Development status and Application benefit analysis of Power energy storage

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Abstract: Power storage is an important support for the development of the future energy industry. Energy storage of power grid enterprises is widely used in the fields of renewable energy grid-connected, user-side, and frequency-assisted auxiliary services. This study introduces the policies, markets, technologies, and applications of electric energy storage, and conducts investment estimation, revenue measurement, and project sensitivity analysis for typical cases of battery energy storage used for peak shaving. It provides reference for the development of energy storage business of power grid enterprises in terms of energy storage technical, economic, security, and other applications.

Introduction

Although electricity is a commodity, its production, transportation, and consumption are almost completed at the same time, so the operation is different from general commodities. Power storage is a difficult problem for nearly a hundred years. It affects the commodity attributes of electricity and can change the way energy is used. It is an important support for the development and transformation of the energy industry in the future.

Energy storage is the core device of the energy Internet, which can achieve rapid dynamic matching between the power generation curve and the load curve. It has the functions of smoothing fluctuations, matching supply and demand, cutting peaks and filling valleys, and improving power supply quality. From the current situation, improving cycle life and improving safety are the basis of energy storage applications. Policy support, financial subsidies, and cost reduction are important drivers of industrial profitability; more importantly, a sound power market mechanism can restore real cost-effectiveness and application value of energy storage.

Energy storage refers to the storage of an energy form from the same or into another form of energy through a medium or device. It is a cyclic process that is released in the form of specific energy and is based on future application needs. Energy storage mainly includes storage of energy such as (cold) heat, kinetic energy, electric energy, electromagnetic energy, and chemical energy. At present, the research, development and application of energy storage technology are mainly based on storage (cold) heat energy and electric energy. It is widely used in energy saving and other fields such as solar energy utilization, shift peak filling of electricity, recycling of waste heat and waste heat, industrial and civil buildings and air conditioners.

This paper introduces the policies, market, technology and application of electric energy storage, and also outlines the application and benefits of energy storage industry in power grid enterprises, which laying a foundation for guiding the development of energy storage business.
Development status of energy storage technology

The cumulative installed capacity of China's put into operation energy storage projects is 28.9GW, with an annual growth rate of 18.9%, and the growth rate is nearly five times that of the world. The pumped storage capacity accounted for the largest proportion, close to 99%, a slight decrease compared with the previous year. The cumulative installed capacity of electric chemical energy storage projects reached 389.8MW, with an annual growth rate of 45%, accounting for 1.3%. In 2017, the new operation scale was 121MW, a year-on-year growth rate of more than 15%. For the perspective of regional distribution, the project is mainly concentrated in East China, North China, South China and Northwest China, while Jiangsu Province has the largest installed capacity, close to 50MW. For the application distribution point of view, the new investment projects are all applied in the centralized renewable energy grid-connected, auxiliary services and user-side fields, while the user-side field has the largest power scale, exceeding 70 MW, and the auxiliary service sector has the largest year-on-year growth rate, close to 1000%. For the technical distribution point of view, the power scale of lithium-ion batteries and lead-acid batteries is basically the same, the proportion is 51% and 49%, respectively, while the lead-acid battery has the largest growth rate, exceeding 81%.

For grid companies, pumped storage is currently the most widely used large-scale energy storage technology, and the application of battery energy storage technology is still in the research and demonstration stage. In the context of the gradual clearing of policy support, with the continuous decline in technology costs and the exploration of the revenue superposition model, the energy storage industry has developed rapidly. In the electric chemical energy storage project, the cumulative installed capacity of lithium-ion batteries is still the largest in both the global market and the Chinese market, with the proportions being 76% and 58% respectively. In addition, in the new investment projects in 2017, China and the global market are mainly concentrated on lithium-ion batteries and lead storage projects.

At present, the energy storage profit is mainly dependent on the peak-to-valley electricity price. In Jiangsu Province, because of the peak-to-valley electricity price is relatively enough, the construction is stable, and basically can run for more than 300 days a year. At the same time, Jiangsu Province has a demand response subsidy policy, and industrial users and industrial user integrators participate in the agreed demand response, subsidizing 20 yuan per kilowatt according to the reduced peak power load. Therefore, many energy storage suppliers and power companies have chosen to invest in the construction and operation of energy storage power stations in Jiangsu Province. For example, a 20 MW, 160 MWh lead carbon battery project, the investor will invest, operate, provide the site for the user and use the electricity of the energy storage station at the preferential electricity price. The main benefit of the project is the electricity and electricity tariffs of the electricity used in the industrial town, while adjusting the peak balance of the industrial town and participating in the demand side response.

The application of energy storage technology in power grid enterprises

At present, the domestic energy storage market is mainly divided into two categories, one is the application of distributed power generation in the customer and the energy storage in the micro-grid, accounting for about 56%, and the other is the centralized wind power station (Renewable energy Network) energy storage applications, accounting for about 35%. The cumulative installed capacity of the two has exceeded 90% of the domestic market, and power transmission and distribution and FM auxiliary services account for about 9% of the market. In recent years, China's energy storage market has shown the development trend of user-side energy storage
applications continue to heat, large-scale deployment of renewable energy storage, and energy storage to participate in the accelerated exploration of power-assisted services.

In terms of renewable energy, Hebei, Liaoning, Gansu, Qinghai and other places are actively planning energy storage peaking demonstration power stations and multi-energy complementary demonstration projects with scales ranging from tens of megawatts to 100 megawatts. Promote the application of energy storage in the field of renewable energy towards large-capacity, large-scale development. The main functions of energy storage in this field are peaking and frequency modulation, smooth output, tracking plan output, and assisting the safe and stable operation of the power grid.

User-side energy storage is one of the most widely used business models, and the application is mainly in peak-filling. Under normal circumstances, the electricity spike period accounts for about 5% of the total electricity consumption period, and the electricity consumption accounts for about 20% of the total electricity consumption. This part of the electricity has the commercial value of energy storage.

The power storage system has been recognized by the peaking and frequency adjusting auxiliary service, and the auxiliary service is attracting more and more energy storage enterprises to explore the commercial application of energy storage.

**Typical case and benefit analysis**

Since most of the energy storage in practical applications is used for peak-cutting and valley filling, this paper takes 10MWh lead-carbon energy storage project as an example, and the total peak discharge is 8 hours per day.

**Project investment estimate**

The entire system investment is about 12.5 million yuan, that is, the fixed cost is 1,250 yuan / kWh, as present in Table 1.

<table>
<thead>
<tr>
<th>Investment composition</th>
<th>unit price</th>
<th>specification</th>
<th>Amount(×10^4 yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead carbon battery</td>
<td>750 yuan/kWh</td>
<td>100,000 kWh</td>
<td>750</td>
</tr>
<tr>
<td>Battery Management System BMS</td>
<td>6000 yuan/set</td>
<td>25 set</td>
<td>150</td>
</tr>
<tr>
<td>Power Conversion System PCS</td>
<td>0.3 yuan/W</td>
<td>4 MW</td>
<td>120</td>
</tr>
<tr>
<td>Energy Management System EMS</td>
<td>1set</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Accessories (interfaces, lines, containers, etc.)</td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Others (including building installation)</td>
<td></td>
<td></td>
<td>110</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>1250</td>
</tr>
</tbody>
</table>

**Project income calculation**

Temporarily do not consider the debt service due to borrowing, the assumption is as follows:

1. The depreciation period is 8 years, the residual rate of lead carbon batteries is 30% (lead recovery), the residual rate of the system is 15%, and the depreciation is based on the sum of years;
2. If the battery capacity is attenuated by 5% per year, the battery usage will be reduced to less than 70% at the end of the 8th year, which is below the optimal use threshold;
3. The electricity price difference is 0.8 yuan/kWh, and the gross income of the first year of the payback period is 10,000 kWh × 26 days × 12 months × 0.8 yuan/kWh = 249.60 million yuan;
4. The energy storage project has tax incentives, the income tax rate is 3% in the first 5 years, and the income tax rate is 9% in the next three years.
It can be seen that the accumulated cash flow after tax becomes positive in the sixth year, that is, static 6 years of recycling. The post-tax internal rate of return IRR is about 6.08%, and the post-tax IRR is related to the project investment amount, electricity price difference, depreciation period, battery decay rate and other factors.

**Project sensitivity analysis**

Two important variables, namely the depreciation period (6 to 10 years) and the electricity price difference (0.6 to 1.0 yuan/kWh), were selected to calculate the post-tax IRR under various scenarios. At present, domestic medium and long-term loan interest rates (more than five years) are 4.9%, and projects with post-tax IRR>6% are economical, and projects with post-tax IRR>10% have better profitability. For example, the post-tax IRR can reach 16.13% under the scenario of depreciation period n=10 and electricity price difference of 1 yuan/kWh, which is a very good energy storage project.

Subsidies for energy storage projects can generally be divided into initial investment subsidies or power subsidies. The impact on post-tax IRR is substantially similar to the decline in fixed costs and the rise in electricity price differences. For example, in some areas of Jiangsu, the energy storage project has an average subsidy of 0.1 yuan/kWh, which is equivalent to an increase of 0.1 yuan/kWh. In this scenario, the tax IRR can reach 9.44%, which has been required for commercialization.

On the other hand, this paper has carried out investment return estimation and sensitivity analysis for lithium battery energy storage projects. Assuming that the depreciation period is 10 years, two important variables of initial investment cost (1000-3000 yuan/kWh) and electricity price difference (0.6-1.0 yuan/kWh) are selected. If the lithium-ion energy storage project is constructed in the 0.8 yuan/kWh area, the initial investment cost will be reduced to 1,500 yuan/kWh, and the post-tax IRR can reach 7.36%. At present, the initial investment cost of lithium-ion energy storage is 2500-3000 yuan/kWh. This means that the cost needs to be reduced by half to have better profitability.

**Prospect**

From the perspective of technological development in recent years, the cost of various mainstream energy storage technologies has been greatly reduced. With the establishment of various verification, demonstration applications and standards, the safety of energy storage technology will gradually increase, meeting the standard requirements, and the commercial application of the industry has laid a solid foundation.

Although the economics and technical performance of energy storage technology are constantly improving, the application point of energy storage is still relatively simple. Later industrial development can focus on the development of compensation mechanism, battery ladder utilization, energy storage sharing mode and energy storage safety.

**References**