Calculation of Energy Storage Cost and Benefit Based on Units-of-production Method

Shuo Yin, Xing Chen, Zhe Chai, Yao Lu, Xingwu Guo, Man Jin

State Grid Henan Electric Power Company Economic and Technical Research Institute, Zhengzhou, Henan, 450052 China

Abstract: Since 2021, the state has successively issued a series of energy storage development policies. Among them, the guiding opinions on accelerating the development of new energy storage, and the notice on further promoting the participation of new energy storage in the power market and dispatching and utilization have defined the boundaries of the energy storage industry in terms of planning and construction, allocation scale, and income mode. The Henan provincial government issued relevant policies in combination with the actual situation, clarifying the direction for the development of energy storage in the province. In order to analyze the economy of electrochemical energy storage, we use units-of-production method to calculate energy storage cost and benefit.

Keywords: Electrochemical energy storage; cost and benefit analysis; units-of-production method.

1. Introduction

The national development and Reform Commission and the National Energy Administration jointly issued the guiding opinions on accelerating the development of new energy storage, put forward the target of installed capacity, and made it clear that by 2025, the installed capacity of new energy storage will reach more than 30million kW, close to 10 times the current installed capacity of new energy storage. In terms of energy storage allocation, the national development and Reform Commission and the National Energy Administration issued the notice on encouraging renewable energy power generation enterprises to build or purchase peak shaving capacity to increase the scale of grid connection. In terms of energy storage ratio requirements, the peak shaving capacity should be allocated and built according to the linkage ratio of 15% of power (more than 4 hours) at the initial stage of the scale beyond the guaranteed grid connection of power grid enterprises, Priority grid connection shall be given to those built according to the linkage ratio of more than 20%.

Henan Province issued the 14th five year plan for modern energy system and carbon peak and carbon neutralization in Henan Province, which proposed to strive to achieve the installed scale of new energy storage of 2.2 million KW. Second, in terms of energy storage allocation, on June 11, 2021, Henan Provincial Development and Reform Commission and Henan Energy Bureau jointly issued the guiding opinions on accelerating the construction of energy storage facilities in Henan Province, which made it clear that the proportion of energy storage allocation for supporting construction of new energy projects is not less than 10%, and the continuous energy storage duration is more than 2 hours.

2. Energy storage construction cost

lithium iron phosphate batteries are used to calculate the construction cost of energy storage, because lithium batteries have comprehensive advantages in energy conversion efficiency, continuous discharge time, self-discharge rate, service life, cycle times, response speed, heat resistance and energy cost. Among them, lithium iron phosphate batteries are safer than ternary lithium batteries. The National Energy Administration issued the twenty five key requirements for preventing power production accidents (2022 Edition) (Exposure Draft), The ternary lithium battery and sodium sulfur battery are excluded from the medium and large-scale electrochemical energy storage power stations, so the lithium iron phosphate battery is more practical and worth popularizing. Lithium iron phosphate batteries account for 95.5% of the battery shipments of energy storage projects in China's power system.

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).

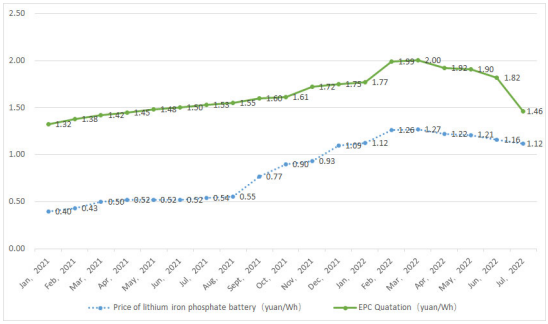

Figure 1 Trends of battery cost

The change of battery cost is the main reason for the change of EPC project contracting cost of energy storage. According to the analysis conclusion of Bloomberg new energy finance, the cost of lithium iron phosphate battery accounts for 55% of the construction cost of energy storage system on average. The cost of lithium iron phosphate battery has increased first and then decreased since 2021. As shown in Figure 1 above, it was the lowest in January 2021, at 0.4 yuan / watt hour, and reached the highest in March 2022, at 1.27 yuan / watt hour, which is highly correlated with the average contracting cost of energy storage EPC project.

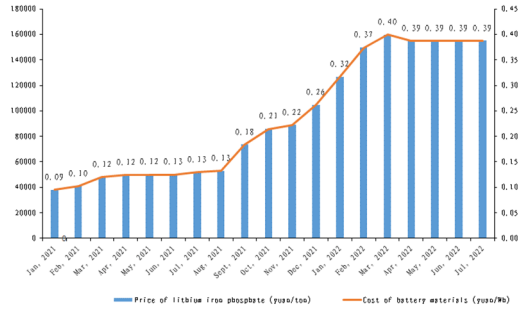

Figure 1 Trends of battery raw material cost

The change of raw materials is the main reason for the price change of lithium iron phosphate energy storage battery. According to the cost analysis of each link in the production of lithium iron phosphate battery, the cost of cathode lithium iron phosphate raw materials accounts for about 20%. From 2021 to now, lithium iron phosphate raw materials have shown an upward and downward trend. As shown in Figure 2 below, the lowest in January 2021 was 37983 yuan / ton, the highest in March 2022 was 159866 yuan / ton, and fell to 155000 yuan / ton in July 2022. The production of 1GWh battery generally requires 2200-2500 tons of lithium iron phosphate. According to this conversion ratio, the raw material cost of lithium iron phosphate in the battery can be obtained. As shown in Figure 2 above, the lowest in January 2021 is 0.09 yuan / watt hour, and the highest in March 2022 is 0.4 yuan / ton, an increase of about 4 times, and decreased to 0.39 yuan / ton in July 2022.

3. Energy storage cost analysis

The operation and maintenance management of the energy storage power station is carried out according to the decentralized layout, centralized operation and maintenance and unattended mode. According to the calculation of material cost of 7.5 yuan / kW and repair cost of 27 yuan / kW, the average annual operation and maintenance cost of 10000 kW / 20000 kwh is 345000 yuan.

Based on the above analysis, we can get the energy storage investment cost boundary of 10000 kW /20000 kwh, as shown in Table 3 below. For the 10000 kW /20000 kwh energy storage project, the self owned capital investment at the beginning of the period is 5.84 million yuan, the loan is 23.36 million yuan, and the annual loan interest is 1.03952 million yuan. The loan principal is repaid at the end of the project operation period. Considering the annual operation and maintenance cost of 345000 yuan, the total cost is 40.27616 million yuan.

Table 1 Calculation results of energy storage investment cost

	EPC capital investment	Loan interest expense	Repayment of loans at maturity	Operation and maintenance cost
Year 1	584	103.952	-	34.5
Year 2	-	103.952	-	34.5
Year 3	-	103.952	-	34.5
Year 4	-	103.952	-	34.5
Year 5	-	103.952	-	34.5
Year 6	-	103.952	-	34.5
Year 7	-	103.952	-	34.5
Year 8	-	103.952	2336	34.5
Total	584	831.616	2336	276

4. Analysis of investment benefit of energy storage

4.1 Reduce peak shaving cost sharing

After the new energy is configured to store energy, it can be charged during the opening period of auxiliary services and discharged during the closing period of auxiliary services, which can reduce the sharing cost of deep peak shaving. The specific calculation method is shown in formula (1):

$$\Delta F_i = \sum_{d=1}^{365} \left\{ Max\left[\int_{t=dk}^{t=dj} C_t, \overline{M} \right] \bullet \frac{Y_{di}}{\int_{t=dk}^{t=dj} P_{dit}} \right\} \quad (1)$$

In the formula, it represents the reduction of the deep peak shaving sharing cost within one year after the new energy type I (wind power or photovoltaic) is configured to store energy, D represents the date, T represents the time, DK represents the opening time of the auxiliary service on day D, DJ represents the end time of the auxiliary service on day D, represents the charging power of the stored energy at time t, represents the charging amount of the stored energy during the opening period of the auxiliary service, and represents the maximum capacity of the stored energy, Represents the maximum charging amount of stored energy during the opening period of auxiliary service. Represents the apportionment amount of new energy type I in the auxiliary service market on day D, represents the output of new energy type I at time t on day D, and represents the power generation of new energy type I in the auxiliary service opening period on day D, that is, the integral of new energy output power in the auxiliary service opening period. Divide the penalty of the day by the wind power and photovoltaic power generation when the auxiliary service is turned on to obtain the unit power penalty corresponding to the wind power and photovoltaic power generation when the auxiliary service is turned on. By multiplying the penalty per unit of electricity of the day by the amount of wind power and photovoltaic power generated when the auxiliary service of energy storage reduction is turned on, the peak shaving sharing fee can be reduced on the day after the new energy is configured and stored. By adding up the daily reduced peak shaving sharing costs throughout the year, we can get the annual reduced peak shaving sharing costs after the new energy is allocated and stored.

4.2 Energy storage income from user side investment

Taking the users with industrial and commercial transformer capacity of more than 315 KVA and voltage class of 110 kV as an example, according to the electricity price table of electrical commercial users purchased by State Grid Henan electric power company in July (see attached table 5), the benefits of 10000 kW /20000 kwh energy storage in one day to save power purchase costs are:one point four four × one point zero four four two two four × 2-1.6 × 0.675599-1.6 × 352244 = 136281632 yuan. Taking 300 days a year as the basis for charging and discharging, the income from saving power purchase costs is about 408844896 yuan, and the income in the 8-year investment cycle is 32.7759168 million yuan. Compared with the total investment of 40.27616 million yuan, the cost cannot be recovered. The specific results are shown in Table 2.

Table 2. Energy storage income of industrial and commercial users of various capacity and voltage levels by 1 kW /2 kwh

Classification of electricity consumption		Voltage level	Electricity price			Annual income	Total revenue
			peak	flat	trough		
Industrial, commercial and other power consumption	Power consumption with transformer capacity below 315 KVA	<1	1.109222	0.716999	0.372944	435.20	3481.56
		1-10	1.066047	0.689499	0.359194	417.69	3341.54
		35-110	1.023971	0.662699	0.345794	400.63	3205.07
		>110	0.982052	0.635999	0.332444	383.64	3069.12
	Power consumption with transformer capacity above 315 KVA	<1	1.097604	0.709599	0.369244	430.49	3443.88
		1-10	1.072484	0.693599	0.361244	420.30	3362.41
		35-110	1.044224	0.675599	0.352244	408.84	3270.76
		>110	1.028524	0.665599	0.347244	402.48	3219.84

4.3 Income from residential users' investment in energy storage analysis

According to the current peak valley time of use tariff policy, only one charge and one discharge can be realized. Take the direct supply and wholesale sale of household electricity for one meter residents, less than 1 kV users as an example, 1 kW /2 kwh energy storage can save the cost of purchasing electricity in one day, and the income of the first level of electricity (2160 degrees and below) is:0.1456 yuan， In the second gear, the power (2160 degrees -3120 degrees) is:0.1376 yuan， In the third gear, the power (3120 degrees and above) is:0.0976 yuan.Based on 300 days a year as the basis of charging and discharging, it is charged once a day, with a single charge of 1.6 degrees, and a total charge of 480 degrees. Assuming that the first level of electricity price is adopted, the cost of power purchase can be saved, and the income is 300 × 0.1456=43.68 yuan, with a return of 349.44 yuan in the 8-year investment cycle. Considering that the cost of installing energy storage batteries for residential users is basically the cost of lithium iron phosphate batteries, it was 1.12 yuan / watt hour in July, and the investment cost of 1 kW / 2 kwh storage was 2240 yuan. The income of resident users' investment in energy storage fails to exceed the cost..

5. Conclusions and recommendations

The notice on further improving the time of use tariff mechanism (Exposure Draft) clearly proposes to encourage industrial and commercial power users to reduce the peak power load, increase the low power consumption, and reduce the power consumption cost by changing the power consumption period by allocating energy storage and carrying out comprehensive energy utilization. Taking the users with industrial and commercial transformer capacity of more than 315 KVA and voltage class of 110 kV as an example, according to

the electricity price table of electrical commercial users purchased by State Grid Henan electric power company in July (see attached table 5), the benefits of 10000 kW /20000 kwh energy storage in one day to save power purchase costs are:136281632 yuan. Taking 300 days a year as the basis for charging and discharging, the income from saving power purchase costs is about 408844896 yuan, and the income in the 8-year investment cycle is 32.7759168 million yuan. Compared with the total investment of 40.27616 million yuan, the cost cannot be recovered.

In terms of rental income, according to the implementation plan of new energy storage in Henan Province, it is proposed that the reference rental price of centralized shared electrochemical energy storage capacity in 2022 is 260 yuan / kwh per year, the annual income of 10000 kW / 20000 kWh energy storage is 5.2 million yuan, and the income within the eight-year investment cycle is 41.6 million yuan. Relative to the total investment of 40.27616 million yuan, the cost can be recovered.

If it is considered that the independent energy storage entity can obtain an internal rate of return of 6.5% on the basis of recovering the investment principal through leasing services, the 8-year investment cycle needs to obtain income: 4027.616+584 × [1.065^8-1] =44.10133472 yuan. According to the annual average cost of 5.51266684 yuan, the price of leasing services provided by energy storage power stations for new energy enterprises should not be less than 275.63 yuan / kWh • year.

References

1. Thang Ngoc Cong.Progress in electrical energy storage system:A critical review[J].Progress in Natural Science,2009,19(03):291-312.
2. Xuli Chen, Rajib Paul,Liming Dai.Carbon-based supercapacitors for efficient energy storage[J]. National Science Review,2017,4(03):453-489.
3. Giray Gozgor, Chi Keung Marco Lau, Zhou Lu, 2018. Energy consumption and economic growth: New evidence from the OECD countries. Energy, 153(15), 27-34. Doi:https://doi.org/10.1016/j.energy.2018.03.158
4. Kraft, J. and Kraft, A., 1978. On the Relationship between Energy and GNP. Journal of Energy Development, 3, 401-403. Doi: http://www.jstor.org/stable/24806805
5. Krausmann, F., H. Haberl, 2002. The process of industrialization from the perspective of energetic metabolish: Socioeconomic energy flows in Austria 1830-1995. Ecological Economics, 41(2), 177-201. Doi:https://doi.org/10.1016/S0921-8009(02)00032-0