storage are evaluated, each beneficiary is identified, and the rationality of the principle of value sharing among the beneficiaries is evaluated. |

4. Conclusions

In the future energy system, energy storage will play an important role in smoothing power fluctuations and improving energy supply quality with large-scale renewable energy integration. Based on the economic development trend of energy storage technology, this paper studies the future trends of energy storage and discusses key issues that may be faced in the future. The paper points out that "renewable energy + energy storage" will be an important development mode in the future, and the direct storage of primary energy is easier to achieve large-scale economic storage than that of electricity-storage. While improving the performance and cost of energy storage technology, expanding the energy storage business model will be an important way to improve the economy of energy storage. Besides, the paper states that the safety, standardization, and evaluation mechanism of energy storage will be the three key factors restricting the development of energy storage.

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