Complementary Characteristics Analysis on Cumulative Load of Asia - North America Energy Interconnection

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Abstract. The idea of Global Energy Interconnection will facilitate a large-scale development and exploitation as well as a wide-scope coordination and balance of clean energy, and Asia-North America energy interconnection is an important link of it. This paper discusses the Asia-North America energy interconnection conception with power grid as the backbone at first. Then, comprehensive analysis and forecast of power load of both Asia and North America has been given respectively. After the comparison between cumulative load characteristics of Asia and North America and their respective characteristics, benefits from interconnection of Asia and North America can be identified preliminary.

1 Introduction

Global Energy Interconnection (GEI), which proposed in [1], is a globally interconnected strong and smart grid, which will serve as a platform for extensive development, deployment and utilization of clean energy globally. The construction of GEI will facilitate a large-scale development and exploitation as well as a wide-scope coordination and balance of clean energy, promote energy revolution and sustainable development, and thoroughly solve the problems that restrict the development of human society involving energy security, environmental pollution and greenhouse gas emission.

An important link of GEI is Asia and North America energy interconnection, which is focused on in this paper. Firstly, this paper discusses the Asia and North America energy interconnection conception with power grid as the backbone. Then, comprehensive analysis and forecast of power load of both Asia and North America has been given respectively. Lastly, comparison between cumulative load characteristics of Asia and North America and their respective characteristics has been done to identify the benefits of energy interconnection.

2 Conception of Asia and North America Energy Interconnection

Both Asia and North America are the most important load centres in the world, also are abundant with solar, wind and hydropower resources. The idea of Asia and North America energy interconnection, which shown in figure 1, mainly has two influences, including transporting the power from Arctic large-scaled wind power bases to Asian and North American load centres, and smoothing power load curve and renewable power output curve benefitted from its hemisphere complementation characteristics, which can improve ability and efficiency of global energy allocation.

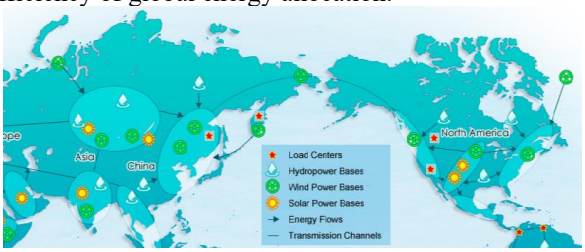

Fig. 1. Asia and North America Energy Interconnection

Asia and North America can both take advantages of time zone differences, the energy interconnection will start from northeast of China and Siberia, across Bering Strait, connecting to Alaska, and then into Canada and the United States, which also called west coast load center. Transmission distances of north-eastern china to Siberia, Bering Strait to Alaska and Alaska to west coast of the United States are less than 3500, 2000 and 4500 km respectively, and underwater electric wire will be only used in Bering Strait, which about 90 km. East Asia and west coast are main load center of Asia and North America separately. Time zone difference between East Asia and west coast is about 9 hours, and about 12 hours between East Asia and eastern part of the United States, which lead to a strong complementary characteristic of their load curves.

In view of power load of Asia is large, considering complementary needs of peak and valley load, overall size of Asia-North America energy interconnection is expected to be over 500 million kilowatts. As the wind farm of Bering Strait is located in the channel between Asia and North America, exploitation and transmission of wind power in Bering Strait can be taken into account and taken good use of. An initial interconnection idea is shown in Figure 1. In consideration of many difficulties,

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such as long distance, alpine region, undersea wire, interconnection is expected to achieve near 2050.

3 Analysis and Forecast of Power Load of Asia and North America

East Asia and west coast of North America are two main load centres, their power load will be analysed and forecasted below.

3.1 the United States & Canada Load Center

The United States and Canada load center mainly includes Canada and the United States East and West Coast load center, which the United States East Coast Coastal load center refers to the US East Coast New York, Pennsylvania and West Coast California. Due to latitude differences, Canada and the United States there are significant seasonal differences in electricity load, Canada's winter heating load is large, the monthly electricity curve showed significant "winter summer small" features, the US summer air-conditioning load and winter heating load , The monthly electricity consumption curve showed obvious "summer and winter big autumn" features.

Taking into account the annual electricity consumption characteristics of Canada and the United States, get the United States and Canada load center in 2015 the monthly electricity consumption. As the US electricity consumption is about 8 times that of Canada, the annual load characteristics of the United States and Canada load center and the US annual load characteristics are basically the same, summer and winter high electricity consumption, spring and autumn low electricity consumption.

According to the historical data from International Energy Agency (IEA), the polynomial autoregressive model is used to forecast the annual electricity consumption in 2020 and 2050, and the seasonal load of the medium and long-term US and Canada regions is assumed to be the same. The maximum annual maximum load and the minimum monthly maximum load Forecast, the forecast results in figure 2.

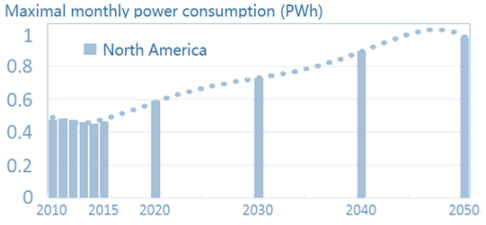

Fig. 2. Forecast of Maximal Monthly Power Consumption of North America

Figure 3 shows typical daily load curve for the summer of 2015 in the United States and Canada. The load of the United States and Canada load center showed obvious “single-peak and single-valley”, the daily maximum load appeared around 6 o'clock in the day, daily minimum load appeared at 17:00, peak-valley difference could reach 338.85 GW and peak-valley ratio reach 39.7%.

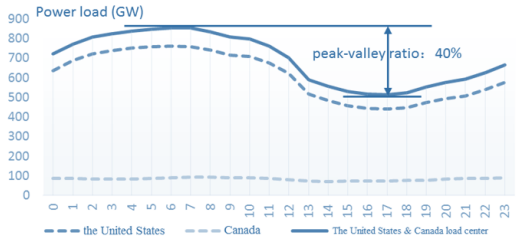

Fig. 3. Typical Summer Daily Load Curve in 2015 of North America Load Center

It is assumed that the medium and long-term the U.S. and Canada load curves keep the characteristics of "single peak single valley", and the peak and valley time is basically the same. According to the multi-factor regression model, consider the future increase with the degree of electricity market and the demand side management level, and consider Energy storage technology in the grid and the user side of the popularity and application of the United States and Canada load center peak valley rate will continue to decline, to 2050 peak rate difference from 40% in 2015 to 30%. Furthermore, the peak and valley differential rates of typical daily load are predicted. The results are shown in table 1.

Table 1. Forecast of Daily Typical Load Characteristics of North America Load Center in 2020-2050

	Peak Load (GW)	Peak valley rate
2015	853	40%
2020	948	39%
2030	1181	37%
2040	1427	34%
2050	1529	30%

3.2 Northeast Asia Load Center

Northeast Asia load center mainly includes China, Japan and South Korea. China's electricity consumption in addition to the Spring Festival in February, the monthly electricity consumption is more stable, slightly higher in summer and winter; Japan and South Korea's annual electricity show high winter, low spring and low characteristics.

Taking into account the annual electricity consumption characteristics of China, Japan and South Korea, the electricity consumption of the Northeast Asia Load Center is formed. As China's electricity consumption accounts for about 80% of the total electricity consumption in Northeast Asia, the annual load characteristics of the Northeast China load center are basically consistent with China's annual load characteristics.

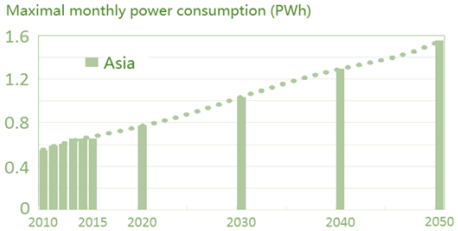

Fig. 4. Forecast of Maximal Monthly Power Consumption of Asia

According to the historical data, the polynomial autoregressive model is used to forecast annual electricity consumption in 2020 and 2050, and seasonal load of the medium and long term Northeast Asia is assumed to be the same. The forecast results are shown in figure 4.

Figure 5 shows typical daily load curve for the summer of 2015 in Northeast Asia. Load curve of load center in Northeast Asia showed characteristics of "multi-peak and single-valley". Maximum daily load was about 11 o'clock in the daytime. Daily minimum load appeared at about 4:00 am, and peak-valley difference could reach 201.6 GW, and its ratio reach 21.6%.

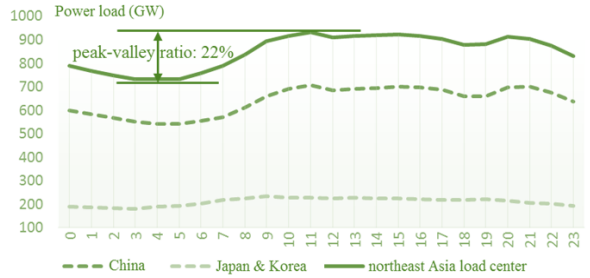

Fig. 5. Typical summer daily load curve in 2015 of northeast Asia load center

It is assumed that the characteristics of the mid-long-term Northeast Asia load curve "multi-peak and single-valley" are unchanged, and the peak-valley time is basically the same. According to the multi-impact factor regression model, considering the future increase with the degree of electricity market and the demand side management level, and consider the energy storage technology in the grid and the user side of the popularity and application of peak and valley rate will continue to decrease; Economic and social development, the proportion of residents in Northeast Asia and the tertiary industry increased, the peak rate will increase. On the whole, it is expected that the peak-valley rate of the load center in Northeast Asia will remain unchanged by 2030. After 2030, the peak-valley rate will decrease slowly, and the peak-valley difference will decrease to 20% by 2050. Furthermore, the peak-valley difference of typical daily load is predicted. The results are shown in table 2.

Table 2. Forecast of Daily Typical Load Characteristics of North America Load Center in 2020-2050

	Peak Load (GW)	Peak valley rate
2015	932	22%
2020	1142	22%
2030	1522	22%
2040	1898	21%
2050	2267	20%

4 Cumulative Load Complementary Characteristics Analysis

Cumulative load is the summing daily load curve of interconnected areas. Figure 6 shows cumulative load curve of typical summer day after Asia-North America energy interconnection in 2050. It can be seen that, because of time zone differences and its complementary characteristics, interconnection of North America and Asia can achieve the goals that reducing both peak load and peak-valley ratio. In 2050, assuming that scale of North America and Asian power grid interconnection is big enough, the peak-valley difference can be reduced from 493.9 GW (North America) and 641.7 GW (Asia) separately, down to 615.6 GW after interconnection, and peak-valley ratio drops to only 16.4%.

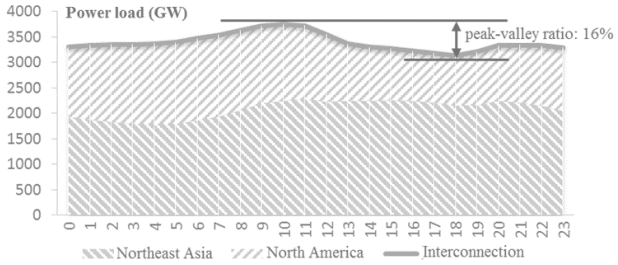

Fig. 6. Typical Summer Daily Cumulative Load in 2050 of Asia-North America Interconnection

The change before and after the interconnection of daily load characteristics in 2050 has been summarized as shown in table 3. It can be seen that after Asia-North America energy interconnection, load characteristics of interconnected power grid have been improved obviously. All of peak daily load, daily peak-valley difference and ratio are significantly reduced.

Table 3. Load Characteristics Comparison of before and after Interconnection in 2050

	Before			After
	Asia	North America	Sum	
Daily peak Load (GW)	1,529	2,267	3,796	↘ 3,699
Daily peak-valley difference (GW)	494	642	1,136	↘ 616
Daily peak-valley ratio	30%	20%	/	↘ 16%

5 Conclusion

As we all know, with the expansion of interconnection, there can be a lot of benefits, including resource optimization configuration, promotion of secure and reliable energy use, and so on. This paper has proved the possibility of these benefits by analysing the decrease of peak cumulative load and its peak-valley ratio due to power load complementary characteristics after Asia-North America energy interconnection. Furthermore, some detailed calculations of the interconnection benefits will be discussed in further study.

References

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