Analysis of the Impact of Dalian Clean Energy Development on the Company's Operation

Zeming Lv[1, a], Xing Sun[2, b], Mingfeng Xu[1, c], Chunhua Lin[3, d], Jiannan Guo[4, e], Mingyu Wang[1, f], Xu Liu[5*]

[a]luckyzm123@163.com, [b]hsing_hsing@126.com, [c]1398285488@qq.com, [d]38854223@qq.com, [e]548360426@qq.com, [f]wangmy0702@163.com, [*]Corresponding Author: guatai315@163.com

[1]State Grid Dalian Changxing Island Lingang Industrial District Power supply Company, Yingkou City, Liaoning Province, China

[2]State Grid Liaoning Electric Power Co., LTD. Dalian Power Supply Company, Dalian City, Liaoning Province, China

[3]State Grid Dalian Power Supply Company, Dalian City, Liaoning Province, China

[4]State Grid Yingkou Power Supply Company, Yingkou City, Liaoning Province, China

[5]Information Security Engineering Laboratory, North China Electric Power University, Beijing City, Beijing Province, China

Abstract—The power grid is the foundation for the development of clean energy. In recent years, the government has invested heavily in the construction of grid-connected projects involving nuclear power, wind power and other clean energy sources to ensure that clean energy is connected to the power grid in a timely manner [1]. The report analyzes the development status and policy development environment of wind power, nuclear power, photovoltaic power and energy storage in Dalian. The growth trend, proportion of installed capacity and power generation of grid-connected wind power, nuclear power and photovoltaic power, as well as regional distribution characteristics of total installed energy capacity in Dalian were analyzed. This paper analyzes the operational impact of large-capacity nuclear power units, grid-connection of wind power [2] and photovoltaic power generation, and energy storage on the company's power grid planning, power grid investment and power grid operation.

The report analyzes and proposes to strengthen the research on the safety and stability of large-capacity nuclear power units connected to the grid and the planning and construction of nuclear power transmission channels [3]. We will speed up the construction of pumped storage and other energy storage power stations to ease the problem of peak-regulating power grids. Strengthen the operation management of wind power connected to the grid and promote the consumption of renewable energy; Strengthen the guiding role of power grid planning for offshore wind power access, optimize the cascade dispatching of power stations, improve the utilization rate of new energy and other relevant suggestions and countermeasures; Make use of its own advantages, strengthen competitive industries, increase the proportion of new energy access; Integrate industry resources, accelerate platform transformation and promote market drive; We will increase investment in scientific research and foster the development of new energy sources such as chemical energy storage and hydrogen energy. Expand financing channels, strengthen policy adjustment, implement new energy planning and construction; Closely follow the weight of consumption responsibility, seize the green electricity consumption and marketing opportunities [4].

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Keywords-grid; clean energy; energy storage; consumption

1. Clean energy development status in Dalian

The report to the 18th National Congress of the CPC stated that ecological progress should be given a prominent position and efforts should be made to build a beautiful China. State Grid Dalian Power Supply Co., LTD., based on the development needs of new power system and closely following the pace of power market reform, put forward the development plan of building "world-class distribution network"[5]. These strategies have created a good space for the development of clean energy and promoted the rapid development of clean energy in Dalian. So far, Dalian City's power supply reliability rate is 99.889%; Comprehensive voltage qualified rate of 99.89%; The complete power grid infrastructure has created favorable conditions for the construction of distribution networks in world-class cities. Clean electricity accounts for 58.3% of the total installed capacity, including 5,575 MW of nuclear power, 72.3% of the total installed capacity, 1,823 MW of wind power, 23.6% of the total installed capacity, 304 MW of photovoltaic power, 3.9% of the total installed capacity and 0.2% of the total installed capacity of clean energy. The ratio of installed capacity is shown in Figure 1 below. The local consumption rate of clean energy has been maintained at 100 percent for a long time, and electric energy accounts for 27.3 percent of terminal energy consumption.

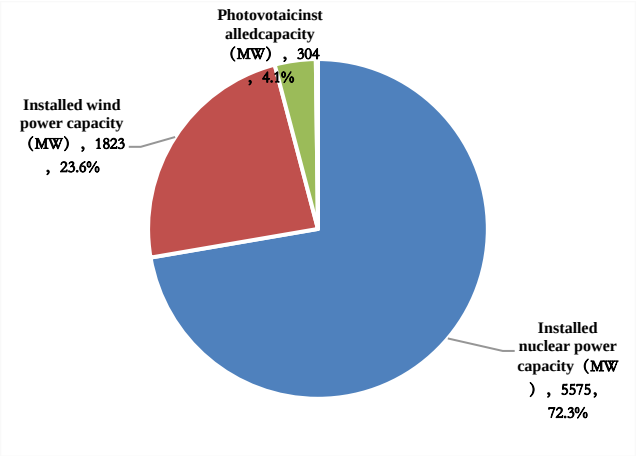

Figure 1. Proportion of installed clean energy capacity in Dalian up to now

1.1 Nuclear power

Dalian coastal nuclear power plant site is rich in resources. Hongyanhe Nuclear Power Plant Phase II Unit 5 was put into commercial operation in July 2021, and the installed nuclear power capacity reached 5.58 million kW, surpassing the installed thermal power to become the largest power source. The second phase of Hongyanhe Nuclear Power Plant is scheduled to be put into commercial operation by the end of 2022. The preliminary work of Zhuanghe Nuclear power Plant project will be carried out in an orderly manner, and the installed scale of nuclear power plant will grow steadily. At present, 6 units of Hongyanhe Nuclear Power Plant have been fully completed and put into operation, with a total installed capacity of 6.7 million kW, which is the

largest nuclear power plant in operation in China and the third largest in the world. At the same time, it is also the nuclear power plant with the most independent innovation and the highest localization rate. In order to improve the independent production capacity of complete sets of equipment, To promote the formation of a more complete independent nuclear power industry system provides a rare opportunity for development. After Hongyanhe nuclear power Plant is put into operation, Dalian has achieved considerable effect on energy conservation and emission reduction.

Up to now, Dalian has built a total installed capacity of 5,575 megawatts of nuclear power projects, which is the main component of Dalian's clean energy.

1.2 Wind power

Dalian's coastal wind energy resources are very rich. In September 2021, Development and Reform Commission of Liaoning Province, Provincial Department of Industry and Information Technology, and Provincial Electric Power Company jointly issued the Construction Plan for New Wind Power Projects in Liaoning Province. According to the requirements, Dalian Development and Reform Commission led the drafting of Work Plan for Competitive Allocation of Onshore Wind Power Projects in Dalian. According to the plan, Dalian City finally decided to build a 700,000-kw onshore wind farm for Northeast Huaneng Branch and a 500,000-kw onshore wind farm for Northeast China Power Investment Co., LTD., all of which were included in the first batch of provincial construction plans.

By the end of June 2022, the total installed capacity of wind power projects in Dalian has reached 1,823 megawatts, among which the total onshore wind power capacity in Dalian is 770 megawatts. In the first half of this year, it generated 1.76 billion kilowatt-hours of electricity. Next, Dalian will accelerate the implementation of the project and ensure that all projects will be put into operation before the end of 2023, when the installed scale of wind power in Dalian will exceed 3,000 megawatts.

1.3 Photovoltaic power

Using abandoned mines, aquaculture reservoirs, coastal beaches and other areas, Dalian develops photovoltaic power generation according to local conditions. Changxing Island Economic and Technological Development Zone has signed a contract to invest 5.8 billion yuan in JA AO 1000 MW photovoltaic power generation, contributing to the continuous investment in Changxing Island's new energy construction. Zhuanghe City has been selected into the national photovoltaic promotion list of the whole county, focusing on the promotion of shoal "complementary fishing and light" photovoltaic demonstration project in areas such as Pulandian and Zhuanghe.

In 2021, the National Energy Administration designated Zhuanghe City of Dalian as a county (city or district) pilot project for the development of rooftop distributed PV, planning to build rooftop distributed PV on the roofs of Party and government organs, schools, hospitals, village committees, industrial and commercial plants, and rural villagers. Under the premise of meeting the requirements of the National Energy Administration on the proportion of photovoltaic power generation that can be installed, the roof area of 1,884,200 square meters will be developed. The installed PV capacity is 210 MW, with an annual average power generation of 252 million KWH. In addition, the State Grid Dalian Power Supply Company has established a resource base for distributed photovoltaic projects that can be developed, planned and constructed power grid

facilities, reformed and upgraded the distribution network, effectively guaranteed the large-scale access demand of distributed photovoltaic pilot projects, and realized reasonable grid-connected consumption.

By 2021, the city has built and put into operation three large-scale photovoltaic power stations. At present, the number of photovoltaic power stations in Dalian is small, and the overall scale is small. There is still a large space for development. The total installed capacity of photovoltaic power stations has reached 304 MW, and the power generation in 2021 will reach 220 million KWH. Six distributed photovoltaic power generation projects with a total installed capacity of 1.8 megawatts have been built in the central city area.

1.4 Energy storage and other new sources of power generation

The Dalian Municipal Government issued the Implementation Opinions of the People's Government of Dalian on Promoting the Development of Energy Storage Industry, giving full play to the industrial foundation and leading advantages of energy storage technology and equipment of Dalian, accelerating the industrialization and promotion of energy storage technology and equipment, further enhancing the industrial competitiveness, driving the rapid development of strategic emerging industries such as new energy, and providing multi-directional technical support. The first light-storage-charging station in Northeast China has been built, with a total installed capacity of 24kWp for photovoltaic subsystem, a maximum output power of 150kW for energy storage subsystem, and a total installed capacity of 525 KWH. The charging subsystem is equipped with 22 DC charging piles and 20 AC charging piles. As the first phase of China's largest liquid flow energy storage peak-regulating power station will be put into operation in Dalian in 2020 (maximum output power of 100 MW, installed capacity of 400 MWH), the second phase of the project will be put into operation in 2023 (maximum output power of 100 MW, installed capacity of 400 MWH), and distributed energy represented by photovoltaic power generation will be promoted and applied. Electric vehicles and other new loads are widely accessible, and the power distribution equipment and management system are developing towards intelligence and automation. Dalian's position as the center of the energy storage equipment manufacturing and supporting industries in the Far East will be further consolidated.

When the Dalian liquid flow battery energy storage peaking power station is put into operation, it will store the renewable energy generation in the off-peak period and put the energy into the grid in the peak period to play the role of "peak cutting and valley filling", realize the consumption of renewable energy generation, further increase the proportion of renewable energy in the energy structure and improve the operation economy of thermal power units. Improve the security of power grid operation.

At present, Dalian City is exploring the development and utilization of Marine energy research, strive to start the implementation of offshore tidal and tidal power generation demonstration projects; Dalian City actively promotes rural biogas project, straw gasification and biomass thermal and electrical trigeneration technology to boost the research and development of bioenergy power generation projects.

1.5 Distribution of total installed energy capacity in the city

By 2021, the power supply area in Dalian will be divided into five categories: A+, A, B, C and D, with no E power supply area.

Power supply area under the municipal jurisdiction:

Class A+ power supply area covers central and mountainous areas, with a total power supply area of 27.28km^2.The long-term load density is 43.84MW/km^2, and the total installed capacity is 1196MW.

Class A power supply area covers Xigang District and Shahekou District, with a total power supply area of 54.11km^2, long-term load density of 27.72MW/km^2, the total installed capacity of 1500MW.

Class B power supply area covers high-tech Park, Ganjingzi District, Jinpu New District (Kai The total power supply area is 215.93km^2, the long-term load density is 14.98MW/km^2, and the total installed capacity is 3235MW.

Power supply area under county jurisdiction:

Class B power supply area covers urban area of Lushunkou District, Jinpu New District and Changxing Island Economic Zone, with a total power supply area of 829.49km^2, long-term load density of 13.06MW/km^2, and total installed capacity of 10,833MW.

Class C power supply area covers Wafangdian City, southern area of Pulandian, non-main urban area of Lusshunkou District, urban area of Zhuanghe City and Mingyang Town, Changhai County Dachangshandao Town and Zhangzidao Town. The total power supply area is 1462.77km^2, the long-term load density is 2.83MW/km^2, and the total installed capacity is 4140MW.

Class D power supply area covers the northern area of Plandian (Anbo, Lejia and Shuangta), non-urban area of Zhuanghe City and Mingyang Town area, Changhai County except Zhang-zidao Town, with a total power supply area of 938.22 km^2, long-term load density of 0.89MW/km^2, and installed capacity of 835MW.

By 2021, the comprehensive table of the city's power generation production and the distribution of the city's installed electric power capacity are shown in Figure 2 and Figure 3.

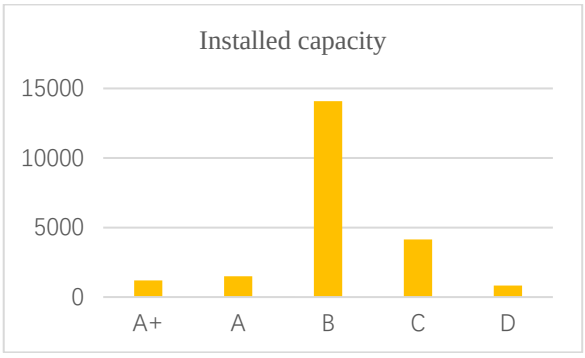

Figure 2. Installed capacity distribution of each power supply area in Dalian by 2021

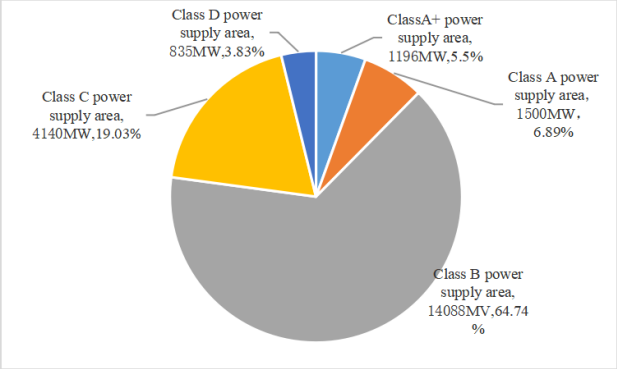

Figure 3. Distribution percentage of installed power capacity in each power supply area of Dalian by 2021

Figure 2 and Figure 3 show that power generation in the province is mainly concentrated in Class B and Class C power supply areas, accounting for 64.74% and 19.03%, respectively. Class B power supply areas cover high-tech Park, Ganjingzi District, Jinpu New Area (Development Zone), urban area of Lushunkou District, Jinpu New Area and Changxingdao Economic Zone. Class C power supply area covers Wafangdian City, southern area of Pulandian, non-main urban area of Lusshunkou District, urban area of Zhuanghe City and Mingyang Town, Changhai County Dachangshandao Town and Zhangzidao Town.

2. Clean energy development Policy and environment

Clean energy is an important branch of China's energy supply system. In recent years, the state and local governments have introduced many policies to support the development of clean energy, mainly focusing on policy guidance, project planning, online electricity price, financial subsidies and value-added tax preference, power station investment and construction, power grid connection and consumption service.

In terms of policy guidelines, the state has issued the Guiding Opinions on Promoting the High-quality Development of Central Enterprises to Achieve Carbon Peaking and Carbon Neutrality, the Opinions of the CPC Central Committee and The State Council on Fully, Accurately and Comprehensively Implementing the New Development Concepts to achieve Carbon Peaking and Carbon Neutrality, and the Notice of Action Plan for Achieving Carbon Peaking before 2030[6]. The key role of clean energy in the goal of carbon peak and carbon neutrality was emphasized to promote the continuous improvement of China's energy structure.

In terms of project planning, the state has promulgated the "14th Five-Year Plan for Green Industrial Development", the "14th Five-Year Plan for Modern Energy System", the "14th Five-Year Plan for Renewable Energy Development" and the "14th Five-Year Plan for Scientific and Technological Innovation in the Field of Energy". Liaoning Province has issued the "14th Five-Year Plan for Energy Development". The "14th Five-Year Plan for Dalian's Energy Development" is introduced in Dalian, which further defines the scale and pace of clean energy development and construction in Dalian, Liaoning province.

In terms of feed-in tariffs, It has issued the Notice on Matters Related to the 2021 New Energy On-Grid Tariff Policy, the Notice of the National Development and Reform Commission on Improving the Onshore Wind Power Photovoltaic On-Grid Benchmark Tariff Policy, the Notice of the National Development and Reform Commission on Verifying the 2020-2022 Provincial Power Grid Transmission and Distribution Tariff, and the Notice on Improving the Wind Power On-Grid Tariff Policy. The benchmark feed-in price for wind power, nuclear power and photovoltaic power generation has been set.

In terms of fiscal subsidies and value-added tax concessions, the state issued the Measures for the Management of Additional Funds for the Electricity Price of Renewable Energy, clarifying that the Ministry of Finance will allocate subsidies for renewable energy power generation projects to power grid enterprises and provincial financial departments in accordance with the principle of determining expenditure based on revenue. The State Administration of Taxation issued the Guidelines on Preferential Tax Policies for Supporting Green Development, which summarized 56 preferential tax policies for supporting green development, including many for promoting the development of wind power and photovoltaic power.

In terms of investment and construction of power stations, the state issued the Measures for the Administration of the Development and Construction of Photovoltaic Power Stations (Draft for Second Consultation), the Guiding Opinions on Promoting the Development of Energy Storage Technology and Industry and the Notice on Matters Related to the Development and Construction of Wind Power and Photovoltaic Power Generation in 2021. Liaoning Province issued the "Wind Power Project Construction Plan of Liaoning Province" and "Photovoltaic Power Generation Project Construction Plan of Liaoning Province" to promote the further development of wind power, photovoltaic power generation and energy storage technology.

In terms of grid connection and consumption services, the State Grid Corporation issued Opinions on the Work of Grid Connection of Distributed Power Supply, Soliciting Opinions on Matters Related to the Development and Construction of Wind Power and Photovoltaic Power Generation in 2021, and the Liaoning Provincial Development and Reform Commission issued the Implementation Plan of Liaoning Province for the Protection of Consumption of Renewable Energy Power (Draft for Comments), which stipulated the grid connection standards. Distributed photovoltaic power generation and wind power projects do not charge for system backup capacity, and the implementation plan of absorption service has been defined.

In April 2022, the National Development and Reform Commission issued the Letter on Extending the Parity Internet Access Policy for New wind Power and Photovoltaic Power Generation Projects in 2022. For newly approved onshore wind power projects, newly registered centralized photovoltaic power stations and industrial and commercial distributed photovoltaic projects, the parity Internet access policy will be extended, and the on-grid electricity price will be implemented according to the benchmark local coal-fired power generation price. Wind power projects, newly registered centralized photovoltaic power stations and industrial and commercial distributed photovoltaic projects can voluntarily participate in market trading to form the on-grid electricity price, so as to fully reflect the green power value of new energy.

In September 2022, the Executive meeting of the Liaoning Provincial Government adopted in principle the Implementation Plan of Liaoning Province to Accelerate the Promotion of the Construction of a Strong Clean Energy Province, clarifying the work tasks in six aspects: first, to accelerate the construction of a new power system; second, to expand the development space

of clean energy; third, to boost the development and expansion of the energy storage industry; fourth, to promote the transformation and upgrading of energy use methods; fifth, to promote the development of clean energy equipment. Sixth, we will improve the environment for clean energy development. It puts forward specific working direction and tasks for the development of clean energy in Liaoning Province and promotes the application and development of clean energy in Liaoning Province.

In recent years, Dalian Rongke has been approved as a national, provincial and municipal innovation platform such as the National Energy Administration Key Laboratory of Energy Flow Energy Storage Battery Technology, the National Development and Reform Commission "National and Local Joint Construction of Liquid Flow Energy Storage Battery Technology Engineering Research Center", and the National postdoctoral research station. The development of energy storage technology provides a good guarantee for the consumption of wind power and photovoltaic power generation.

In the process of clean energy development, policy plays a good guiding and promoting role. Clean energy such as wind power, nuclear power and photovoltaic power generation has become an important part of our energy transformation strategy. These policies and measures have been introduced to ensure the sound and circular development of clean energy in terms of guiding ideology, methodology and implementation standards.

3. Dalian clean energy development trend

State Grid Dalian Power Supply Company takes "carbon peak and carbon neutrality" as the goal, adheres to new energy as the main supply body, takes ensuring energy and power safety as the basic premise, takes ensuring economic and social development as the primary goal, takes strong smart grid as the hub platform, and supports the interaction of charge and storage and multi-energy complementing of source network. We will speed up the building of a new type of power system that is clean, low-carbon, safe, controllable, flexible, efficient, intelligent, friendly, open and interactive. Surrounded by the sea on three sides, Dalian is rich in renewable energy such as wind, solar and tidal energy, which is conducive to promoting the access and consumption of a high proportion of new energy. Power grid is a platform for clean energy transmission and optimal allocation. The company actively invests in the construction of energy transformation and reform projects, and strives to ensure the safe, reliable and timely access of clean energy power generation projects to the power grid. In 2021, Dalian power Grid accommodated 7 centralized new energy projects, with an additional capacity of 1.964 million kW. At present, the total installed capacity of new energy in Dalian power grid is 7.835 million kW, accounting for 59.2%, including nuclear power, wind power, photovoltaic, energy storage and other energy types [7].

3.1 Development trend of clean energy installed capacity in the city

The city's electricity consumption parameters from 2019 to 2021, and the installed capacity of wind power, photovoltaic power and nuclear power are shown in FIG. 5 and FIG. 6.

Based on the city's power supply demand, Dalian Power Supply company has made statistics on the basic power consumption parameters of users in 2021. As shown in Figure 4, the company has divided power supply types according to the central urban area and coastal areas, and

conducted detailed statistics on power consumption area, population, power consumption, power sold and other parameters. By the end of 2021, the power supply reliability rate of Dalian City is as high as 99.889%. Comprehensive voltage qualified rate of 99.89%; The maximum social load in Dalian is 7.04 million kW, the social electricity consumption is 47.02 billion KWH, and the electricity sold is 36.343 billion KWH.

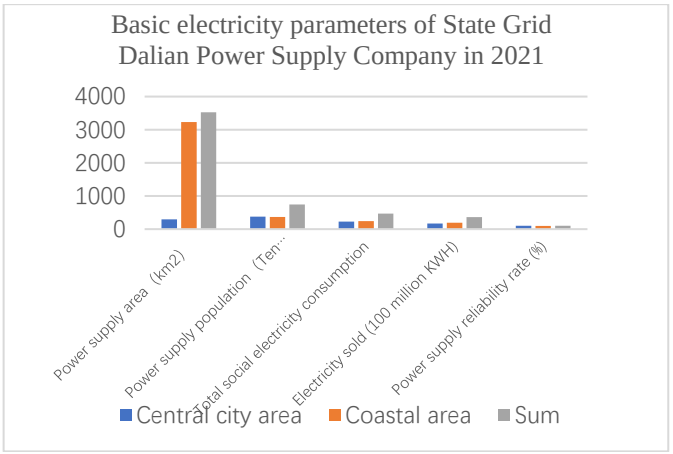

Figure 4. Statistics of basic electricity consumption parameters of State Grid Dalian Power Supply Company in 2021

At present, Dalian's installed clean energy capacity accounts for 61.3%, ranking first in Northeast China and leading in the country. Figure 5 shows that from 2019 to 2021, the city's nuclear power construction has been steadily promoted, a number of key power grid projects such as Hongyanhe Nuclear power[8] delivery project have been successfully implemented, nuclear power generation has increased strongly, the supply of clean energy has increased, the energy supply of Dalian has been guaranteed, the structure has been optimized, and the sound and rapid development of the city's economy and society has been effectively guaranteed.

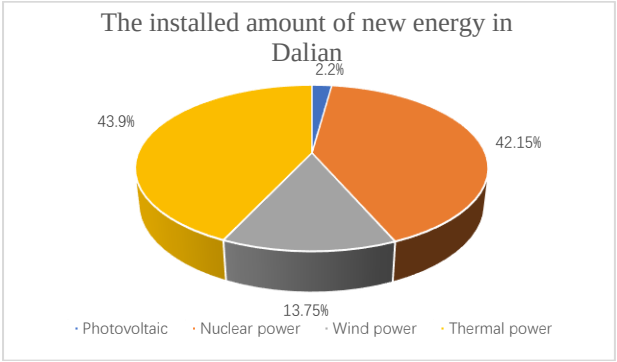

Figure 5. Proportion of installed energy capacity in Dalian

Relying on coastal advantages, Dalian offshore wind power has developed rapidly. Since 2017, the city has started the construction of all planned offshore wind power projects. Built in November 2020, Zhuanghe Ⅲ Offshore Wind Farm is the first large-scale grid-connected offshore wind farm in northern China. According to the requirements of "Construction Plan for Additional Wind Power Project in Liaoning Province" issued by the Liaoning Development and Reform Commission and other three departments in September 2021, the city has built and put into production 1.05 million kw of offshore wind power, which is the largest offshore wind power base in northern China. In 2021, State Grid Dalian Power Supply Company will build a new Hongheyan nuclear power plant with an installed capacity of 1,118.79MW, and build a new Dongfeng Nissan photovoltaic power Station, Huaneng Bihai Wind Power Plant, Haiwang Island Wind Power Plant, Nandao Wind Power Plant, Shulong Island Wind Power Plant and Shenneng Power Plant with a total installed capacity of 855MW. The installed wind power capacity of the city is 1,823 megawatts, accounting for 23.6%, the consumption rate of clean energy remains 100% for a long time, and the electric energy accounts for 27.3% of terminal energy consumption [9].

In view of the development of new energy in the offshore islands of Dalian City, the municipal government of Dalian City has accelerated the development and utilization of renewable energy in Changxing Island, and invested in the construction of the new phase of distributed photovoltaic demonstration project. After the completion of the project, the local government will form the industrial development of 500 ~ 1000 MW distributed "multi-energy complementary new energy + intelligent micro-grid", to help the high-quality development of power supply in Changxing Island with practical actions [10]. In 2022, Changxing Island Economic and Technological Development Zone held the "Signing and Starting of Major Projects and the foundation laying Ceremony of Zhonglin Group (Bohai Rim) Imported Wood Trading and Processing Demonstration Base Project (Phase I)". A total of 32 projects were signed and started, including JA Ao 1000MW photovoltaic power generation and 200MW energy storage project with an investment of 5.8 billion yuan. For Changxing Island new energy construction continued investment force.

In addition, in the second half of 2021, Liaoning Province will build a pumped storage power station in Zhuanghe, Dalian. Zhuanghe is a city under the jurisdiction of Dalian, and the territory is covered with rivers and rivers. The total investment of the pumped storage power station project will be 6.789 billion yuan, the installed capacity will be 1000 MW, and the annual power generation will reach 1.673 billion KWH. Can act as an emergency power supply to ensure the safe and stable operation of the system; Reduce the difficulty of system peak balancing and reduce system energy consumption; Reduce abandoned electricity and improve the use of clean energy.

3.2 Development trend of clean energy power generation in the city

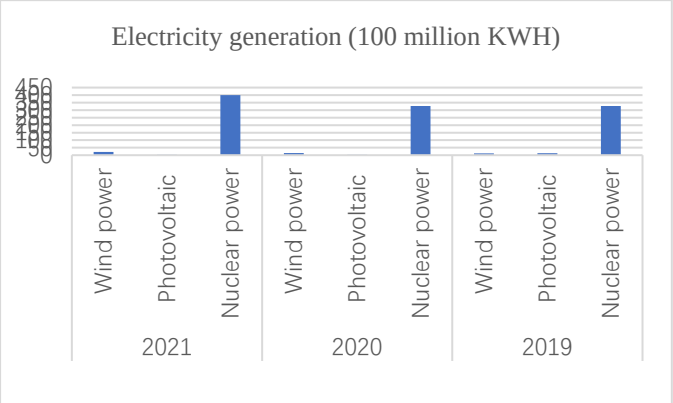

Figure 6. City-wide power generation from 2019 to 2021

Starting from 2021, the National Energy Administration has designated Zhuanghe City of Dalian as a county (city or district) pilot project for the development of rooftop distributed PV. It plans to build rooftop distributed PV on the roofs of Party and government organs, schools, hospitals, village committees, industrial and commercial plants, and rural villagers. On the premise of meeting the requirements of the National Energy Administration on the proportion of photovoltaic power generation that can be installed, The development of the roof area of 1,884,200 square meters, photovoltaic installed capacity of 210 megawatts, annual average power generation of 252 million KWH. In addition, the State Grid Dalian Power Supply Company has established a resource base for distributed photovoltaic projects that can be developed, planned and constructed power grid facilities, reformed and upgraded the distribution network, effectively guaranteed the large-scale access demand of distributed photovoltaic pilot projects, and realized reasonable grid-connected consumption.

Relying on its coastal advantages, Dalian's wind power has developed rapidly. Since 2017, the city has started the construction of various offshore wind power projects within the planning. Built in November 2020, Zhuanghe Ⅲ Offshore Wind Farm is the first large-scale grid-connected offshore wind farm in northern China. According to the requirements of "Construction Plan for Additional Wind Power Project in Liaoning Province" issued by the Liaoning Development and Reform Commission and other three departments in September 2021, the city has built and put into production 1.05 million kw of offshore wind power, which is the largest offshore wind power base in northern China. In 2021, State Grid Dalian Power Supply Company will build a new Hongheyan nuclear power plant with an installed capacity of 1,118.79MW, and build a new Dongfeng Nissan photovoltaic power Station, Huaneng Bihai Wind Power Plant, Haiwang Island Wind Power Plant, Nandao Wind Power Plant, Shulong Island Wind Power Plant and Shenneng Power Plant with a total installed capacity of 855MW. The installed wind power capacity of the city is 1,823 megawatts, accounting for 23.6%, the consumption rate of clean energy remains 100% for a long time, and the electric energy accounts for 27.3% of terminal energy consumption.

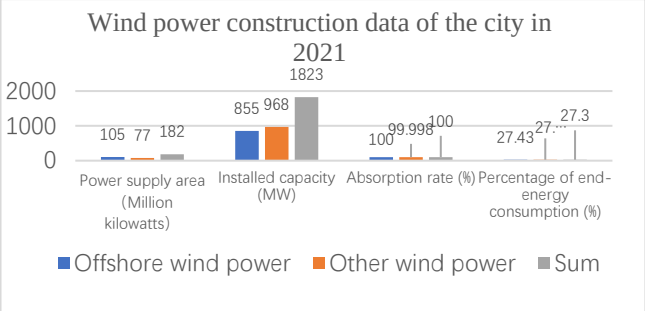

Figure 7. Wind power construction data of the city in 2021

Judging from the development of clean energy installed capacity and power generation in Dalian in the past three years, nuclear power and wind power have been the main contributors to the development of clean energy in our province in recent years, and this situation will remain in the future. Photovoltaic power generation construction should also be placed in an equally important position, and continue to promote the continuous growth of new energy access ratio. It is suggested to strengthen the planning, construction, operation and dispatching management of grid-connected nuclear power, wind power and photovoltaic power lines, do a good job in providing grid-connected technical services, and study the impact of clean energy grid-connected on power grid stability.

4. Analysis of the impact of clean energy development on power grid operation

Fresh energy mainly refers to hydropower, nuclear power, wind power, photovoltaic and other related clean energy. Distributed access is mainly to connect a lot of distributed power sources with the distribution network. The access process of the distribution network is reflected in the form of distribution. Through the control of power transmission loss, the nearby power compensation trend in the power network is summarized in time to reduce the power network expansion effect caused by load. With the high proportion of distribution network and distributed new energy access in recent years, the process of national carbon neutrality has been accelerated and the rapid upgrading of the national energy structure has been promoted.

4.1 Influence of nuclear power grid connection on power grid operation

Once a large-capacity nuclear power unit breaks down, it may not only threaten the safety of the nuclear power plant, but also greatly reduce the available capacity of the power grid, reduce the reliability of the system power supply, and have a great impact on the system operation, which may lead to the overload of some lines. In addition, the operation of large capacity units may cause certain transmission pressure on some key transmission sections and affect the power transmission of the original generating units in the region. Therefore, compared with other types of generating units, nuclear power units have more stringent access requirements, which need to meet the "N-2" condition, resulting in a relatively large number of outlet and return routes and access points of nuclear power units.

The connection of large-capacity nuclear power units to the power grid puts pressure on the safe and stable operation of the power grid. When the nuclear power transmission line breaks down seriously, the power grid may become unstable. It is necessary to rely on the safety and stability automatic control device to remove appropriate number of nuclear power units to maintain the safe and stable operation of the power grid. On the other hand, the input or withdrawal of large-capacity nuclear power units will bring great changes to the system voltage, power flow distribution and reactive capacity, which may lead to excessive changes in the power flow of related lines. Effective voltage regulation and control measures are needed to avoid excessive fluctuations in the system voltage and reactive capacity.

The peaking capacity of nuclear power units is poor, and with the continuous production of large capacity nuclear power units, it will bring serious problems to the peaking operation of Dalian power grid. Among them, the problem of peak adjustment in the morning and evening is increasingly prominent, and even some years and some time periods of the grid electricity cannot be balanced. Therefore, a pumped storage power station with a certain capacity is needed to carry out peak regulation on the power grid, so as to improve the frequency modulation and peak regulation capacity of the power grid.

At the same time, as the on-grid electricity of nuclear power plant in Dalian City increases year by year, the company's power transmission and distribution price space is compressed, which has an adverse impact on the company's profits.

4.2 Influence of wind power grid-connection on power grid operation

In recent years, the installed capacity of wind power in Dalian has been growing rapidly. With the development of the scale of wind power, the influence on the safe and stable operation of local power grid will be increased. Because the development location of the wind farm is relatively concentrated, the wind power is centralized online in the high wind period, resulting in the main transformer and the line does not meet the N-1 requirements.

At the present stage, the wind power forecasting system is not perfect, the basic data is lacking, the accuracy is not high, and it is not possible to make the day ahead plan according to the predicted wind power. There are uncertainties in the arrangement of wind turbine operation mode. With the increase of wind power capacity in Dalian City, it will have an impact on the county power grid dispatching.

Wind power is characterized by intermittency, randomness and reverse peak regulation, which poses new challenges to power flow control, auxiliary service invocation, short-circuit current control and power quality assurance. For example, in order to eliminate these influences, the company needs to increase the investment in supporting equipment to ensure the reliability of the grid and the quality of power supply, which will increase the investment cost of the company.

Due to its limited ability to withstand grid faults and disturbances, wind power is prone to be affected by grid faults, resulting in disorderly off-grid phenomenon. Wind power associations are not consistent with the pace of the grid, and too much emphasis is placed on resource planning. Wind power will affect the power quality of the power grid. Due to the fluctuation of the output power of wind turbines, there will be adverse phenomena such as voltage deviation in some extreme weather, which is not conducive to the power quality.

When wind turbines are connected to the power grid, the unidirectivity of power flow in the distribution network will be changed to a certain extent. This phenomenon increases the security risks of the power grid operation around the wind farm, and even causes voltage collapse in serious cases. Since wind power generation will inject a large amount of electricity into the grid during operation, it will affect the frequency and stability of the grid. In addition, this will increase the probability of short circuit problems, thus increasing the loss of circuit parts.

4.3 The impact of PV power grid connection on power grid operation

Clean energy is characterized by volatility, randomness and intermittently. After large-scale photovoltaic is integrated into the power grid, the peak-valley difference of the power grid load will become larger, which will hinder the operation of the long-term planning project of the power distribution network, lead to the change of the power grid circuit structure, and increase the failure rate.

A high proportion of grid-connected photovoltaic power generation will lead to more serious problems of distribution network interference, affecting the efficiency of power transmission, reducing the margin corresponding to node voltage, uncertain generation power, limited frequency adjustment level, and increased frequency modulation pressure of distribution network, which is the condition of abnormal frequency fluctuation of the power grid.

The connection of photovoltaic grid-connection with the distribution network will lead to the reduction of the effect of active power regulation in the distribution network, and the resulting effect of active power regulation in the distribution network will be reduced, which is not conducive to ensuring the balance construction of the power distribution network and difficult to ensure the stable construction of the power system. At the same time, it will increase the occurrence rate of island phenomenon and lead to voltage fluctuation of the grid.

The grid-connection of photovoltaic power generation has certain influence on the operation control of power grid. Photovoltaic power generation mainly uses sunlight to generate electricity, so it is greatly affected by the weather and the power generation is unstable. The grid-connection of photovoltaic power generation system will cause an increase in the number of power supply points of the electricity generated by photovoltaic power generation devices, and the distribution and quantity of points have no rules to follow, so the control of power supply and the operation of the grid have increased a certain degree of difficulty.

4.4 The impact of energy storage on grid operations

Energy storage systems in the grid can be deployed and operated in conjunction with renewable energy generation facilities to effectively provide energy time-shift and peak load reduction services. Energy storage systems increase the efficiency of a variety of power assets and reduce emissions of pollutants from fossil fuel generation facilities. The energy storage system will also improve and stabilize the operation of the power grid, improve the utilization rate of certain transmission lines, reduce congestion in power lines, and improve the utilization rate of transmission assets.

In the process of providing energy transfer, storage systems are able to store available energy at a lower price for release when electricity prices are higher. As the share of zero-marginal cost renewables in the power system continues to grow, a major use of energy storage systems is to store electricity during periods of overgeneration by renewable generation facilities, which can

be used to avoid or reduce fossil fuel generation facilities with high start-up costs. The energy storage system can also provide auxiliary services or as a backup power supply to provide a reliable source of power for the power system. In addition, energy storage systems can meet peak demand by discharging when the power system needs it, avoiding or delaying transmission or distribution system upgrades, especially in areas where traditional generation resources may be difficult to site-build.

5. Suggestions and Countermeasures

5.1 We will make use of our superior resources to strengthen competitive industries and increase the proportion of access to new energy

Based on the resource endowment and industrial foundation, Dalian should further expand and strengthen the three advantageous industries of energy storage, nuclear power and wind power in accordance with the overall plan, classified implementation, highlighting key points, technological innovation and rolling development. Meanwhile, it should adjust and optimize the industrial structure of new energy power generation, and focus on cultivating the development of new energy industries with strong market competitiveness, such as solar energy, tidal energy and biological energy. We will actively introduce advanced technologies and business forms, form a complete industrial chain, and promote the scientific and orderly development of the new energy power generation industry.

Under the dual goals of promoting the implementation of "dual carbon" strategy, promoting the reform of power grid, transforming and upgrading industries, and actively serving the public, Dalian City is based on the geographical and climatic conditions, energy types, energy installed capacity, and energy distribution of the whole city of Dalian and the island regions including Changxing Island and Changhai. It is suggested to build a regional dual low-carbon power consumption mode of source and load and a precise power marketing service mode to support the access of a high proportion of regional new energy, and help realize the "dual carbon" and build a new power system.

5.2 Energy Internet, distributed micro grid construction drive, promote the consumption of renewable energy

At present, a large proportion of renewable energy is connected to the power supply side of Dalian City. In order to alleviate the pressure of peak regulation, it is suggested to build regional energy Internet and distributed intelligent user-level micro-network, and realize multiple businesses such as cloud energy information storage, intelligent optimization control, intelligent information analysis and processing, equipment condition monitoring and evaluation, and comprehensive energy services through information technology. It creates a good environment for local new energy generation, access and consumption, thus encouraging all kinds of enterprises and users in the city to actively participate in the construction of new power system. Form an optimization mechanism for regional green energy supply and active consumption based on dispatching priority, realize the intelligent interaction between demand-side load management, distributed power supply and superior distribution network, and ensure the safe and stable operation of power grid while meeting the demand of users, making contributions to the development of social economy.

5.3 Integrate industry resources, accelerate platform-based transformation, and promote market-driven collaboration

To develop the new energy power generation industry, we should give full play to the role of Dalian's abundant intelligence resources of energy science and technology industry, coordinate industrial development through industry associations, provide corresponding industrial information, plan and construct industrial parks, organize related enterprises, focus on cultivating leading enterprises, and enhance the effect of industrial agglomeration.

In order to fully tap the response potential of demand-side resources, Dalian needs to develop its demand response towards diversification and refinement. It is suggested that the use of new energy should be promoted to the main position. Firstly, based on the consumption, flexible scheduling and multiple control requirements of renewable energy in the distribution network, load management optimization scenario including distributed renewable energy is proposed, and the source load collaborative optimization scheme based on energy router is designed, which is conducive to the optimal decision of demand response business in the electricity market environment. The second is to construct the renewable energy consumption guidance mechanism based on dispatching priority, which is conducive to the identification and prediction of user response behavior.

5.4 Increase investment in scientific research, and focus on cultivating the development of chemical energy storage

We should increase our efforts in such fields as resource evaluation, technology research and development, platform construction, personnel training and inspection and certification system construction of the new energy power generation industry. We should keep up with the international pace, increase investment in scientific and technological innovation, break through the bottleneck of key technologies, transform technological achievements well, enhance core competitiveness, and seize the commanding heights of future industrial development. At the same time, we will integrate the resources of universities and scientific research institutions to build the energy science and technology base, and form the industrial positioning and industrial advantages with Dalian characteristics.

In order to accelerate the investment of Dalian clean, low-carbon, safe and efficient energy system. It is suggested to develop nuclear power safely and steadily in the power generation side, so that the installed scale of nuclear power will increase steadily. We will vigorously develop onshore and offshore wind power, and build the largest offshore wind power base in northern China. The use of abandoned mines, aquaculture reservoirs, coastal areas, such as active development of photovoltaic power generation. In the energy storage side, the energy storage technology of all-vanadium flow battery is vigorously developed to improve the peak and frequency regulation ability of the power system, improve the toughness of the power system operation, and help the high proportion of energy consumption.

5.5 With zero carbon emissions as the main line, we will promote the healthy and rapid development of the hydrogen energy industry

With the proposed target of carbon peaking and carbon neutrality and the continuous innovation and breakthrough of hydrogen energy utilization technology, in order to realize zero-carbon emission energy utilization in Dalian, it is suggested to make full use of innovation resources and basic advantages of manufacturing industry, study the problems and demands of hydrogen

energy industry development from the perspective of market, and integrate all resources. We will carry out projects of "chain building", "chain reinforcing", "chain strengthening" and "chain extending" for the hydrogen energy industry, focusing on building an ecological environment for the industry, speeding up the process of hydrogen energy industrialization, and putting the industry on a path of sound and rapid development.

5.6 We will expand financing channels, strengthen policy adjustment, and implement planning and construction

Open up market access conditions, increase investment attraction, encourage foreign capital, state-owned capital, private capital and other social capital to invest in the construction and operation of projects through tax and fee reduction and other means, and actively guide banks, venture capital and other financial institutions to give certain support to the development of new energy projects through low-interest loans, investment and loan linkage and other modes. An investment and financing mechanism featuring government guidance, policy regulation and market operation will be established.

Support the intentions and plans for the development and utilization of new energy, incorporate the needs of the development of new energy economy into infrastructure construction plans, implement effective promotion plans, formulate reasonable price compensation mechanisms and direct fiscal subsidy mechanisms, and establish and improve fiscal and tax policy systems and risk-sharing mechanisms to support the development of the new energy power generation industry. It provides a strong foundation for the development and expansion of the new energy power generation industry.

5.7 Bear closely the weight of consumption responsibility, seize the opportunity of green electricity marketing

Green electricity consumption quota needs to be decomposed into various market players. As the main body of the emerging market that undertakes the absorption responsibility system, Dalian Power Supply Company needs to focus its green power marketing on large industrial and commercial users, develop exclusive green energy supply schemes for high-energy-consuming enterprises that are more sensitive to the rise in electricity price, closely grasp the leading enterprises, "point and line" lead other enterprises, and provide green power solutions that reduce electricity costs and carbon emissions. Not only for enterprises to remove the consumption responsibility assessment pressure, but also let enterprises truly feel the advantages of green electricity.

The utilization of renewable energy in Dalian is combined with the advanced power selling concept of Dalian Power Supply Company to create an integrated mode of green power generation, transmission and sale that is truly for the benefit of users and guarantees the quality of users' electricity consumption. In this way, the utilization of clean energy increases significantly and the consumption of renewable energy with all kinds of users can be cooperatively optimized.

6. Conclusion

Through the analysis of the current situation of clean energy in Dalian, it is concluded that wind power, nuclear power, thermal power, photovoltaic and other new energy on the operation of

power grid companies. Measures such as increasing the access proportion of new energy, increasing the proportion of energy, promoting market drive, increasing investment in scientific research, energy conservation and emission reduction can make Dalian achieve long-term development of clean energy and make the production and life of power grid operation companies more in line with the national green energy development policy.

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