Proceedings World Geothermal Congress 2023
Beijing, China, April 17 – 21, 2023

Energy structure analysis and new energy development in Hainan Yangpu Development Zone under the background of carbon peak and carbon neutralization

Lu Zhao, Tang Guo

Luzhao.xxsy@sinopec.com

Keywords: Carbon peak, carbon neutralization, energy structure adjustment, new energy development, path and measures

ABSTRACT

In 2020, Chinese President Xi Jinping solemnly promised at the seventy-fifth Session of the United Nations General Assembly that China would strive to achieve carbon dioxide emission peak by 2030 and carbon neutral by 2060, which put forward higher requirements for China's sustainable energy development. Yangpu Development Zone is the only industrial base in Hainan Province. It is the leading area and demonstration area of Hainan free trade port. It also has a large space for development in terms of energy consumption and carbon emission. Through the investigation of the energy structure of Yangpu Development Zone, this paper analyzes the main problems and challenges in energy conservation and carbon reduction, environmental protection and energy structure adjustment, and discusses the main paths and measures of energy structure adjustment and new energy development.

1. INTRODUCTION

New energy, also known as unconventional energy, refers to the systematic development and utilization of renewable energy on the basis of new technologies, such as nuclear energy, solar energy, wind energy, biomass energy, ocean energy, etc. New energy is characterized by less pollution, large reserves and sustainability. Developing new energy has become an important direction and field of world energy development (LIU Zhixiong, CHEN Guoping).

Yangpu Development Zone is located on the Yangpu Peninsula in the northwest of Hainan Province. It is the only industrial base in Hainan Province and the pilot and demonstration zone of Hainan Free Trade Port. The development zone is positioned as a "logistics center for Southeast Asia, a new petrochemical industry base and a high-end manufacturing industry base". By taking advantage of its unique geographical advantages, excellent port conditions and complete dock berths, the zone has initially formed an industrial chain of oil and gas processing and warehousing trade. With excellent environmental quality, the policy dividend is gradually embodied and the future market space is huge. At present, the short board of the industrial chain is obvious, the degree of industrial aggregation needs to be improved, the infrastructure construction of the park lags behind, the research and development strength is weak, and there is still a large space for development in terms of energy consumption and carbon emissions. At present, this paper will study the characteristics of energy development in Yangpu Development Zone, the main paths and measures of energy structure adjustment and new energy development (LIAO Wei, YE Bo.).

2. CURRENT SITUATION OF ENERGY CONSUMPTION IN YANGPU DEVELOPMENT ZONE

In 2019, Hainan produced 4.23 million tons of standard coal, 320,000 tons of oil, 105 million cubic meters of natural gas, and about 13.3 billion KWH of primary electricity. Energy sources in Hainan Province are still fossil fuels such as coal, electricity and petroleum.

Coal consumption in Yangpu Economic Development Zone is mainly concentrated in coal-fired generating units (coal-fired units of Hainan Jinhai Pulp and Paper Power Plant), coal-fired heating boilers, industrial raw materials, etc. According to statistics, coal consumption in Yangpu Economic Development Zone was about 1.4 million tons in 2020, an increase of about 7.6 percent compared with 2019.

Oil consumption in Yangpu Economic Development Zone is mainly concentrated in oil refining, coal-to-oil, industrial raw materials, service industry, and living consumption. According to the data, oil consumption in 2020 is about 1.65 million tons, up about 11.7 percent year-on-year in 2019.

Natural gas consumption in Yangpu Economic Development Zone is mainly concentrated in gas-fired generating units (gas units of China Offshore Hainan Power Generation Yangpu Power Plant), oil refining, coal-to-oil, industrial raw materials, and household consumption, etc. According to data, natural gas consumption in 2020 will be about 750 million cubic meters.

In 2020, the total electricity consumption of Yangpu Economic Development Zone was 4.4 billion KWH. In 2015, the total electricity consumption of Yangpu Economic Development Zone was 4.08 billion KWH, with an annual growth rate of about 1.5%.

During the 13th Five-Year Plan period, the average annual growth rate of coal and oil was 0.2% and 5.9%. By 2020, fossil energy consumption such as coal and oil will account for 75.12%, which means that the current energy consumption structure of Yangpo Economic Development Zone is still dominated by fossil energy such as coal and oil. The energy consumption of Yangpu Economic Development Zone is summarized in the table.

Table 1: Overview of energy consumption in Yangpu Economic Development Zone during the 13th Five-Year Plan Period

Energy category	2015	2016	2017	2018	2019	2020	Annual growth rate
Coal (10,000 tons)	138.5	129.2	144	146.6	129.9	140	0.2%
Oil (10,000 tons)	124	120.3	138.6	143.3	147.8	165	5.9%
Natural gas (million cubic meters)	7.5	5.9	6.2	7.0	6.2	7.5	1.5%
Total social electricity consumption (100 million KWH)	40.8	40.1	40.6	42.1	43.3	44.0	1.5%
Total consumption (10,000 tons of standard coal)	342	317	357	372	361	406	3.4%

3. CURRENT SITUATION AND CHARACTERISTICS OF NEW ENERGY DEVELOPMENT IN YANGPU DEVELOPMENT ZONE

3.1 The installed capacity of self-supplied power supply is high and the proportion of new energy is small

The 14th Five-Year Plan was a crucial turning point. The installed capacity of new energy power generation increased rapidly, while the proportion of installed capacity of coal power generation decreased year by year. The power structure dominated by coal power is facing profound reform. In order to achieve the goal of carbon peaking and carbon neutrality, the installed scale of non-fossil energy, mainly wind power and photovoltaic power generation, will further increase and become the main body of future energy increase.

In 2020, the installed power capacity of Yangpu is 1418.9MW, of which the integrated power supply accounts for 47.1%, mainly natural gas power generation; Self-supplied power supply accounts for 58.3%, mainly coal and biomass. The self-provided power supply has a high capacity, which reflects the heavy load of large users. This kind of load is relatively stable and continuous, and has a relatively high guarantee for power supply security.

As can be seen from the installed power installation and structure of Yangpu Economic Development Zone, renewable energy accounts for about 11%, including wind power accounting for 7% and photovoltaic accounting for about 4%. It shows that renewable energy has a certain foundation and become a beneficial supplement to the overall power supply structure. Meanwhile, the low proportion also reveals that renewable energy still has a large space for development and consumption.

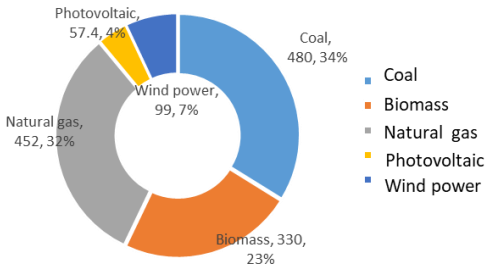

Figure 2: Power installation and structure of Yangpu Economic Development Zone

3.2 Higher energy demand will be generated in the future

According to the 14th Five-Year Plan outline, Yangpu takes international and domestic advanced petrochemical bases as the target, gives full play to its port advantages, utilizes two markets and two raw materials at home and abroad, adheres to the development concept of "high-end, green, intensive and intelligent", follows the development idea of "vertical extension and horizontal coupling", is market-oriented, guided by planning and driven by scientific and technological innovation. With energy conservation and emission reduction as the starting point, optimize the industrial layout, extend the industrial chain, expand the industrial cluster, strive to build a Marine low sulfur fuel oil production and supply base with quality and price advantages, build downstream deep processing of ethylene and petrochemical and high-end fine chemical industry and new chemical material industry cluster supporting strategic emerging industries. To build a "domestic leading and world class" green ecological world-class petrochemical industry base, cross-coupling with Dongfang Lingang Industrial Park, interconnecting and enhancing the stability of industrial chain, supply chain and value chain. By 2025, the output value of the petrochemical industry will reach 140 billion yuan.

Based on the predicted energy consumption of each category and the total energy consumption of planned energy consumption projects, it is estimated that the total energy consumption of Yangpu Economic Development Zone in 2025 and 2030 will be 8.23 million tons of standard coal and 10.88 million tons of standard coal, respectively.

4. THE MAIN PATH AND MEASURE OF NEW ENERGY DEVELOPMENT IN YANGPU DEVELOPMENT ZONE

4.1 We will optimize the energy mix and focus on supporting the development and utilization of natural gas

According to the investigation of the projects under construction or planned in Yangpu Economic Development Zone, the heat demand of the planned projects is shown in the table. During the 14th Five-Year Plan period, the heat demand reaches 1143t/h. After 2025, the heat demand of ethylene downstream industry, Shandong high-speed Hainan Petrochemical new material Industry base project and other projects should be considered. As well as replacing Hainan Yisheng Petrochemical coal-fired boiler and Hainan Jinhai pulp and paper coal-fired boiler, the accumulative heat demand of the whole region is expected to reach 2064 t/h.

Gas-fired cogeneration units are built in industrial parks and do not touch the red line of ecological protection. The utilization of water resources is mainly in the form of step development, multi-purpose water and waste water recycling. The type of soil and water loss in the park is hydraulic erosion, and the erosion intensity is slight, so it does not belong to the polluted land. It can realize central heating and avoid the occupation of land resources by self-built heat source. Natural gas is clean energy and meets the ecological environment access list. Therefore, the impact of gas cogeneration units on the ecological environment is mainly atmospheric emission pollution. Compared with coal power of the same installed scale, gas NOX emissions are 30% less than coal power, SO2, particulate matter emissions are more than 90% less than coal power. In the future, with the continuous progress of low nitrogen combustion technology, NOX emissions are expected to further decline. In terms of economic benefits, enterprises can choose two modes: self-built heat source and central heating. The self-built heat source takes a 45t/h gas boiler of a brand as an example, the boiler and a full set of auxiliary equipment are 2.5 million yuan, the steam consumption per ton of the equipment is 70 cubic meters, the gas intake price per cubic meter is 2.5 yuan, and the annual utilization hours of the unit are calculated by 3500 hours. The central heating cost per kilometer pipeline laying is 1.4 million yuan, the initial installation is 50,000 yuan per ton, the heating price is 180 yuan per ton, and the annual steam demand is 157,500 tons (3500×45). The investment and operation costs of self-built heat source and central heating source are shown in the table. According to the known investment costs, the investment of central heating pipeline, initial installation cost and heating cost are slightly higher than the equipment purchase and fuel cost of self-built heat source, but the self-built heat source also needs to be invested in plant, land, labor, operation and maintenance, etc. Generally speaking, for the enterprises using heat, there is a small gap in the expenditure of the two heating modes. Economic equivalence.

In the aspect of hydrogen production from natural gas, the process of hydrogen production using natural gas as raw material is one of the more mature and suitable for large-scale production. Hydrogen production equipment is built in the industrial park, which does not touch the ecological protection red line; The utilization of water resources and land resources is less; The type of soil and water loss in the park is hydraulic erosion, and the erosion intensity is slight, so it does not belong to the polluted land. Hydrogen production from natural gas mainly discharged a small amount of boiler wastewater, CO2, water vapor and a small amount of waste catalyst, which has good environmental protection. Energy consumption is mainly natural gas, which conforms to the ecological environment access list. In terms of economy, the price of natural gas accounts for more than 70% of the cost of hydrogen production. According to the calculation of Hainan natural gas contract price of 3219.36 yuan/ton in 2017, the cost of hydrogen production per unit is about 12 yuan/kg (refer to the cost of hydrogen production in Hainan refining and chemical industry). Compared with the unit selling price of hydrogen at 7 yuan/kg in a hydrogenation station in Shanghai, the cost of hydrogen production is higher than the selling price. Gas-fired vehicles, fueled by natural gas, have the advantages of stable combustion and reduced engine fuel consumption. In 2020, the Yangpu Economic Development Zone will have about 33 gas vehicles. Gas vehicles are often used in urban transportation and do not touch the red line of ecological protection. Not to occupy water resources and land resources; Gas vehicle CO emissions than gasoline cars reduce more than 90%, hydrocarbon emissions reduce more than 70%, NOx emissions reduce more than 35%, is a more practical low emission vehicle; Natural gas is clean energy and meets the ecological environment access list. In terms of economy, according to the oil and gas price adjustment notice of Hainan Development and Reform Commission in December 2020, the gas price of Yangpu gas Station is 4.17 yuan/cubic meter (equivalent to 5.80 yuan/kg), and the oil price of 92# gasoline is 6.87 yuan/liter (equivalent to 7.712 yuan/kg). If a taxi consumes 7 liters of fuel and 10 cubic meters of gas per 100 kilometers, it will cost 48 yuan for a fuel car and 42 yuan for a gas car. In terms of residential gas consumption, the province vigorously promotes the work of sending gas to the countryside to "substitute gas for firewood". By means of "appropriate pipe, appropriate tank, and appropriate tank", the utilization rate of natural gas in urban residents and rural remote areas is improved, and the replacement of loose coal is realized. In 2020, the ventilation rate of natural gas pipelines in Yangpu Economic Development Zone will be less than 50%, and gas pipelines and bottled liquefied natural gas will not touch the ecological red line. Not to occupy water resources and land resources; Natural gas is clean energy and meets the ecological environment access list. In terms of economy, the calorific value conversion efficiency of natural gas is high. The average daily gas consumption of urban residents is about 0.5 cubic meters, lower than the average daily gas consumption of 1 cubic meter.

suggestions on the development of natural gas in Yangpu Economic Development Zone: First, gas cogeneration units can effectively replace coal-fired boilers and self-built heat sources to achieve central heating, and play a role in promoting the sustainable development of petrochemical industry in Yangpu Economic Development Zone. It is suggested to build gas cogeneration units according to the time sequence of putting into operation of thermal enterprises. Second, based on raw material cost, hydrogen production process and other factors, it is suggested that hydrogen produced from natural gas should be used as chemical raw materials under the condition that the current price of natural gas remains high. With the construction of free trade port, the price of natural gas drops, hydrogen produced from natural gas can be used to support the development of hydrogen fuel vehicles. Third, gas vehicles emit better than fuel vehicles, but they have nitrogen oxide emission problems. According to the development path of Hainan Clean Energy Vehicle Development Plan, gas vehicles are transitional models, so it is suggested to promote a certain number of gas vehicles in rental, public transportation and other fields. At the same time, actively promote the existing gas station renovation and new energy supply station planning. Configure or reserve air filling devices of the appropriate scale. Fourth, the improvement of residents' natural gas utilization rate is an important measure to implement the province's "gas instead of firewood", which is conducive to improving

the utilization level of clean energy. It is suggested to speed up the construction of urban gas pipelines and the utilization of canned gas in remote areas.

Natural gas guarantee scheme of Yangpu Economic Development Zone: In terms of natural gas heating and power generation, the construction of "Huaneng Yangpu 2×460MW Natural gas cogeneration Project" has been started at present. The site is located in the north of the zone. Considering the balance of site layout, it is suggested to plan the "Yangpu 2×460MW Remote Reconstruction and Expansion Project" as the southern site of the zone during the 15th Five-Year Plan Period. In terms of hydrogen production from natural gas, considering the preferential tariff policy of Hainan Free Trade Port, the intake price of natural gas is expected to decrease, and it is suggested to promote the use of surplus hydrogen to support the development of hydrogen fuel vehicles. In terms of gas vehicles, the priority will be given to cruise taxis, and it will be gradually promoted to large buses and heavy trucks. 115 natural gas cruise taxis were promoted during the 14th Five-Year Plan. In terms of residential gas consumption, in order to implement the province's "gas substitute firewood", it is suggested to increase the household rate of natural gas residential users by pipeline gas to 85% during the 14th Five-Year Plan period, and to increase the household rate of natural gas residential users by pipeline gas to 100% during the 15th Five-Year Plan period. In accordance with the principle of "appropriate pipelines, appropriate tanks", we will promote gas coverage in all rural areas.

4.2 Moderate scenery electricity industry, a steady increase of new energy accounted

Hainan Province is surrounded by the sea with a coastline of 1,528km. The wind power density of offshore wind farms is basically above level 3. The annual average wind speed at the height of 90m is 6.76-7.78m/s, and the annual equivalent full load hours are 2,600-3200h. Is the most favorable area for developing offshore wind power. In 2014, Hainan commissioned a professional organization to compile the overall plan for offshore wind power in Hainan Province, which was approved by the National Energy Administration. The sea area of Hainan offshore wind Power plant is within 40km offshore and within 50m water depth around Hainan Island. Hainan has planned 5 offshore wind power bases and 15 offshore wind farms in Dongfang, Ledong, Lingao, Danzhou and Wenchang, with a planned area of 917km^2 and a total installed capacity of 3.95 million kW (LI Xuezhong).

Based on the comprehensive consideration of the Marine function zoning of Hainan Province and the avoidance of restricted development areas, three offshore wind power sites with an estimated installed capacity of 1.2 million kW have been selected in accordance with the principles of making full use of wind energy resources, maximizing power consumption by enterprises within the system and large-scale centralized contiguous development. Among them, Yangpu No. 1 wind power plant is planned to cover an area of 70 square kilometers, with an estimated installed capacity of 450,000 kW. The water depth is between 15 and 25 meters, and the offshore distance of the site center is 32 kilometers. Yangpu No. 2 wind Power Plant covers a planned area of 69 square kilometers, with an estimated installed capacity of 450,000 kW. The water depth is 15-20 meters and the offshore distance of the site is 30 kilometers. Yangpu No. 3 wind Farm covers an area of 45 square kilometers, with an installed capacity of 300,000 kW. The water depth is between 5-20 meters, and the site is 25 kilometers offshore. Considering the factors such as power generation and investment cost, Yangpu 2# wind Farm has the best development conditions and is recommended to be developed first.

In photovoltaic power generation, we should make full use of infrastructure land and plant roof conditions to promote the construction of distributed photovoltaic. According to the 14th Five-Year Plan energy development plan of Hainan Province, during the 14th Five-Year Plan period, the solar energy industry in Hainan Province will develop and utilize solar energy in an orderly way, insisting on distributed development and centralized development. Comprehensive utilization of unused land, fish ponds, abandoned mining areas, hotels, residents, residential buildings, factories, transportation hubs, large public and commercial buildings to construct solar power projects and photovoltaic building integration projects. We will expand distributed photovoltaic power generation in large public buildings, industrial and commercial enterprises and residential buildings. We will promote solar photovoltaic lighting renovation projects in urban landscape roads and tourist attractions. Promote the application of solar water heating system and solar air conditioning system in government office buildings, hospitals, schools, shopping malls, factories and other urban public buildings. Combined with the development and construction of small-scale photovoltaic application systems and micro-energy networks, China actively carries out integrated energy storage application demonstrations such as "photovoltaic + energy storage + charging facilities" and "distributed power station + micro-energy network + energy storage".

4.3 Actively develop the surface water geothermal energy refrigeration

4.3.1. Utilization of geothermal resources

Medium and deep geothermal resources: Relying on the 36 upland mountain geothermal fields in Hainan Island and the sedimentary basin geothermal resources concentrated in the northern Qiongzhuang area, the company enters the hot spring tourism development market through joint ventures and cooperation. In the vicinity of Haikou, Sanya, Danzhou, Qionghai and other cities, select areas with beautiful natural environment and rich hot spring resources (such as Jiuqu, Guantang, Nantian), and build hot spring tourism resorts integrating sightseeing, vacation and entertainment; In the distance from the city, but hot spring (geothermal) water quality is good, especially with high concentration of special elements of medical and health care, the construction of the theme of recuperation, health, health resorts.

Geothermal resources of hot and dry rock: With the Qiongbei Quaternary volcanic active area of Hainan as the key area, geological and geophysical exploration of modern and contemporary volcanoes such as Maanling volcanic Group of Haikou will be carried out, reserve the exploration and development target area of hot and dry rock resources of modern and modern volcanic type, carry out the experimental development of hot and dry rock at an appropriate time, and build the demonstration project of hot and dry rock power generation.

Shallow geothermal energy: Geological and geophysical exploration shall be carried out in the vast areas where extrusive rocks are distributed in Hainan Island, and the volcanic rock structural fracture zone and favorable volcanic rock facies with good physical properties (such as explosive facies) shall be implemented. The shallow geothermal energy refrigeration project shall be built by taking advantage of the favorable conditions of constant temperature and rapid migration of the lower water bodies in these areas. For Yongxing Island and other coral reef islands in Sansha City, shallow groundwater that is connected with seawater but whose

temperature is lower than that of seawater can be used as a cold source to reduce the energy consumption level of air conditioning system, improve the energy supply security of islands and other off-grid areas, and reduce the power grid pressure. In addition, the use of underground water as the source of heat and cold can reduce the area of heat dissipation equipment and make full use of island land resources.

4.3.2. Utilization of seawater resources

The huge sea surface receives the radiation from the sun all the time, and is affected by the ocean circulation and the specific climate conditions around the sea area, so the sea temperature value will vary from place to place and time to time. Sea water refrigeration is a kind of green air conditioning system which has the significance of energy saving and environmental protection. In order to improve the efficiency of Marine water cooling and the economy of the whole system as far as possible, it is necessary to study the alternative forms and operation modes to meet the needs of thermal users under different seawater resources. At present, the technical route of sea water source heat pump + water chiller + energy storage is adopted. The main construction contents are: 1 new energy station computer room, the construction of centralized cooling system (including 13 centrifugal chiller units and 2 centrifugal water source heat pump units, 1 13000m3 water storage tank, 2 plate heat exchangers, 14 circulating pumps, etc.), water treatment equipment, fire water supply and drainage, electrical and automatic control engineering, 13 cooling towers and air conditioning water supply and return pipe network system, etc.; Newly built 2000m3/h sea water source water withdrawal system 1 set, etc. The estimated total investment of the project is about 647,626,500 yuan, the after-tax payback period is 10.73 years, and the financial internal rate of return is 8.46%.

Seawater cooling technology has been applied in industry in our country, and engineering technology reaches international advanced level. More than 90% of the applications of seawater cooling are thermal power enterprises in our country, followed by chemical industry. According to different technological processes, seawater cooling can be divided into two ways: direct current cooling and circulation cooling. Currently, Hainan CNNC Huaneng Changjiang Nuclear Power Plant, Huaneng Oriental Coal-fired Power Plant and CNOOC Yangpu Gas-fired Power Plant all adopt seawater DC cooling, with seawater circulation capacity of 153,000 m^3/h, 176,400 m^3/h and 20,000 m^3/h respectively. In the West Coast industrial corridor, sea water cooling can be used to replace the cooling tower of conventional circulating water farm in combination with the 20 million tons/year refining and chemical integration project of Hainan Refining and Chemical Expansion Phase II. The economic benefits are good, the incremental investment can be recovered in about 5 years, and the water saving is significant.

REFERENCES

LIU Zhixiong, WANG Yue. The analysis and path choice of the development of new energy in China[J]. China Mining Magazine, 2012,21(06):1-4.

CHEN Guoping, DONG Yu, LIANG Zhifeng. Analysis and Reflection on High-quality Development of New Energy With Chinese Characteristics in Energy Transition[J]. Proceedings of the CSEE. 2020, 40 (17) : 5493-5506.DOI:10.13334/j.0258-8013.pcsee.200984.

LIAO Wei, YE Bo. Analysis on the present situation of the development of Yangpu Economic Development Zone in Hainan[J]. Business news,2019(25):19.

National Bureau of Statistics. China Energy Statistical Yearbook[M].Beijing:2020 China Statistics Press Co., LTD,2021.

The 14th Five-Year Plan for Energy Development in Hainan Province

Outline of the 14th Five-Year Plan for Yangpu Economic Development Zone

Hainan Provincial Department of Industry and Information Technology. Hainan clean energy vehicle development plan, Press conference, [EB/OL].(2019-03-05)[2022-08-09]

LI Xuezhong, Suggestions on accelerating the development of offshore wind power resources in Hainan[EB/OL].(2021-06-17)[2022-08-09].