Summary

Hengqin Island is located in the south of Zhuhai City, adjacent to Hong Kong and Macao. It covers an area of 106.46 square kilometers and is the largest island in Zhuhai City. Located at the intersection of "one country, two systems" and the junction of "internal and external radiation", Hengqin Island is the only place in the mainland of China that connects Hong Kong and Macao with roads and Bridges, with an extremely advantageous geographical position.Hengqin New Area was established in 2009, Hengqin Free Trade Zone was officially listed in 2015, and it was approved to become an international leisure tourism island in 2019.

Hengqin as a major platform for the Guangdong-Hong Kong-Macao Greater Bay Area to build an international first-class bay area and a world-class city cluster, focuses on the development of scientific and technological innovation, characteristic finance, medical and health care, cross-border trade and trade, cultural and tourism exhibition, professional services and other industries.Up to now, Hengqin has more than 53,000 registered enterprises, including 80 of the world's top 500 enterprises and more than 1,000 of various headquarter enterprises, with a total investment of more than 423 billion yuan.

Hengqin CCHP project consists of 1 gas power plant and 10 energy stations.Two 9F class (390MW) units of the gas-fired power plant project have been put into operation in November 2014.The planned cooling area of 10 energy stations is about 20 million square meters, the installed capacity is more than 450,000 cold tons, the planned cold (hot) water pipe network is 120 kilometers, and the total investment is about 5 billion yuan. After completion, it will become the largest regional cooling project in the world. No. 3 energy station has been put into operation in May 2016, and No. 1 energy station has been put into operation in July 2020.

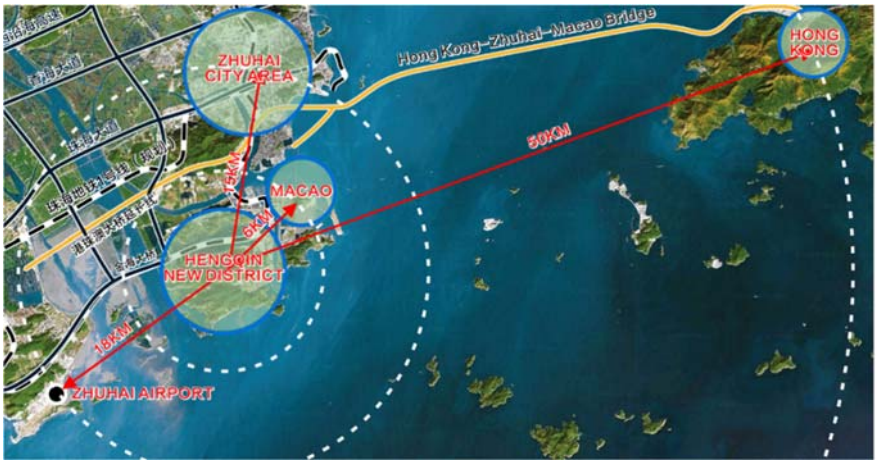
The gas power plant will be built and operated by Zhuhai Hengqin Thermal Power Co., Ltd., and the 10 energy stations will be built and operated by Zhuhai Hengqin Energy Development Co., Ltd. Both companies are part of the State Power Investment Corporation.State Power Investment Corporation (SPIC) is one of the Fortune 500 companies in the world. It is also the first green smart energy enterprise with 98.88 million kW of clean energy installed capacity in China, and has 407 green smart energy projects.

The key factors for the success of the project are as follows: 1. To meet the local energy demand and future development direction; 2.2. Strong support from the local government;3. Sustainable business model;4. Intelligent and standardized control management;Efficient and full range of energy production technologies.

Through energy cascade utilization, regional cooling and ice cold storage energy technology, the primary energy utilization rate is over 73%, which can reduce the electricity consumption for cold source electric refrigeration by about 400 million kWh/ year, and reduce the emission of carbon dioxide by 1.68 million tons/year, sulfur dioxide by 35.5 million tons/year and nitrogen oxide by 32.16 million tons/year.The loss of floating water used to replenish the cooling tower is saved about 1.15 million tons/year, which effectively reduces the energy consumption per unit GDP and ensures the sustainable development of energy consumption and production.

Introduction of hengqin Hengqin CCHP System

Hengqin Island is located in the south of Zhuhai City, adjacent to Hong Kong and Macao, with an area of 106.46 square kilometers. Located at the intersection of "one country, two systems" and the junction of "internal and external radiation", Hengqin Island is the only place in mainland China that connects with the roads and Bridges of Hong Kong and Macao, with an extremely advantageous geographical position.



Location map of Hengqin

In August 2009, the State Council officially approved the implementation of the "Hengqin Master Development Plan", and in December of that year, Hengqin New District was established.In March 2015, Hengqin Free Trade Zone was officially launched.In April 2019, the State Council officially approved Hengqin as an international leisure tourism island.Up to now, there are more than 53,000 registered enterprises in Hengqin, including 80 of the world's top 500 enterprises, more than 1,000 of all kinds of headquarters enterprises in the region, and 1,360 enterprises from Hong Kong and Macao, with a total investment of more than 423 billion yuan.Hengqin, as a major platform for the Guangdong-Hong Kong-Macao Greater Bay Area to build an international first-class bay area and a world-class city cluster, will establish a green, intelligent, energy saving and low-carbon way of production and life, promote the integration of energy conservation and environmental protection with big data, the Internet and the Internet of Things, and realize green, low-carbon and circular development.

A panoramic view of Hengqin

1.Introduction

Hengqin CCHP System built by the gas plants, 10 energy stations, formed a set of power supply, heating, cooling, energy storage as one of the "source - net - load - store" integrated energy system, is the hengqin area construction "intelligent island" and "ecological island" to build a low carbon city ， the important energy depends on the pilot project.At the same time, it is also the main power supply support point of China Southern Power Grid for Macao. It undertakes the social responsibility of ensuring the security of Macao's power supply, promoting the prosperity and stability of Macao, and promoting the construction of the energy supply system of the Guangdong-Hong Kong-Macao Area.

plan of Hengqin Combined Cooling, Heating, Power Sytem

Eight gas-steam combined cycle units are planned to be constructed and operated by Zhuhai Hengqin Thermal Power Co., Ltd. (a wholly-owned subsidiary of Guangdong Electric Power Co., Ltd.). The first phase of the plant, two 9F class (390MW) units were put into operation in November 2014.According to the natural gas development "much starker choices-and graver consequences-in planning in our country, the natural gas is a high-quality, efficient and clean low-carbon energy, is the most realistic choice of clean energy supply, hengqin cold hot electric installations, project relatively abundant natural gas resources, more can directly go to the use of the south China sea natural gas as fuel, compared with coal, fuel power plants, there is almost no dust and sulfur dioxide emissions.Gas turbine adopts the world's advanced DLN2.6+ low nitrogen combustion system, NOx emission is less than 15ppm.It is of great help to protect the ecological environment, improve environmental quality and promote the sustainable development of society and economy. It is a good practice for "building a clean, low-carbon, safe and efficient energy supply system" in the Outline of the Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area.By June 2021, 20.23 billion kWh of electricity had been generated.

Hengqin Gas Power Plant

10 energy stations are constructed and operated by Zhuhai Hengqin Energy Development Co., Ltd., a comprehensive energy service enterprise registered on September 6, 2015 by Guangdong Electric Power Co., Ltd. (55% shares) and Zhuhai Dahengqin Real Estate Co., Ltd. (45% shares).Mainly for hotels, schools, office buildings, shopping malls, government and other industrial and civil buildings (except residential) to provide cold water and hot water.Ten energy stations are located in five cooling areas of Hengqin Free Trade Zone, covering an area of about 20 million square meters, with an installed capacity of more than 450,000 cold tons, a planned cold (hot) water pipe network of 120 kilometers, and a total investment of about 5 billion yuan. After completion, it will become the world's largest regional cooling project.The 10 energy station projects will be constructed in three phases. Among them, No. 3 energy station has been put into operation in May 2016, No. 1 energy station has been put into operation in July 2020, No. 7 energy station has been completed and ready to be put into operation in December 2020, and No. 10 energy station has been put into operation in April 2021.The steam pipe network (9.2 km) from the gas power plant to the No. 3, No. 7 and No. 10 energy stations has been fully connected.By June 2021, the project has accumulated 132 developed users, 73 signed users, 48 formal cooling users, a total cooling load of 300,000 tons, a total cooling supply of 227 million kilowatt hours.

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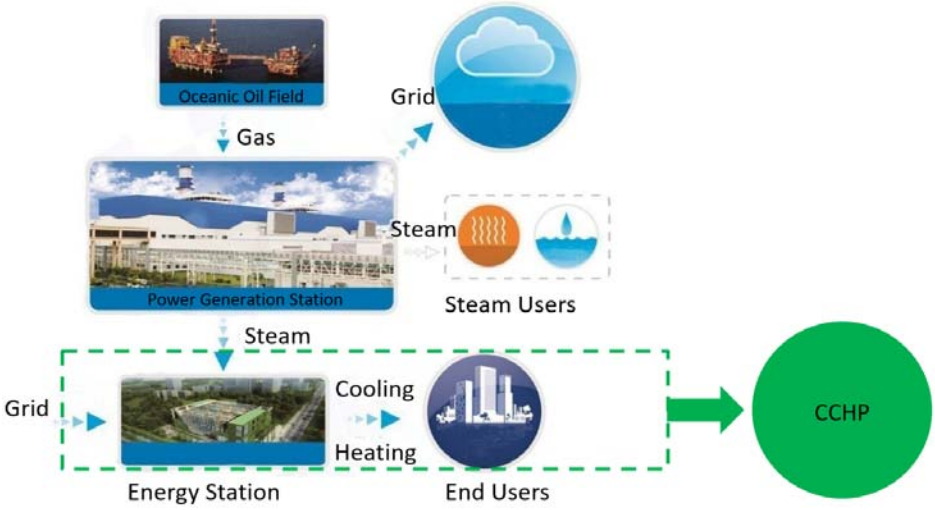
2.Design

Hengqin CCHP, the project adopted the more cold and heat power trigeneration, district cooling, ice storage cold energy storage technology.

（1）Hengqin Combined Cooling, Heating, Power Sytem

The excessive heat (steam) from the power plant will be transmitted to the energy station for cooling and heating through the Lithium bromide process, before reaching the end users through the pipeline system, realizing cascading use of energy with utilization rate at 73%.

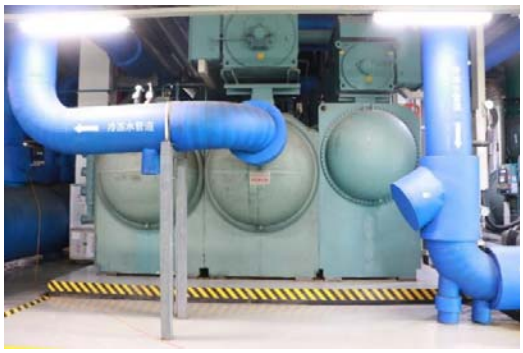


Hengqin Combined Cooling, Heating, Power Sytem

（2）District cooling

The project adopts regional cooling technology to provide centralized cooling for the whole Hengqin Island.Because the regional cooling technology can reduce the installed capacity by optimizing the distribution of users and increasing the coefficient of simultaneous use and other intensive and large-scale means, it can reduce the installed capacity of air conditioning load of 20 million square meters in the region to 1725MW, which is only 69% of the original distributed air conditioning system. At the same time, combined with the ice storage and energy storage technology,The installed capacity of electric refrigeration and air conditioning can be further reduced to 1208MW, and the installed capacity of electric refrigeration and air conditioning can be finally reduced to 845MW through the waste heat refrigeration technology, which can reduce about 66.2% of the installed capacity of electric

refrigeration and air conditioning compared with the regional distributed air conditioning system.

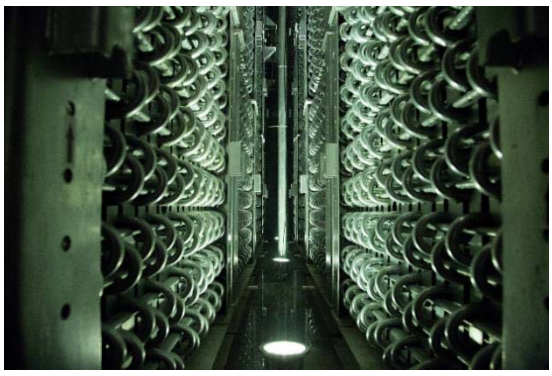



Electric refrigeration unit, lithium bromide refrigeration unit


Frozen water pump, cooling water pump

（3） Ice storage cooling

The ice storage and energy storage cooling system of this project is 700,000 kWh. It adopts advanced and mature phase change ice storage and energy storage technology combined with intelligent control and other modern control means to store the cold at full speed during the power trough at night to minimize the daytime peak power and the switchon probability of flat power mainframe.In the peak period of daytime power load, cooling can be released at full speed to reduce power consumption and give full play to the advantages of energy storage. A large amount of peak power can be transferred to the valley area at night, so as to improve the operating efficiency of the power grid and the economic benefits of the cooling system.

Ice storage cooling

（4） Hot/cold water pipe network

Energy station of directly buried installation with insulated power supply pipe network to the user, the temperature loss per kilometer < 0.1 ℃, the energy station distance as far as most no more than 1500 m users, only individual users far distance energy station more than 2500 m, power network to the user has access to the end automatically adjust according to the user's load. The total length of the hydraulic balance pipe network is 120km, and the branch pipe network is adopted. The temperature of supply and return water is 4/12℃, and the temperature difference is 8℃, which can effectively reduce the energy consumption of the frozen water transportation and the cost of the frozen water pipe network.

The total length of the hot water pipe network is 32.35km, the maximum steam transport capacity is 1.6MPa, and the steam at 270℃ is 412t/h.

3.Impact of climate change

This project uses the waste steam heat generated by the thermal generating unit of the power plant for refrigeration, and uses the ice energy storage system to provide centralized cooling and heating for users in Hengqin New Area, so as to reduce the installed capacity of the refrigeration host machine of the regional air conditioning system, save the capacity of the supporting power transformation and distribution system and the corresponding room area, and reduce the carbon emission of the local construction.According to the hengqin new area construction scale, if separate using central air conditioning system electric refrigeration host installed capacity of 2500 mw, the district cooling and ice storage, electric refrigeration host installed capacity can be reduced to 845 mw, reduce about 192000 ㎡ area of cooling machine and transformer substations, reduce a year on cold source electric refrigeration and power consumption of about 400 million kWh;Reduce the use of about 180,000 tons of standard coal/year, reduce the emission of about 480,000 tons of carbon dioxide, reduce the emission of about 1,500 tons of sulfur dioxide, save the loss of floating water used to replenish the cooling tower about 1.15 million tons per year, reduce the annual Freon filling volume of 500 tons, reduce the annual Freon leakage volume of 2.5 tons.Compared with coal-fired power plants of the same scale, the two gas-fired units can reduce the emission of carbon dioxide by 1.68 million tons, sulfur dioxide by 35.5 million tons and nitrogen oxide by 32.16 million tons per year.

4.Operation of the project

(1) Business model

The cooperative development model of the Hengqin Integrated Smart Energy Project is mainly the BOO model, that is, construction-Owning-operation. The project company is jointly organised by the central enterprise and the local state-owned enterprise. It is responsible for investing in and undertaking the design, construction, operation, maintenance and other work of the project, and owning the ownership of the project. The government is responsible for macro-coordination, creating the environment and raising needs. This model reflects the requirements of the integration of construction, management and protection of "general planning, step-by-step implementation, government supervision and enterprise operation".

Hengqin Government: The government is responsible for project planning, review and

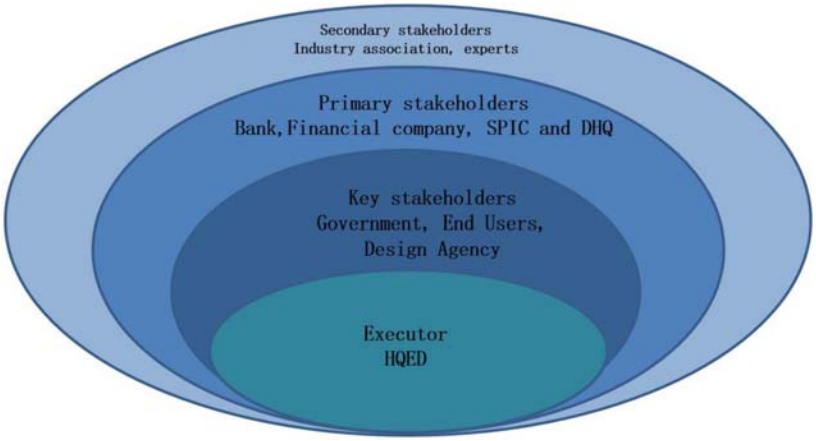
supervision, project construction coordination, reasonable supervision of fees, acceptance of user complaints and market coordination.

Holders: Guangdong Electric Power Co., Ltd. (accounting for 55% of the shares) of the State Power Investment Group. State Electric Power Investment Group Co., Ltd. is a large state-owned backbone directly managed by the central government and the world's top 500 enterprises, covering power, heat, coal, aluminum industry, logistics, finance, environmental protection, photovoltaic, power station services, etc. In the field, electricity is installed at 151 million kilowatts, accounting for 50.5% of clean energy. Guangdong Electric Power Co., Ltd. of State Power Investment Group is a wholly-owned subsidiary of State Electric Power Investment Group Co., Ltd. It is responsible for the energy development, construction, production and operation of the State Electricity Investment Group in Guangdong.

Shareholding party: Zhuhai Dahengqin Real Estate Co., Ltd. (accounting for 45%) is a wholly-owned subsidiary of Zhuhai Dahengqin Investment Co., Ltd. It is mainly responsible for the investment, development, construction, asset operation and other businesses of the real estate business sector of the group company, while shouldering the task of government-invested public service facilities projects.

Joint venture company: Zhuhai Hengqin Energy Development Co., Ltd. is responsible for the development, construction, operation and service of Hengqin comprehensive smart energy projects.

Design unit: South China University of Technology Research Institute of Architectural Design Co., Ltd., responsible for the overall program design of the project to ensure the scientific and advanced nature of project design.



Map of Stakeholders

(2)Income

The project implements the "two-part system" charging model, that is, "one-time municipal infrastructure capacity fee + monthly metering fee", which greatly improves the company's financial structure and cash flow and reduces financial costs in accordance with the principle of not being higher than the user's own construction investment cost and not higher than the user's comprehensive operating cost. As of May 2021, the Hengqin CCHP project had received a total capacity fee of 767 million yuan, accounting for 15% of the investment in the whole project.

At the same time, active use of low-valley electricity to store ice (peak, flat and grain electricity price difference 1:0.63:0.18) not only realizes the demand for grid displacement

peak filling, but also improves the safety, stability and performance and economic benefits of regional power grids. The grain electricity consumption of the 2020 project accounts for 48% of the total electricity produced throughout the year.

The project calculates according to the boundary conditions of the production node and the two-part system charging model. The internal return on the whole investment of the project is 8.55%, the internal return on capital is 11.31%, and the recovery period is 12.57 years.

5.Innovative method

（1）Innovative business model:

In order to build the Hengqin ecological island and low-carbon island, the local government will give full play to the government's macro-control and market guidance and supervision functions, and through the formulation of energy development plans, actively introduce efficient and clean green energy to promote the sustainable development of the city.

Adopting the construction-owning-operation (Building-Owning-Operation) cooperative development model, the central state-owned enterprise and the local state-owned enterprise jointly form a project company, responsible for investment and undertaking the design, construction, operation, maintenance, etc. of the project, and own the ownership of the project . Jointly develop the regional market, effectively reduce project investment and construction risks, create a good business environment, and enhance the confidence of local governments and users in the development and use of regional cooling.

When carrying out the project feasibility study, both the holding and equity holding parties actively promoted the inclusion of the project into the "Hengqin Overall Development Plan" approved by the State Council, and then incorporated the project implementation plan into the local government's "Hengqin New District Regulatory Detailed Plan" to ensure The overall functional layout of the project meets the actual needs of local economic development.

The joint venture company is solely responsible for the construction and operation of the project. The joint venture company implements shareholders, directors, supervisors and managers, a strict corporate governance structure, and uses advanced management tools to carry out scientific management of the enterprise to ensure that all decisions are democratic, scientific, standardized and efficient.

In accordance with the principle of not higher than the user’s self-built investment cost and not higher than the user’s comprehensive operating cost, a two-part system of charging is adopted, that is, "a one-time charge for municipal infrastructure capacity + a monthly metering fee", which will reduce the pressure on project operations. Operating risks were significantly reduced, and cash flow continued to increase. Make full use of low electricity prices to store ice, and play the role of low electricity prices (peak, flat, and valley electricity price difference 1:0.63:0.18).

（2）Innovative energy supply technology

The gas-fired power plant has the FCB function, which realizes the self-starting power supply function of "the unit and the grid are separated from the power grid to operate with

auxiliary power" in the event of an accident. The continued reliability of power supply in Macau.

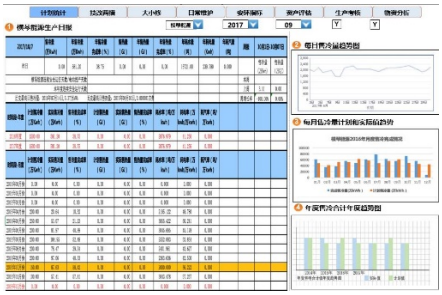
Adopt the energy cascade utilization technology of electric heating and cooling to improve energy utilization efficiency, realize energy saving and emission reduction, and a strong guarantee for low-carbon economy and sustainable development, in line with relevant national industrial policies.

Adopt advanced and mature ice storage and energy storage technology, combined with modern control methods such as intelligent control, intelligently regulate the amount of ice storage at night, minimize the daytime peak power and normal host startup rate, give full play to the advantages of energy storage, and take advantage of the trough Electricity price stores ice, and the scale of economic benefits is outstanding.

（3）Innovative intelligent control technology:

The project is based on the "global automatic optimization" technology, establishes a smart energy management system, and realizes the "self-identification", "self-organization" and "self-seeking" of the energy management system through the coordinated control of "source-network-load-storage" “Excellent”, promote the peak-shaving and valley-filling of various loads such as regional cooling, heating and electricity, and realize energy interconnection and service interaction through the construction of energy optimization allocation network and smart public service network, build a smart city energy integration ecosystem, and improve the system's renewable energy Acceptance rate and reliability.

Establish an ERP system platform with data standardization, unification of processes, centralized management, and integration of financial services to achieve integrated management of procurement, inventory, projects, equipment, human resources, asset life cycle, and financial management. Establish a CRM (customer management) system to automate marketing, sales, and service activities, so that companies can provide customers with satisfactory and thoughtful services more efficiently, and establish a good corporate brand and image.



ERP、CRM

Carried out scientific and technological innovation, completed 9 scientific and technological research and development projects, obtained 4 invention patents, 2 utility models and 22 computer software, vigorously promoted technological development and product service innovation, catalyzed the transformation of scientific and technological achievements and technological innovation, and strengthened the core Competitiveness. Compile the "Code for Distributed Energy Supply Marking System (National Standard)" and "Technical Standards for Comprehensive Energy Supply Engineering (Trade Standard)" to fill the gaps in domestic multi-generation projects without special standards, establish the commanding heights of industry standards, and finally realize the project's "availability Copy and promote".

6. Project implementation steps

(1)Planning and layout from a high starting point, growing simultaneously with Hengqin New District.During the feasibility study of the project, the project was actively promoted to be included in the "Hengqin Overall Development Plan" approved by the State Council, the project implementation plan was incorporated into the government's "Hengqin New District Regulatory Plan", and the environmental impact assessment was carried out simultaneously to ensure The overall functional layout of the project meets the actual needs of local economic development.

(2)Obtain support from the local government and vigorously promote project construction.In May 2012, the Management Committee of Hengqin New District officially promulgated and implemented the "Administrative Measures for District Cooling and Heating in Hengqin New District", stipulating that: "Industrial and civil buildings in Hengqin New District shall adopt Hengqin district cooling and heating systems. The chilled water and hot water provided are used as the cold source of air-conditioning and the heat source of winter heating and domestic hot water", which ensures a stable growth load for the development of the project and minimizes the project's operating risks.

(3)The local government establishes a cooling and heating coordination group to coordinate the solution of project construction problems.Led by the main leaders of Hengqin New Area and attended by the leaders of various competent units, the Hengqin New Area Cooling and Heating Coordination Leading Group was established. Regular meetings are held to coordinate the problems in the project construction and effectively guarantee the smooth progress of the project.

(4)Powerful alliances, joint development of regional markets.Jointly establish project companies with local state-owned enterprises to jointly develop regional markets, effectively reduce project investment and construction risks, create a good operating environment, and enhance the confidence of local governments and users in the development and use of regional cooling.

(5)Partition planning and construction stages.According to user load requirements, according to the five major cooling areas and energy station cooling installed capacity, a construction plan that matches the user load requirements is formulated, and the engineering construction plan of "energy station civil construction is completed at one time, facilities and equipment are constructed and installed step by step",, construction staging and coordinate the various energy stations Hengqin municipal planning to proceed with the construction schedule to ensure the rational and orderly energy station construction.Flexibly

adopt the construction plan that matches the formal station and the mobile station to meet the individual needs of users.

(6)The pipeline network cooperates with the simultaneous planning of municipal roads.The design stage, the use of digital modeling BIM, and the structure of the network to optimize the spatial layout depth;Construction phase, the energy station supporting the outer pipe network construction into the construction of municipal facilities management, and municipal roads synchronized planning, construction and strive to build synchronization, supporting the same period, one step to ensure the construction progress of the construction program.

(7)Flexible optimization of refrigeration technology solutions.Full use of waste heat, waste heat energy by way of priority to re-use will be supporting the design;In the most economical length range of the heating pipeline, the waste heat steam is the first choice for the cold and heat cogeneration supply;At the same time, it is equipped with electric refrigeration for load filling, reasonable use of peak and valley electricity prices for ice storage, shifting peaks and filling valleys, to maximize economic operation.

In the future, the Hengqin CCHP Project will continue to go all out to promote the efficient cascade utilization of heat, electricity, and cold clean energy, and build it into a high-quality benchmark for the regional energy industry, helping Hengqin deepen reform and industrial upgrading, and develop Zhuhai City to make contributions and strive to become a model for cooperation between central enterprises and local governments.