Case Collection on Sustainable Development towards Carbon Emission Peak and Carbon Neutrality 2022

ISO/TC268 Sustainable Cities and Communities
By SAC/TC567 City Sustainable Development
International Smart Sustainable City Club (ISSCC)

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Editorial Committee

Foreword

Since March 2022, under the guidance of the International Organization for Standardization (ISO) and the Standardization Administration of China (SAC), with the support of member cities of the International Smart Sustainable City Club (ISSCC), enterprises and research institutions, the ISO Technical Committee for Sustainable Cities and Communities (ISO/TC268), Chinese National Technical Committee for City Sustainable Development (SAC/TC567) and ISSCC jointly initiated and organized the public collection of good practices of sustainable development on carbon emission peak and carbon neutrality. The three organizations jointly established case study committee and set up working groups. After five months of collection, more than 30 cases at home and abroad were received. Through discussions among the technical group and think tank, according to the relevance of carbon neutrality, social impact and technological innovation content of the cases, after more than 10 times of field visits and nearly 20 webinars, 12 cases were finally selected and classified into cities, communities and industries (agriculture, heavy industry and service sectors). These cases has been compiled and formed this *Case Collection on Sustainable Development towards Carbon Emission Peak and Carbon Neutrality 2022*. This compilation is divided into five chapters of "city", "community", "heavy industry", "agriculture" and "service sector".

In Chapter I, "city", from the perspective of how cities of different sizes and from different regions can achieve the goal of carbon emission peak and carbon neutrality, three cases are included: the comprehensive transformation and development of Shenzhen as China's metropolitan and the national economic, scientific and technological innovation center; Haiyan county in the coastal area with Qinshan Nuclear Power Station in the region; the transformation of resource-exhausted city in Shanxi Province.

The Chapter II, "community", shows two cases of Sino-Singapore Tianjin Eco-city (SSTEC) and Dameisha Vanke Center dedicated to the exploration and application of new technologies on carbon neutrality.

The Chapter III "heavy industry" introduces the cases of comprehensive carbon flow management system of the State Grid Corporation of China, the Zero-carbon Industrial Park of Danfoss Haiyan Factory, and the Delingha Zhongkong Solar Power Station.

The Chapter IV "agriculture" shares the carbon neutrality path of agricultural industry from the

perspective of new agriculture, and introduces of Zhongcha Company's ecological low-carbon tea garden construction and management system.

The Chapter V, "service sector", consists of three cases with international influence and innovation ideas: green and low-carbon management system certification system of SGS, greener store certification plan of Starbucks and Meituan's green travel development on technology innovation, recycling and carbon reduction.

Case providers and drafters are listed as follow:
Chapter I: Shenzhen Administration for Market Regulation: Shi Shizhen, Xu Lijie, Tang Yunlu, Su Liliang; Development and Reform Bureau of Haiyan: Zhang Jianhong, Yao Ying, Sun Zhenxiao, Peng Na; Nuclear Power Industry Development Service Bureau of Haiyan: Shi Mintao, Sun Dongkui; Development and Reform Bureau of Xiaoyi: Su Guangjian; Market Supervision Administration of Xiaoyi: Zhang Wuhong;

Chapter II: Administrative Committee of SSTEC: Sun Xiaofeng; Economic Bureau of SSTEC: Yan Xu, Liu Yinben, Wang Yuan; Construction Bureau of SSTEC: Li Xiaoyuan, Li Bo; Deeprock Net Zero Technology (Shenzhen) Co., Ltd: Ji Wenxuan;

Chapter III: State Grid Zhejiang Electric Power Co., Ltd.; State Grid Zhejiang Hangzhou Xiaoshan Power Supply Co., Ltd: Xu Weifeng, Liu Zhijun, Xu Jintong, Feng Xionglong, Yu Bin, Lai Hanbin, L ü Bin, Luo Man, Zhou Guohua; Zhejiang Holip Electronic Technology Co., Ltd: Lu Zhongping, Yu Xiaoping; Shanghai Electric Wind Power Group Co., Ltd: Peng Ming, Zhan Zhonglei, Xu Wangjian; Xizi Clean Energy Equipment Manufacturing Co., Ltd: Liu Keliang, Xu Zhigui, Ying Renli, Xu Lihua, Lin Zhenyu;

Chapter IV: Zhongcha Hangzhou Longguan Industrial Co., Ltd: Jiang Aiqin, Sun Yeliang;

Chapter V: SGS-CSTC Standards Technical Services Co., Ltd: Yue Qingsong, Jia Jia, Yang Yuxuan, Fan Junna; Starbucks Enterprise Management (China) Co., Ltd: Ye Hairong, Xiang Yajuan; Hanhai Information Technology (Shanghai) Co., Ltd: Qin Hao.

ISO/TC268, SAC/TC567 and ISSCC would like to express our gratitude to all case providers and individuals involved in the preparation of this book.

This case collection will be shared to the public on the Good Practices of Carbon Emission Peak and Carbon Neutrality Sustainable Development Forum & ISSCC 2022 Global Annual Conference. Through discussion of experts and representatives participating in the conference, the outstanding cases will be recommended and submitted to drafting committee of ISO/TR37115 *Best practices of low-*

carbon cities.

It is hoped that under the support and guidance of ISO/TC268, SAC/TC567 and ISSCC,with the careful sorting and refining by the editorial board, the most representative and innovative cases will be shared to the world through media. The case collection may provides experience for cities, communities, towns and villages, enterprises and other organizations committed to the carbon neutrality goals, and also provide the international community with pragmatic near zero carbon experience and practices in a standardized way.

Introduction of some proper terms, institutions and organizations involved in this case collection are given in the follow for your reference.

1. Carbon emission peak and carbon neutrality

Carbon emission peak refers to the process that the annual carbon dioxide emissions of a certain region or industry reach the historical highest value, and then go through a stable period to enter the continuous decline. It is the historical turning point of carbon dioxide emissions from increase to decrease. Carbon neutrality means that the total amount of greenhouse gas emissions directly or indirectly generated by a region in a certain period of time is offset by afforestation and other forms to achieve "zero emission" of carbon dioxide. The international community generally believes that the excessive emission of carbon dioxide is the main factor causing climate change. Climate change has a direct impact on the global ecological environment, and then affects human survival and development.

2. ISO/TC268

ISO/TC 268 is the technical committee of sustainable cities and communities under the International Organization for Standardization. It is. ISO/TC 268 was established in February 2012 as a cross industry and cross department technical organization. Its working scope covers the standardization of sustainable cities and communities, including the indicator system, management system and related supporting technologies and tools of cities and communities, smart cities and resilient cities. Based on the Sustainable Development Goals of the United Nations (SDGs), it aims to help the development in urban and rural areas become more sustainable.

3. SAC/TC567

SAC/TC567 is the technical committee of city sustainable development under the Standardization Administration of the People's Republic of China (SAC). Established in December 2017, the SAC/TC567 is undertaken by the China National Institute of Standardization (CNIS). It is mainly responsible for the development and revision of the sustainable city development management system, requirements, guidelines and national standards in related fields (excluding urban construction standards). Under the guidance of SAC, SAC/TC567 is the Chinese mirror committee of ISO/TC268.

SAC/TC567 is committed to developing a new standard system for sustainable city development, promoting the implementation of sustainable city development standards, and continuously carrying out international cooperation on smart city & sustainable city development standards.

4. ISSCC

International Smart Sustainable City Club (ISSCC) is founded in June 2017. It was jointly initiated by 16 cities globally. It has received strong support from the ISO, the United Nations Environment Programme (UNEP), Association Francaise de Normalisation (AFNOR)and SAC.

ISSCC has actively practiced the SDGs and the concept of "clear waters and lush mountains are gold and silver mountains", organized the establishment of ISO/TC268 international pilot city system, built a standardization exchange platform for sustainable development among global cities, and improved the sustainable development ability and government management efficiency of member cities. It is also the aim for ISSCC to promote cooperation in standardization of sustainable development among cities.

5. Carbon Emission Peak, Carbon Neutrality and Sustainable Development Forum of China Quality (Hangzhou) Conference

From September 16 to 17, 2021, China Quality Conference was held in Hangzhou, Zhejiang Province. At the same time, the "carbon emission peak, carbon neutrality and sustainable development" forum and the 2021 ISSCC global annual meeting was held on the conference. As one of the parallel sessions of the China Quality Conference, the forum shared international standards and advanced experience, effectively promoted the systematization and standardization of the top-level design in the whole field of carbon neutrality in China, promoted the integrated and sustainable development of carbon neutrality, and received wide attention from relevant organizations, industries and enterprises at home and abroad, laying a foundation for the drafting and collection of this case collection.

The collection and compilation of this case collection have come to an end. The promotion and implementation of the strategic goal of carbon emission peak and carbon neutrality has become a global consensus. We will continue to pay attention to the experiences and practices of carbon neutrality and sustainable development in key regions and fields and pursue the standardization of carbon neutrality. It is also expected that cities, communities and industries will summarize the good experiences and practices of green and low-carbon and generate new cases.

You are welcome to contact the ISSCC Secretariat at any time to submit cases of good practice. We will organize ISO/TC268, SAC/TC567 and ISSCC experts to conduct discussion and review on the selected cases with field visits and webinars, develop them to national and international standards, and work together for the carbon neutrality goals and better future.

Due to the limited time and limited knowledge of the author, some mistakes and errors in the book are unavoidable.Thus we welcome all readers to offer your kind criticism and correction.

International Smart Sustainable City Club
Collection Committee (compilation and translation working group) of the 2022 Global Good Practices on Sustainable Development towards Carbon Emission Peak and Carbon Neutrality
August 2022

Preface

Under the guidance of the strategic objectives of carbon emission peak and carbon neutrality, it has become a global consensus to achieve sustainable development with green and low-carbon scientific and technological innovation. As the most dynamic and promising field and an important support for the sustainable development of human society, green and low-carbon innovation is also an important direction of scientific and technological revolution and industrial transformation. The high-quality development must be the ecology, green and low-carbon development. With the concept of "clear waters and lush mountains are gold and silver mountains", we should strengthen the dual core of technology and digital energy, and promote precise, smart and safe carbon reduction. As a means of modernizing the national governance system and governance capacity, standardization plays an important role in the green and low-carbon development and is an important guarantee for achieving high-quality development.

The achievement of the carbon neutrality goal is an extensive and profound economic and social systematic reform, which requires carbon emission peaking and green carbon reduction actions from energy, industry, urban & rural construction, transportation, circular economy, scientific and technological innovation to every residents. In order to strengthen the exchange of experience and technology among the cities and find out the good practices and standardization paths of carbon neutrality, International Smart Sustainable City Club (ISSCC), ISO technical committee of sustainable cities and communities (ISO/TC268) and SAC technical committee city sustainable development (SAC/TC567) jointly launched the public collection of good practices of carbon emission peak and carbon neutrality. After more than half a year's efforts of the case collection committee and working group, and under the coordination of the ISSCC Secretariat, the *Case Collection on Sustainable Development towards Carbon Emission Peak and Carbon Neutrality 2022* is edited and printed.

The content of this case collection covers a wide range of fields such as cities, communities, heavy industries, building construction, new energy, low-carbon agriculture and green lifestyles. These include the cases from Chinese metropolitan such as Shenzhen and Tianjin, as well as regional carbon reduction cases such as Xiaoyi and Haiyan. There are carbon flow management system of the State Grid and green and healthy travel plan of Meituan, as well as the cases from international enterprises such as Danfoss, Starbucks and SGS. The low-carbon tea garden management of Zhongcha is also included in the case collection.

The above-mentioned cases will be further selected and promoted to "best practices of carbon neutrality" (ISO/TR37115) ISO technical report initiated by ISSCC member cities. This case collection

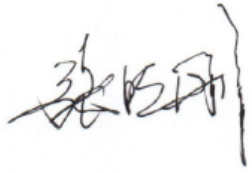
will also provide ideas and technical guidance for governments and industrial enterprises to implement the carbon neutrality goal, and promote the cooperation, experience exchange and standards development among ISSCC member cities and more stakeholders. It is expected that this compilation will be further improved according to the opinions of experts participating in the 2022 annual conference of ISSCC and ISO/TC268, and will be officially published and shared globally. I hope that these cases will provide useful demonstration and reference for promoting global carbon neutrality and sustainable development, and generate more standard documents in carbon reduction fields.

Thanks to the all the enterprises, organizations and local governments for their outstanding wisdom and hard work in the implementation of case projects. Thanks to ISO/TC268, SAC/TC567, ISSCC and case collection working committee for their efforts in case collection, coordination, editing, translation and review.

I wish the 2022 annual conference of ISO/TC268 and ISSCC a complete success!

Former president of ISO

Dr. Zhang Xiaogang



September 7, 2022

Letter of Congratulation

Through the joint efforts of the "carbon emission peak and carbon neutrality" case collection committee and the secretariat of the International Smart Sustainable City Club (ISSCC), the *Case Collection on Sustainable Development towards Carbon Emission Peak and Carbon Neutrality 2022* has been completed, reviewed and put into print, and will be shared and discussed at the 2022 ISSCC annual meeting. On behalf of the International Electrotechnical Commission (IEC), I would like to extend warm congratulations on the smooth implementation of the above work and the successful convening of the 2022 annual meeting of ISSCC!

Founded in 1906, IEC is the earliest international organization on standardization of electrotechnical in the world. IEC is responsible for international standardization in the fields of electrical engineering and electronic engineering. The purpose of IEC is to promote international cooperation on standardization and related issues in the field of electrical and electronic engineering and enhance mutual understanding among countries.

In October 2021, China Quality Conference (Hangzhou) was held. As one of the parallel sessions of the conference, I was invited to speak at the Carbon Emission Peak, Carbon Neutrality and Sustainable Development Forum jointly held by Huaneng Group, and shared the key paths and measures for low-carbon transformation of energy production.

On August 20, 2022, the 2022 International Standardization Conference was held in Nanjing, China. The conference carried out exchanges around the theme of "international standardization supporting carbon emission peak and carbon neutrality". Participants of the conference witnessed the establishment of IEC International Standards Promotion Center (Nanjing). As one of the world's three major international standards organizations, IEC actively responds to global climate change, initiates IEC's strategic planning for the next ten years, includes topics such as carbon neutrality, energy transformation, and zero carbon power
system in its strategic planning, cultivates and forms a large number of international standards, vigorously promotes the green transformation of energy sources, and helps achieve the United Nations 2030 sustainable development goals (SDGs). As one of the permanent members of IEC, under the guidance of the carbon emission peak and carbon neutrality goals, China dedicated to promoting the establishment of a carbon emission peak and carbon neutrality standard system, building a conformity assessment service platform that is in line with international standards, advancing green and low-carbon development through standardization, and injects strong impetus into building a community with a

shared future for mankind and a clean and beautiful world.

On the basis of the 2021 China Quality Conference forum, ISSCC, together with ISO/TC268 and SAC/TC567, jointly initiated the collection and preparation of this carbon emission peak and carbon neutrality case collection, which is an in-depth summary of carbon emission peak and carbon neutrality cases at home and abroad. The publishing of this book both in Chinese and English is of great help of experience sharing and discussion among all countries in the world.

In the case collection, I am very pleased to see that low-carbon innovative technologies such as ultra-high voltage, flexible transmission, DC power grid, photovoltaic power generation of high conversion efficiency have been widely applied in cities, communities and other organizations in the case collection, including the piloting and demonstrations of new generation technologies, which have greatly improved the green and sustainable development ability of urban and rural areas. It is the key direction of IEC international standards to promote the low-carbon transformation of energy through the path of cleaning, electrification, digitalization and standardization. The collection, editing and distribution of the case collection are highly consistent with the work direction of IEC, and will promote the whole community to focus on energy structure optimization, energy conservation, emission reduction and innovation of low-carbon technology.

Finally, I wish the publicity and distribution of the *Case Collection on Sustainable Development towards Carbon Emission Peak and Carbon Neutrality 2022* a huge success and the 2022 ISSCC annual conference achieve fruitful outcome!

Chairman of International Electrotechnical Commission (IEC)
Academician of Chinese Academy of Engineering
President of China Society of Electrical Engineering
Chairman of China Huaneng Group
Shu Yinbiao

September 2022

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Chapter 1 City

1.1 Carbon Emission Peak and Carbon Neutrality Sustainable Development of Shenzhen

I. Green and Low Carbon Transformation Route of Metropolitan

1.1 Background

As early as 1996, China upgraded sustainable development to a national strategy and comprehensively promoted its implementation. The 11th and 13th goals of the UN 2030 agenda for sustainable development are "building inclusive, safe, disaster resilient and sustainable cities and human settlements" and "taking urgent action to deal with climate change and its impacts". In December 2016, in order to promote the implementation of the United Nations 2030 agenda for sustainable development, the State Council of China issued the *Development plan of China's innovative demonstration area for implementing the 2030 agenda for sustainable development*, The working goal of "forming a number of practical and typical models of sustainable development innovation demonstration, giving play to the demonstration and driving effect on the sustainable development of other regions in China, and providing Chinese experience for other countries to implement the 2030 agenda for sustainable development" was put forward. In August 2019, the CPC Central Committee and the State Council issued the *Opinions of the CPC Central Committee and the State Council on supporting Shenzhen in building a leading demonstration zone of socialism with Chinese characteristics*, which endowed Shenzhen Special Economic Zone with the new historical mission of "global benchmark city" and the strategic positioning of "high-quality development highland and sustainable development pioneer", requiring Shenzhen to take the lead in developing a beautiful Chinese model of harmonious coexistence between people and nature.

As a major carbon emitter, China has long attached great importance to addressing climate change, earnestly implemented the United Nations Framework Convention on climate change and the Kyoto Protocol, and adopted a series of policies and measures to address climate change, striving to control and mitigate greenhouse gas emissions. On March 13, 2021, China issued the *14th five year plan for national economic and social development of PRC and the outline of long-term goals for 2035*, which put forward the development goal of "achieving new progress in the development of ecological civilization", and required to actively respond to climate change and incorporate the carbon emission peak and carbon neutrality goals into the plan.

1.2 Innovative ideas

Shenzhen has achieved remarkable outcomes in energy conservation and emission reduction. During the "13th five year plan" period, the energy consumption per unit of GDP in Shenzhen continued to decline. In 2020, the energy consumption per unit of GDP was about 1/3 of the national average level and 1/2 of the province. The carbon emission per unit of GDP is about 1/5 of the national average level and 1/3 of the province, both of which have reached the domestic leading and international advanced level. Shenzhen proposed to promote carbon emission peaking and carbon neutrality with leading demonstration standards. Shenzhen's green and low-carbon industry focuses on high-energy consumption and high emission sectors such as energy, transportation, construction and digital economy. Starting from the aspects of clean energy transformation, energy conservation and efficiency improvement, smart transportation, it provides support for exploring high-quality carbon neutrality mode that economic development and carbon emission reduction go together.

Figure 1 Lingao Nuclear Power Station of Daya Bay nuclear power base

In the field of energy, Shenzhen will carry out the demonstration of clean and efficient development of coal power, reduce the consumption of standard coal for power generation, and continue to carry out the pilot demonstration project of carbon capture, utilization and storage (CCUS)[1]. Shenzhen will accelerate the construction of natural gas infrastructure, build a natural gas supply pattern of "multiple gas sources, one network, interconnection and land-sea coordination", thus to achieve the "all-round transformation of pipeline natural gas". Based on the demonstration standards and the increasing local clean power supply, Shenzhen will continue to develop the Ling'ao nuclear power phase III project. While making full use of roof resources, Shenzhen will also actively expand the diversified utilization range of "photovoltaic +" and promote the large-scale increase of distributed photovoltaic applications. In addition, Shenzhen will vigorously promote the construction of wind power projects, actively carry

[1] Carbon Capture, Utilization and Storage (CCUS) . CCUS technology is one of the key technologies to deal with global climate change, and has been highly valued by countries around the world. CCUS technology is the new development trend of CCS (Carbon Capture and Storage) technology, that is, the carbon dioxide emitted in the production process is purified and put into a new production process that can be recycled, rather than simply stored. Compared with CCS, it can recycle carbon dioxide, generate economic benefits, and be more practical. With the advancement of technology and the reduction of cost, CCUS has a bright future.

out hydrogen energy application demonstration, promote the development of new energy storage with high quality, and take the lead in achieving the full incineration of domestic waste in China.

For industries, Shenzhen has taken the lead in legislating and starting carbon emissions trading in China since 2013. With the help of this work, the industrial energy level in Shenzhen has continued to improve and the emission reduction has been remarkable. The carbon market in Shenzhen has the smallest control area, but the total number of organizations under control ranks second in the country, these organizations and enterprises lies in various industry categories. Statistics show that in 2020 in Shenzhen, the value of advanced manufacturing industry increased by 3.9%, the value of strategic emerging industries increased by 3.1%, and the value of modern service industry increased by 6.4% over the previous year. In addition, Shenzhen has also implemented the first green finance regulation in China and the first comprehensive act regulating green finance in the world. *The Green Finance Regulation of Shenzhen Special Economic Zone* has been implemented since March 2021, which further defines the main responsibilities of financial institutions and green enterprises, and has achieved remarkable outcomes in the guidance of green finance system, the ecological development of green finance, the innovation of green financial products, and the international cooperation of green finance.

Figure 2 Shenzhen International Low Carbon City Cultural Conference Center

Regarding transportation, Shenzhen is systematically promoting the development of green transportation system, building a high-quality city suitable for travel. Shenzhen took the lead in achieving 100% pure electrification of buses and taxis in China. The green transportation travel rate of Shenzhen is 71%, and the number of new energy vehicles is about 400000, ranking in the forefront of global cities. More than 83,000 charging piles and 5,000 charging stations have been built in Shenzhen, with a total installed power of 2.3 million KW, and the density of public piles ranks first in China, which effectively guarantee the charging demand of new energy vehicles in city. According to the *Work plan for the promotion and application of new energy vehicles in Shenzhen (2021-2025)* shows that during the "14th five year plan" period, the proportion of new energy vehicles in the city's newly registered vehicles (excluding replacement and renewal) will reach 60%. By 2025, the number of new energy vehicles in the city will reach 1 million, and a total of 43000 fast charging piles for public and private networks and 790000 slow charging piles for basic networks will be built.

For building construction, Shenzhen has vigorously promoted the improvement of building energy efficiency. As early as 2006, it promulgated the country's first building energy efficiency regulation, *Regulations on building energy efficiency of Shenzhen Special Economic Zone*, which took the lead in implementing the strictest mechanism for building energy efficiency in the country. At present, the scale of green buildings in Shenzhen ranks first in China. By 2020, Shenzhen has carried out 1359 green building identification projects, with a green building area of 128million square meters, of which 91% are high star green buildings. It is one of the cities with the largest scale and density of green building in China. *The Regulations on green buildings in Shenzhen Special Economic Zone*, which came into force on July 1, 2022, proposed to establish a working mechanism for building carbon emission control, encourage the demonstration of near zero energy consumption buildings, zero carbon buildings and near zero carbon emission pilot areas, and reduce the intensity and total amount of carbon emissions from buildings.

1.3 Implementation objectives

In June, 2021, Shenzhen issued the *14th five year plan for Shenzhen's national economic and social development and the outline of the long-term goals for the year 2035*, which put forward the sustainable development goal of "forming a green and low-carbon development mode with low consumption, less emissions, recycling and sustainability, and taking solid steps to promote carbon emission peak with leading demonstration standards". It is also required to focus on building a low-carbon energy system, a strategic emerging industry system, and a policy system that is compatible with carbon emission peaking and carbon neutrality, promote energy conservation and low-carbon in key areas such as industry, construction, transportation, public institutions, encourage key energy users to improve comprehensive energy efficiency, promote low-carbon pilot demonstration, and deepen innovation.

In January 2022, the municipal of Shenzhen issued the *14th five year plan for ecological environment protection in Shenzhen*, Further clarify the sustainable development goal of "By 2035, develop as a pioneer of sustainable development, create a beautiful Chinese model of harmonious coexistence between man and nature, achieve the world-class level of ecological environment quality, improve the green production and lifestyle, significantly improve the level of green low-carbon cycle, and steadily decline after the peak of carbon emissions. By 2025, the quality of ecological environment will reach the international advanced level".

Government departments at all levels in Shenzhen has issued a series of planning documents or regulations, such as *Measures on further promoting the steady growth and quality of Shenzhen's industrial economy*, *14th five year plan for power grid development of Shenzhen, 14th five year plan for comprehensive transportation of Shenzhen*, *Regulations of Shenzhen Special Economic Zone on green buildings*, and the *Regulations of Shenzhen Special Economic Zone on green finance*. These documents have deployed and proposed to promote the construction of energy infrastructure projects; pursue the development of power grids to be greener and smarter; advance the clean development of

transportation vehicles; establish a working mechanism for building carbon emission control; and promote the development of green and sustainable financial demonstration. Shenzhen has established a systematic and comprehensive goal of carbon emission peak, carbon neutrality and sustainable development in the city.

II. Actions for Overall Management

As one of the first batch of low-carbon pilot cities, carbon emissions trading pilot cities, and innovation demonstration zone for Sustainable Development Agenda in China, Shenzhen has always adhered to the sustainable development strategy, and actively gave full play to be the pioneer of the country. In promoting energy structure optimization, low-carbon transportation, green building promotion, low-carbon pilot demonstration, carbon emissions trading market, green finance law and other projects, Shenzhen has made significant progress. A low-carbon development mode with Shenzhen characteristics has been initially formed.

2.1 Building a clean and low-carbon energy system

To build a clean and low-carbon energy system, Shenzhen is:

(1) coordinating and promoting the planning and construction of energy infrastructure. Key projects such as Shenzhen Pumped Storage Power Station, Huadian Pingshan Distributed Energy and Northwest Yunnan DC project have been completed and put into operation;

(2) optimizing the utilization of fossil energy. Shenzhen promotes the development of natural gas production, supply, storage and marketing system, and advancing the completion of the interconnection pipeline between CNOOC Shenzhen LNG[2] project and Guangdong Dapeng LNG project;

(3) accelerating the development of renewable energy and biomass energy[3]. Three waste treatment facilities, including the eastern environmental protection power plant and Mawan urban energy ecological park, were successfully completed and put into operation, and took the lead in achieving the full incineration of domestic waste in super large cities;

(4) promoting the high-quality development of hydrogen energy. *The Shenzhen hydrogen industry*

[2] Liquefied Natural Gas, or LNG, is the main component of methane and is recognized as the cleanest fossil energy on Earth. Colorless, tasteless, non-toxic and non-corrosive, its volume is about 1/625 of the same volume of gaseous natural gas, and the mass of liquefied natural gas is only about 45% of the same volume of water.

[3] Biomass energy is the energy provided by living plants in nature. These plants use biomass as a medium to store solar energy, which belongs to renewable energy. It has been calculated that biomass stores two times more energy than the world's total energy consumption.

development plan (2021-2025) requires that by 2025, a relatively complete hydrogen industry development ecosystem should be formed, and hydrogen industry technology sources, advanced manufacturing industries, and multi-scene application demonstration bases should be developed to achieve the commercial application of hydrogen energy, and the scale of hydrogen energy industry should reach 50 billion yuan.

2.2 Carbon emissions trading helps reduce greenhouse gas emissions

In June 2013, Shenzhen was the first city in China to launch the carbon emissions trading and innovate market-oriented mechanisms to effectively control greenhouse gas emissions. Since the launch of Shenzhen carbon market, the market liquidity rate has ranked first in the country for eight consecutive years. The spot transaction volume of the national secondary market quota took the lead in breaking the two thresholds of 100 million and 1 billion, and the performance rate has always remained above 99%. There are 750 enterprises in Shenzhen carbon market, covering 33 industries such as computer, communication and electronic equipment, machinery manufacturing, rubber and plastic products, water, gas and public transportation. By the end of 2020, the average carbon emission intensity of pipe control manufacturing enterprises has decreased by 40.29%, and the average value-added has increased by 61.64%, achieving the dual decline of carbon emissions and carbon intensity, and effectively controlling carbon growth while keeping economic growth.

Figure 3 Launching of "low carbon planet" carbon inclusive app

2.3 Development of Shenzhen carbon inclusive system[4]

In November 2021, in order to develop the green and low-carbon potential of the residents, the Shenzhen government issued the *Work plan for the development of the Shenzhen carbon inclusive system*, requiring the goals of the connection, exchange and trading of carbon credits, carbon inclusive emission reductions and the carbon trading market. In addition, Shenzhen launched a series

[4] Carbon inclusion system is an incentive mechanism established to give value to the energy saving and carbon reduction behaviors of the public and small and micro enterprises.

of preparation work for carbon inclusive methodology. Integrated with Tencent's IT innovation capability and a wide range of user social platform contacts, Shenzhen published the *Carbon inclusive methodology of Shenzhen low carbon public travel* and the "low carbon planet" app in December 2021. It is estimated that, compared with the general urban transportation travel, people traveling by pure electric bus can reduce 26.9 grams of CO_2 emissions per kilometer per person, and people traveling by subway can reduce 46.8 grams of CO_2 emissions per kilometer per person.

2.4 Piloting of near zero carbon emission zone

In November 2020, Ecology Environment Bureau of Shenzhen Municipality and the Shenzhen Development and Reform Commission jointly issued the *Implementation plan for the pilot development of near zero carbon emission zones in Shenzhen*, soliciting the first batch of pilot projects of near zero carbon emission zones in the city, selecting regions, communities, industrial parks, enterprises, buildings and campuses with great emission reduction potential or a good low-carbon foundation. By promoting the pilot development of near zero carbon emission zones in batches and by categories, and advancing near zero carbon zero, Shenzhen is working to form a demonstration driving effect. In December 2021, 28 projects including the Antuoshan headquarters park of Huawei were nominated as the first batch of pilot projects in the near zero carbon emission zone of Shenzhen. In August 2022, Shenzhen launched the collection and application of the second batch of near zero pilot projects. The first batch of pilots is also under development.

2.5 Build a carbon capture, utilization and storage (CCUS) test platform for China Resources Haifeng power plant

In May 2019, the CCUS test platform project of China Resources Haifeng power plant was fully completed and put into operation. This platform is the third in the world and the first CCUS test platform in Asia. At present, the CCUS test platform of China Resources Haifeng power plant has achieved good social and environmental benefits: it has successfully captured more than 10000 tons of high-purity carbon dioxide, directly reducing greenhouse gas emissions and reducing the impact on the environment. The project is making contribution to CCUS technological innovation, and has formed a direction with international cutting-edge CCUS scientific research topics. The project has a good demonstration effect in China and even the world, and has been widely recognized and well-known in professional fields at home and abroad. The completion of CCUS test platform will help cities in GBA solve the carbon emission problems of coal-fired power plants faced by urban development, and help GBA[5] achieve carbon emission peak and medium and long-term emission reduction under the condition of ensuring energy supply.

[5] GBA: Abbreviation for Guangdong-Hong Kong-Macao Greater Bay Area.

III. Experience and Practice

3.1 Building the legal system and policy system of carbon emissions trading.

As one of the seven pilot provinces and cities of carbon emissions trading, Shenzhen has formed the most complete legal system and policy system of carbon trading in China, laying a good legal and policy foundation for the smooth development and operation of the carbon market. In October 2012, the *Regulations on carbon emission management of Shenzhen Special Economic Zone* was published, which was the first local regulation on carbon trading in China. In March, 2014, the *Interim measures for the management of carbon emissions trading in Shenzhen* was promulgated, taking the lead in forming the most complete legal system for carbon trading in China. The first Chinese guideline for the quantification, reporting and verification of greenhouse gas emissions for organization were published in 2012 in Shenzhen. The Shenzhen guidelines for the quantification and reporting of greenhouse gas emissions for waste incineration power generation enterprises, bus and taxi enterprises and other industries were published in 2016, and the above standards were revised and improved in subsequent years to support the operation of the carbon trading market. In addition, Shenzhen also plans to expand the focus of carbon market control industry from industry to service sector. According to the feasibility and actual management of carbon emission control, service enterprises (organizations) will be promoted to enter the management of Shenzhen carbon market in batches, forming a differentiated and complementary development circumstance with the eight key industries of national carbon market control.

3.2 Green finance supports low-carbon development

In December 2018, Shenzhen government issued the *Implementation opinions on developing a green financial system*, formulated reward and subsidy policies for green credit, green bonds, green insurance and other products, supported the development of regional environmental equity trading markets, and further optimized the allocation of green financial resources. In October 2020, the *Regulations on green finance in Shenzhen Special Economic Zone* was approved and officially implemented on March 1, 2021. This is not only China's first local regulation on green finance, but also the world's first comprehensive act to regulate green finance. According to the *Requirements of the regulations of Shenzhen Special Economic Zone on green finance*, investment projects with annual greenhouse gas emissions expected to reach 3000 tons of carbon dioxide should carry out green investment evaluation, and endure strict evaluation in the supervision process. In addition, Shenzhen has launched a number of carbon financial products and services, supported investment institutions to set up the first private carbon fund, achieved the first domestic pure quota carbon pledge business, completed the first domestic and largest cross-border carbon asset repurchase business. Shenzhen also achieved the largest domestic single carbon quota replacement transaction, and took the lead in introducing overseas investors in the carbon market, providing more convenient price discovery tools, risk management tools

and low-carbon financing tools for carbon market participants, which greatly activated market transactions.

3.3 Low carbon transportation promotes the low-carbon development of urbanization

First, Shenzhen accelerates the promotion of new energy vehicles. In 2009 and 2010, Shenzhen issued the *Shenzhen new energy industry revitalization and development plan* (2009-2015) and the *Shenzhen new energy industry revitalization and development policy*, making the focus on the development of new energy vehicles. By 2017, Shenzhen was the first city in the world to achieve the full electrification of public transportation. In 2018, Shenzhen successfully realized the full electrification of taxis. The development of green public transportation in Shenzhen plays a leading role in the world, and it was awarded as the *Representative case of global green transportation*. In September 2021, the World Bank released the first overall electrification case report, which promoted the "green bus" mode of Shenzhen Bus Group to 189 countries around the world;

Second, Shenzhen focuses on promoting green transportation. Shenzhen is working on the integration of rail transit, public transport and slow travel networks, and the share of public transport in motorized travel will reach 62.6% during traffic peak in 2019. Since the year 2016, the transportation of Shenzhen has basically formed a multi-level green public transportation system with rail transit as the framework, conventional public transportation as the network, taxis as the supplement, and non-motorized transportation as the extension;

Third, Shenzhen is developing the green non-motorized transportation. During 2016 to 2020, Shenzhen has built a total of 1257 kilometers of non motorized lanes, and the scale of the bicycle road network has increased by 132%. The share rate of non-motorized travel in the city has remained at more than 50%, ranking first among the metropolitan in China. In September 2021, the *Shenzhen bicycle traffic development plan (2021-2035)* was issued as the first municipal bicycle traffic plan in China, which made it clear that bicycle traffic is an important part of city transportation, and introduced policies such as rational allocation of row and setting of bicycle lanes.

3.4 Achievements in energy conservation of green buildings

In 2006, Shenzhen issued the Regulations of *Shenzhen Special Economic Zone on building energy conservation*, which effectively promoted the management of building energy conservation and improved energy efficiency. In 2013, Shenzhen issued the *Measures for the promotion of green buildings in Shenzhen* to advance the development of green buildings in Shenzhen and promote Shenzhen to be one of the cities with the largest scale and density of green buildings in China. Shenzhen is implementing contract energy management, and introducing social funds to complete the energy-saving transformation of existing buildings, covering an area of more than 20 million square meters. In

2020, the new green building area in Shenzhen was about 17 million square meters, with a total area of more than 130 million square meters, and the cumulative number of green building evaluation and identification projects reached 1388. In addition, Shenzhen is accelerating the implementation of prefabricated construction projects, promoting the improvement of quality and expansion of prefabricated construction projects, and gradually expanding from residential buildings to public buildings, industrial buildings and municipal infrastructure. The prefabricated buildings in Shenzhen is awarded the title of *National renewable energy building application model city*. Shenzhen is also doing research on ultra-low energy consumption and near zero energy consumption buildings, and the construction of the main buildings has been carried out for ultra-low energy consumption and near zero carbon emission building projects.

IV. Implementation and Effectiveness

4.1 Improvement on industrial structure and energy structure

Shenzhen implements the upgrading of industrial structure and energy structure. In 2020, the GDP of Shenzhen reaches 2.77 trillion yuan, the proportion of primary, secondary and tertiary industries is 0.1:37.8:62.1, and the added value of strategic emerging industries is1.02 trillion yuan. The energy consumption per unit of GDP and carbon dioxide emission per unit of GDP is 1/3 and 1/5 of the national average respectively, with a decrease of 19.3% and 23.2% in five years. Form an energy structure dominated by electricity and LNG, Shenzhen completely eliminated civilian bulk coal and ordinary industrial & commercial coal. Shenzhen was the first metropolitan in the world to achieve the full electrification of buses and taxis in 2018. The installed capacity of nuclear power, gas power and other power sources accounts for 77% of the total installed capacity of the city, which is about 25% higher than the national average level. Shenzhen vigorously develops biomass energy, and the total installed power generation capacity of domestic waste incineration power plant reaches 540 MW.

Figure 4 Center area of Shenzhen International low carbon city

4.2 Low carbon industry promotes high-quality economic development

Focusing on improving the quality of economic development and effectively reducing carbon emissions, Shenzhen has carried out *Enterprise technological transformation support plans* and *Industrial foundation projects support plans* for traditional industries, supporting more than 3700 technological transformation projects, undertaking the construction of 12 national industrial foundation projects, and establishing green and low-carbon support plans for new energy, bio-medicine, new materials, new information technology and other low-carbon strategic emerging industries and energy-saving and low-carbon key technologies. During the year 2016 to 2020, Shenzhen's regional GDP increased by 7.1% annually. Its energy consumption and water consumption per unit GDP ranked lowest in large and medium-sized cities in China. The total output value of industries above designated scale leaped to the first place in the country, the added value of strategic emerging industries exceeded trillion yuan, and the development of high-tech industries has become a model in the country. In 2020, the strategic emerging industries in Shenzhen accounted for 37.1% of the regional GDP, and the added value of high-tech manufacturing and advanced manufacturing accounted for 66% and 72% of the added value of industries above designated scale respectively. The output GDP per square kilometer ranked first among major cities in China.

4.3 Develop a green & low-carbon city development model

First, Shenzhen establishes a GEP[6] accounting system to be an important starting point for achieving the goal of carbon emission peak and carbon neutrality. In 2014, Shenzhen launched the pilot of urban GEP accounting in Yantian District, which helped promote the integrated development of ecological civilization and economic society. According to the data, Yantian District achieved a year-on-year GDP growth of 5.8% in 2020, ranking first in all districts of Shenzhen for the first time in 17 years, truly realizing the mutual promotion of industry development and green development. In March 2021, Shenzhen announced that it would implement GEP accounting throughout the city.

Second, Shenzhen is developing an International Low-carbon City in the city as an exchange and exhibition window for low-carbon development. From planning to the construction and operation of the start-up area, Shenzhen International Low-carbon City absorbed the most advanced low-carbon concept in the world, and applied ten major technical systems and hundreds of advanced technologies, such as green building, clean transportation, sewage recycling, waste recycling, low-carbon energy and so on. After the launch of the Shenzhen International Low-carbon City project in 2012, the benefits of low-carbon transformation have initially emerged. The regional GDP increased from 4.28 billion yuan in 2011 to 15.13 billion yuan in 2019, with an average annual growth rate of 17.1%.

[6] GEP=Gross Ecosystem Production

4.4 The quality of ecological environment and the level of sustainable development have been improved.

According to statistics, in 2020, the emission reduction of major pollutants in Shenzhen exceeded the target, and the ecological environment quality improved steadily. The water quality of five major rivers in Shenzhen, including Maozhou River and Shenzhen River, reached or better than class IV, PM2.5 fell to 19 micrograms / cubic meter, AQI compliance rate reached 97%, the growth rate of total carbon emissions continued to slow down, the intensity of carbon emissions fell steadily, and the energy consumption per unit GDP and carbon emission intensity have fallen to 1/3 and 1/5 of the national average level. With these achievements, Shenzhen has won the title of *National demonstration city of ecological civilization*. In 2020, the urban sustainable development indicator of Shenzhen reached 88.10.

V. Problems and Suggestions

5.1 Problems

5.1.1 Shenzhen's economy and society maintains rapid development, and the demand for energy resources is very strong. With large amount of discharged pollutants, the conflicts between supply and demand of resources and environment in the city will be further highlighted. Furthermore, the space for land development in the city is close to the upper limit, issues such as water resources and energy supply, urban sewage and solid waste treatment will bring high pressure.

5.1.2 Although there is a significant positive correlation between energy consumption and carbon emissions, the management indicator of energy consumption in Shenzhen has not been established with the total setting and initial allocation of carbon emission quotas. The installation and application of distributed renewable energy and the performance of carbon emission accounting, and the purchase of green power cannot be reflected in the urban carbon inventory and enterprise carbon emission reduction. There is a disconnect between carbon emission trading and key assessment work such as management of urban energy consumption and reduction of carbon intensity, multiple mechanisms cannot work in coordination, and a large amount of data has not been developed and utilized.

5.1.3 Achieving carbon emission peak and carbon neutrality depends on a systematic and complex technical system, which requires all-round scientific and technological support. At present, Shenzhen's carbon emission reduction technology in key areas such as power, construction, industrial production, transportation and so on is not mature, the utilization efficiency of new energy technology is still of low level, the industrialized application of green & low-carbon technology is insufficient, and the replacement of green technology in high carbon emission industries lacks momentum. Shenzhen is till striving to improve the abilities of basic research, original innovation and development of key technology.

5.1.4 Carbon emission peak and carbon neutrality will have a far-reaching impact on Shenzhen's economic development, industrial layout, energy transformation and other aspects. Due to the strong professionalism and practicality in the carbon neutrality, it is difficult to meet the requirements of practical work only by short-term training or theoretical study. Shenzhen is in need of experts on the top-level design, technical research, and management & operation of specific carbon asset.

5.2 Suggestions

5.2.1 For cities on the path of carbon neutrality, smart land, building energy conservation, resource recovery and other technologies shall be adopted to improve the efficient utilization of resources. For cities with short supply of urban land property, it is important to reform and optimize land policies, adhere to the road of intensive and efficient use of land space, and develop underground space. Cities and communities are also suggested to improve the incentive mechanism for water saving, and strengthen water-saving management in industries, public institutions, resident areas and other fields. For instance, in Shenzhen, the city management will strengthen the establishment of "zero direct sewage discharge area", continue to promote the construction, repair and transformation of pipe networks, and accurately carry out the sewage system quality and efficiency improvement project. Shenzhen will also deepen the development of "waste free cities" and strengthen the safe utilization and disposal of solid waste.

5.2.2 For city management, it is important to enhance the liaison and communication between government departments to achieve the synergy between carbon trading, energy right trading, green power trading and other policies, and include the total setting and initial allocation of carbon emission quotas into the carbon control indicators of energy consumption for special assessment. For Shenzhen, the implementation plan of carbon emission peak has been issued, and the carbon neutrality work will be included in the performance assessment of Shenzhen government. All departments and districts of Shenzhen should effectively connect the tasks in the implementation plan of carbon emission peak with the local and industrial development plans, and ensure that all tasks can be completed.

5.2.3 Shenzhen will focus on power, construction, industrial production, transportation and other fields, accelerate the development of innovation platforms, and implement key technology projects for energy conservation and emission reduction. Shenzhen will encourage green and low-carbon scientific and technological innovation, promote core technological breakthroughs, and create technological and cost advantages for market-oriented applications. The incentive mechanism will be imposed to encourage enterprises to improve their technological innovation ability in the carbon reduction. Shenzhen will also strengthen international scientific and technological exchanges and cooperation in carbon neutrality, advance joint research and development with overseas scientific researchers. To pursue this goal, Shenzhe n will deepen the transfer and exchange of carbon emission reduction technologies, and actively introduce and absorb international advanced low-carbon / zero carbon /

negative carbon technologies.

5.2.4 Shenzhen will strengthen the capacity-building related to the carbon market, accelerate the training of professionals in low-carbon industries. The government will encourage and support enterprises to cooperate with universities and other research institutions to develop international expert training bases, cultivate expert teams on carbon neutrality, and improve the development of Shenzhen think tank on carbon emission peak and carbon neutrality. Shenzhen will also encourage and support universities to cooperate with overseas universities to cultivate international professionals who can participate in the international climate management and the operation of the global carbon market.

VI. Plan for Future Green Development

Shenzhen will thoroughly implement the sustainable development strategy, actively participate in the development of GBA, Shenzhen Demonstration Zone and Comprehensive Reform Pilot Projects. Shenzhen will take solid steps to promote carbon emission peaking and carbon neutrality with leading demonstration standards, develop action plans for climate change and carbon emission peak. Shenzhen will focus on promoting low-carbon development in energy, industry, construction, transportation and other fields. The city will strive to build a beautiful Chinese model of harmonious coexistence between man and nature, make "Shenzhen contributions" to the achievement of carbon emission peak and carbon neutrality in China, and provide "Shenzhen experience" for the implementation of the 2030 United Nations agenda for sustainable development. The specific plan as follow:

(1) Shenzhen will develop clean and low-carbon energy, strictly control coal consumption, improve the installed capacity of clean energy power generation, develop renewable energy such as offshore wind power and photovoltaic, and support the application of distributed energy based on hydrogen energy. By 2025, the installed proportion of clean power supply in the city will reach about 85%, and the proportion of non fossil energy consumption will reach about 40%.

(2) Shenzhen will further strengthen industrial carbon reduction and emission reduction, promote industrial energy conservation and efficiency improvement, upgrade the manufacturing industry, optimize energy consumption control in high energy consuming industries, build green data centers, and carry out green transformation of existing data centers. The city will develop about 100 national green parks, green supply chains and green factories by 2025.

(3) Shenzhen will develop green and low-carbon transportation, promote the integrated development of multi-level urban rail network, eliminate old transportation equipment with high energy consumption and high emissions, and promote the planning and construction of charging, hydrogenation and other

supporting facilities. By 2025, the number of new energy vehicles in the city will reach 1 million, the mileage of new railways and rail transit will be 415 kilometers, and the share of public transport in motorized travel during traffic peak hours will reach 70%.

(4) Shenzhen will continue to develop the green energy conservation of buildings, improve the star standard of new buildings, expand the application scale of prefabricated buildings, accelerate the transformation of existing public construction and residential buildings, improve the management level of building energy consumption, and increase the application of renewable energy technology in the field of public buildings. The city will increase 70 million square meters of green building area by 2025, and the proportion of prefabricated building area in the new building area will reach 50%.

(5) Shenzhen will promote the key work of combating with climate change, improve the carbon emission trading mechanism and pursue the development of near zero carbon emission demonstration projects. The city will also advance the reform of investment and financing mechanism on climate change, and carry out research on cutting-edge technologies of carbon capture, utilization and storage based on the carbon dioxide capture test platform of Huarun (Haifeng) Power Plant. Shenzhen will support key enterprises such as Huawei, Tencent and BYD to play the leading roles in carbon neutrality and drive energy conservation and carbon reduction in the industrial chains.

1.2 Green & Zero Carbon Development of City with Nuclear Resource and Industries

I. Zero Carbon Concept on Nuclear Industry

Haiyan County is in Jiaxing City, Zhejiang Province. As one of the earliest established counties in Zhejiang Province, Haiyan was founded in Qin Dynasty and got its name from the old saying of "the seashore is widely scattered, and the salt fields face each other". Haiyan is located in the northwest of Hangzhou Bay, 118 kilometers away from Shanghai and 98 kilometers away from Hangzhou. It governs 4 sub-districts and 5 towns, with a total land area of 584.96 square kilometers, a sea and river area of 537.90 square kilometers, and a permanent population of 450,000. Haiyan County has an average altitude of 3-4 meters. The whole terrain tilts from southeast to northwest. The south part of Haiyan is plain and hill, accounting for one third of the county. The western Haiyan is a plain area with waterways, accounting for about two-thirds of the county. Haiyan is located in the southern edge of the north subtropical zone, which is a typical East Asian monsoon climate. The annual average temperature of the county is 15.9 ℃, and the annual average accumulated days of high temperature are significantly lower than those in cities at the same latitude in the middle and lower reaches of the Yangtze River. Haiyan is also the location of Qinshan nuclear power station, the first commercial nuclear power station in Chinese Mainland. At present, Qinshan nuclear power plant has 9 operating units, which is the nuclear power plant with the richest reactor types in China and the largest power generation base in Zhejiang Province (see Figure 1).

With outstanding geographical conditions and rich agricultural products, the economy of Haiyan is developing rapidly. Under the concept of *Clear waters and green mountains are as valuable as mountains of gold and silver*, Haiyan vigorously learn from the experience of green development at home and abroad. In recent years, Haiyan carries out development strategy of net-zero, give full play to its advantages and complement its development weaknesses. Haiyan develops zero-carbon clean energy to promote high-quality economic and social development. The regional GDP of the whole county increased from 38.348 billion yuan to 54.451 billion yuan in five years. The per capita regional GDP of the permanent population in Haiyan reached US $17,300, higher than the average level of Zhejiang province. The county has been shortlisted as one of the Chinese top 100 counties in the comprehensive economy competitiveness for consecutive years.

II. Green Development Path of Nuclear Town

Through the development of national green ecological demonstration urban areas, Haiyan is developing photovoltaic projects, net-zero clean energy, energy conservation and green building pilot projects, and the demonstration of comprehensive utilization of nuclear energy. Haiyan is also accelerating the transformation and upgrading of green and low-carbon industries. Aiming at building a new zero carbon development model of "full-chain zero carbon in the beautiful county ", the county is promoting the coordinated development of economy, society and environment.

In this process, Haiyan adheres to the idea of exploring urban-rural integration and common prosperity with the concept of zero-carbon development. Through the development of a zero carbon energy supply system based on "nuclear energy + photovoltaic", the low-carbon industrial clusters characterized by nuclear related industries, and a model of urban-rural integration with the connotation of ecological zero carbon livability, Haiyan has formed a zero carbon development route based on integrated governance of cities, towns and villages.

Figure 1 Qinshan nuclear power plant

III. Practices on Green and Low Carbon Development

3.1 China-EU cooperation for development of green & low-carbon coastal city

3.1.1 Learn from the advancing experience of Europe to establish the keynote of green development.

In November 2013, Haiyan as the only county-level city among the first batch of 12 EU-China urbanization partnership cities in China, signed the *Letter of intent for EU China urbanization cooperation city project* with Sonderborg, Denmark. The signing ceremony was witnessed by Chinese Prime Minister Li Keqiang and then President Jose Manuel Durao Barroso of the European Union. Since the signing of the contract, Haiyan has actively carried out exchanges and visits with Sonderborg, continuously deepened liaison of projects and expanded cooperation in multiple fields.

In April, 2017, Haiyan officially established a sister city with Sonderborg. With the continuous expansion and deepening of cooperation in recent years, Haiyan is following the Belt and Road Initiative to expanded and deepened its cooperation with Danmark, Germany, France, Sweden and other countries, drawing on the experience of green, low-carbon and sustainable urban development in Europe. By learning from urban planning, construction concepts and service management of EU cities, Haiyan is exploring the coordinated development mode of urbanization and ecological environment.

In 2015, Haiyan developed and published China's first local standard for green development in counties - *Evaluation indicators for green development in counties*. This is an important tool to measure the capability of green development. Up to now, the *Haiyan green development annual report* has been published for seven consecutive years to summarize the practical experience and achievements of Haiyan on green development and guide the development in next stage.

3.1.2 Visualize the concept of zero carbon with a small "zero carbon house".

Figure 2 Haiyan "zero carbon house"

Through partnership with Sonderborg, Haiyan learned from its green development experience. As one of the initiator of zero carbon in China, Haiyan took the lead in building a "zero carbon house" in county-level cities in China (Figure 2) as a green science popularization and education base. Zero carbon house delivers the concept of low-carbon environmental protection to the whole society with six systems: smart light, efficient thermal insulation, smart air conditioning, recyclable reclaimed water and rainwater, wind and solar complementary power generation, and smart building management. It opened to the public at the end of 2015 for free, and has become an important place for teenagers to carry out scientific practice activities. It has science facilities such as exhibition hall, lecture hall and experience zone.

3.1.3 Promote industrial transformation and upgrading by recycling of resources.

(1) "Waste free cells" for the development of "waste free city". The development of "waste free city" is a major reform task for Haiyan in the field of ecological civilization. Focusing on the development goals of "no growth of waste production, no waste of resources, no shortage in facilities, no dumping of solid waste, no direct discharge of waste water, and no odor of waste gas", Haiyan carries out building a venous industry[7] functional area to improve the harmless, reduction, and recycling utilization of all kinds of solid waste. The Haiyan government focuses on promoting the developing of "waste free cells" such as "waste free factories", "waste free parks" and "waste free villages", so that the county can fully achieve "waste free". The government also implemented the *Plan for the development of "waste free city" in Haiyan County*, of which 37 indicators have been involved in the development of "waste free city", and 36 have been completed. There are 67 development tasks of "waste free city" in the plan, of which stage tasks have been completed in 100%.

(2) The "one enterprise, one policy" mode for accurate transformation. Based on the big data platform of "Heroes per mu" of Zhejiang, Haiyan studies and analyzes each enterprises, accurately verify the annual list of high consumption and low efficiency enterprises, and establish energy consumption record for all enterprises. According to the "transformation and upgrading, recycling and circulation, merger and reorganization, promotion to the industrial park, shutdown and elimination" methods, Haiyan classified rectification and implementation. In 2020, Haiyan completed five tasks to eliminate backward production capacity, and a total of 106 sets of backward equipment will be eliminated. For new construction, 27 small and micro enterprise parks and 4 digital small and micro parks have been built, among which the New Economy Industrial Park of Haiyan Development Zone and Chengchuang Innovation and Entrepreneurship Center in Tongyuan Town have been rated as the 2019 Zhejiang digital pilot park. A total of 836 enterprises (workshops) were renovated, of which 178 were shut down and eliminated, 520 were upgraded, 129 were integrated into the industrial park, and 2501.18 mu[8] of land was vacated. In 2019, Haiyan was rated as the advanced county in Zhejiang Province for eliminating backward production capacity.

3.2 Develop a zero carbon town with "nuclear energy + photovoltaic"

In 2015, Haiyan nuclear power town was included in the list of the first batch of provincial featured towns in Zhejiang. Based on Qinshan nuclear power plant, the town will accelerate the green and low-carbon transformation of the industry and develop a clean energy system based on "nuclear energy + photovoltaic". By constantly explore a zero carbon development model, Haiyan strive to promote the coordinated development of economy, society and environment.

3.2.1 Optimize the supply structure and develop green photovoltaic energy.

7 "Venous industry" refers to industries that turn solid industrial waste into reusable resources, which will then be used in production once again.
8 Mu: a unit of area (=0.0667 hectares)

In 2021, Haiyan was listed as a national pilot county for photovoltaic development. Taking the opportunity of the pilot program, Haiyan accelerated the development of photovoltaic projects and actively explored new models and application scenes for photovoltaic development in the following aspects:

(1)Haiyan carries out innovation in management system and mechanism. The county took the lead in planning and published the Pilot work plan for photovoltaic development in Haiyan County. Haiyan State-owned Assets Investment & Management Company provided a registered capital of 50 million yuan to establish the Haiyan Zero-carbon New Energy Technology Company. The new company is dedicated to carrying out the promotion of photovoltaic in the villages while accelerating the development of photovoltaic projects in the public sector. The running of the company will also provide new vitality into the village collective economy, and support zero carbon demonstration and common prosperity;

(2) Haiyan develops the model of "government guidance - market leadership - benefit for all". The government adheres to the principle of "reasonable construction as much as possible", vigorously attracts private capital and strengthen the development of industrial and commercial roofs. As per the mode, the enterprises and the government specify the construction of distributed photovoltaic power generation in the project investment agreement, and decide the photovoltaic installation area and capacity in the planning and design stage. As a necessary content of energy-saving review, the acceptance of grid connection shall be carried out synchronously during the project acceptance, and the development of photovoltaic shall be implemented as per specifications;

Figure 3 Haiyan photovoltaic project

(3) Haiyan is exploring the multi-scene application of clean energy. Photovoltaic street lamps, photovoltaic leisure trestles, photovoltaic corridors, photovoltaic charging piles and other service facilities are constructed in the county, which helps to expand zero carbon energy application scenes.

Haiyan has developed a "five minute clean energy life circle" based on these infrastructures. The county will further promote the integrated development of photovoltaic and tourism, vegetable greenhouses, fisheries, Chinese herbal medicine planting and other industries, and carry out the development of characteristic photovoltaic projects in the fields of Chinese herbal medicine planting, tourism, waste mines (see figure 3), so as to speed up in development of photovoltaic resource.

3.2.2 Promote consumption substitution and develop a clean energy system.

As the location of Qinshan nuclear power plant, Haiyan is taking the advantages of nuclear power to build a clean energy base. In December, 2021, the first nuclear heating demonstration project in southern China was successfully put into operation in Haiyan, which benefited 4,000 households with a total of 460,000 square meters of central heating area. Haiyan County was awarded the title of *Demonstration city of comprehensive utilization of nuclear energy in Zhejiang Province* approved by Chen Jinbiao, then the executive vice governor of Zhejiang Province (see Figure 4). Haiyan is developing nuclear heating for civil use and promoting the industries and agriculture sectors to replace the use of fossil energy to nuclear energy to achieve the goal of carbon emission reduction. At present, the pilot of nuclear heat for industry has started its implementation. After the completion of the project, it will focus on heating supply to industrial enterprises in the town such as Guanyu Lithium Battery Company, replacing the original fossil energy such as natural gas, achieving the goals of waste heat recycling and carbon emission reduction. The project is expected to become the first nuclear energy industrial heating demonstration project completed and put into operation in China.

Figure 4 Certificate of demonstration city of comprehensive utilization of nuclear energy in Zhejiang Province

In the following stage, Haiyan will further explore the application of nuclear waste heat in modern agriculture in the town. Through the development of demonstration projects in civil, industry, agriculture and other scenes, Haiyan will build a clean energy base and high-quality industrial clusters based on nuclear energy. Meanwhile, Haiyan is taking the power market reform as an opportunity, pursuing the green power supply mode in the town and achieving zero carbon emission of electric energy consumption by signing power purchase agreements, providing power purchase services, and

supporting the whole process of nuclear power supply.

3.2.3 Development of green industrial base

On December 26, 2020, Haiyan County and Qinshan Nuclear Power Plant signed a overall strategic cooperation agreement (see figure 5). This agreement is for development of a top-notching nuclear power industry town. Haiyan and Qinshan Nuclear Power Plant will focus on three nuclear power industries of nuclear power equipment manufacturing, nuclear power producer services, and nuclear power digital information industry, especially on following two aspects:

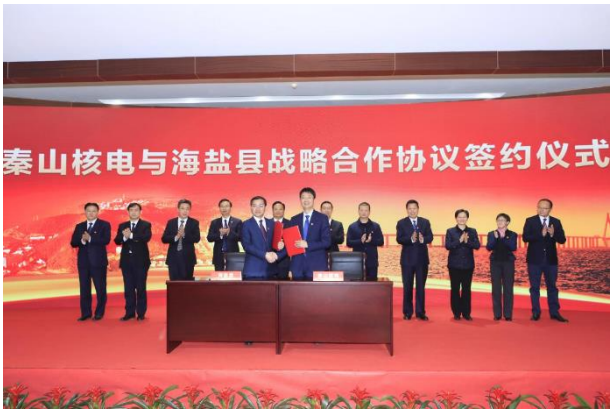

Figure 5 Signing ceremony of the comprehensive strategic cooperation agreement

Figure 6 China Nuclear Power City

(1) Haiyan is developing a demonstration of isotope industry. The heavy water reactors 2 in Qinshan Nuclear Power Plant is the only heavy water reactor nuclear power station for commercial use in China. By holding industrial and medical cobalt-60 large-scale production technology and other heap irradiation isotope production technology, Qinshan Nuclear Power Plant has significant advantages in isotope production. Based on nuclear power heavy water reactors, Haiyan focuses on building a nuclear technology application (isotope) industrial base, promoting the transfer of enterprises to the high end of the industrial value chain, and accelerating the development of a "Silicon Valley of nuclear medicine".

At present, the construction of the isotope industrial park covering an area of 1,500 mu has been started, and six nuclear technology application projects including isotope packaging and nuclear medicine industry have been signed and launched. Haiyan is striving to double the average industrial output value and industrial tax per mu of the town by 2025 .

(2) Haiyan government is guiding the development of nuclear industrial chain clusters. In2021, Haiyan government issued the Opinions on further supporting the development of nuclear power related and nuclear technology application industries. Haiyan established a nuclear industry fund of 1 billion yuan. Cooperating with Qinshan Nuclear Power Plant, Haiyan established China's first nuclear power industry alliance. In order to give full play to the industrial driving force of military enterprises in the nuclear industry system and actively expand the development of nuclear power related industries, Haiyan built a China Nuclear Power City and a military-civilian cooperation platform, dedicated to cultivating military-civilian integration industrial clusters (see figure 6).

3.3 Build a "zero carbon village" in Xueshuigang village with high standards and create a model of green common prosperity

Xueshuigang village is in the southeast of Tongyuan Town, Haiyan County. The village got its name because it is surrounded by mountains on three sides and a river passes through the village. Over the past 16 years, xueshuigang village practiced the concept of "green water and green mountains are golden mountains and silver mountains", adhered to the original intention and bravely competed to build a rural ecological community with the development of zero carbon village, committed to achieving economic, social and ecological benefits. (see figure 7).

Figure 7 Xueshuigang Village

(1) Xueshuigang achieve mutual benefits in all parties by "replacing firewood with electricity". The third *National agricultural general survey data report of China* shows that 45% of rural households are

still in the stage of using traditional high emission fuels such as firewood, straw and coal. Xueshuigang village once faced this dilemma. Firewood was piled up in front of and behind the house, and black smoke was constantly emitted from the chimney, which not only polluted the environment, but also had risks of fire hazards. In 2016, xueshuigang village launched the development of Beautiful Village project. In 2019, it started to develop an upgraded version of Beautiful Village. Xueshuigang village actively seeks a solution to the problem of burning firewood and straw. The Haiyan Power Supply Company of State Grid is promoting the newly developed product for replacing firewood with electricity in rural cooking stoves. The Xueshuigang village took this opportunity to installs electromagnetic stoves at the bottom of the original stoves in villagers' home. The installation project fully considered the use habits of local villagers, and did not change the original appearance of the local cooking stoves. The installation of electromagnetic stoves changed the traditional heating of firewood into electromagnetic heating, which is environmentally friendly and safe, and also protects the stove paintings. In order to prevent power failure, a portable energy storage generator "shared power storage" has also been developed as a backup power supply for the kitchen.

In this project, Haiyan government subsidize the purchase of "electric stoves", the power supply agencies guide the transformation and installation for residents. The village committee uniformly disposes of straw and firewood, and biomass manufacturers recycle straw and firewood on-site, so that villagers can enjoy multiple benefits.

(2) Haiyan lights up the road to a zero carbon village with photovoltaic power generation. In Xueshuigang village, photovoltaic street lights, photovoltaic leisure trestles, photovoltaic corridors and other service facilities can be seen everywhere, and a "zero carbon village" promotion zone has also been opened in the village hall. At present, Xueshuigang village has drawn a road map for the development of rural clean energy, with wind, solar and other clean energy. From the installation of solar photovoltaic panels by enterprises and farmers in the village, to photovoltaic street lamps, photovoltaic leisure trestles and photovoltaic corridors, the development of clean energy in Xueshuigang village is on the path.

Figure 8 Modern agricultural science and technology innovation park

(3) Xueshuigang village develops and expands the collective economy through industrial diversification. In 2011, Xueshuigang carried out the reform of share division of collective assets, established joint-stock economic cooperatives, and carried out the first batch of land circulation in the same year. In February 2019, Haiyan agricultural economic development zone was established in Tongyuan town. Xueshuigang village took advantage of this opportunity to introduce modern agricultural science and technology innovation park and other projects to facilitate the employment of villagers at their homes. In 2021, the land circulation rate of the village was 98%, and there were five family farms. Adhering to the guidance of standardization, greening, recycling, large-scale and digitalization, the village built a modern agricultural science and technology innovation park with high standards (see figure 8), increased the research and demonstration of high-quality and efficient core technologies and smart agricultural core technologies in grain, fruit, vegetable, fishery and other industries. For instance, the village developed high-value-added and high-quality fruit planting industries such as sunshine rose grape and red beauty citrus.

In addition, based on the concept of regional park and the standard of 3A scenic spot, Xueshuigang village improves supporting facilities to expand the industrial integration of "rural + cultural tourism". The village vigorously develop leisure and sightseeing agriculture, cultivate beautiful villages tourism routes, integrate high-quality fruit and vegetable resources, and launch brands such as "picking fruit every month" and "picking tour for fresh vegetables", so as to develop Xueshuigang village into a demonstration area of modern agriculture, an exhibition zone of smart agriculture, a pilot area of agricultural innovation and cultivation, and an experience area of agricultural civilization.

IV. Social and Economic Benefits

Through development of green carbon reduction projects, the air quality of Haiyan has reached the level II of Chinese national standard for two consecutive years, and the excellent air rate has ranked first in Jiaxing City for five consecutive year. In addition, Haiyan has won the title of Excellent County in the Development of Beautiful Zhejiang for four years. The other honors and titles are listed as follow:

National ecological civilization development demonstration county;
National ecological county;
National green ecological demonstration city;
National garden county;
National renewable energy building application demonstration county;
National county-wide photovoltaic development pilot county;
the first batch of China EU urbanization partnership demonstration zones;
Clean energy Demonstration County of Zhejiang;
Provincial excellent county of building energy conservation and green building.

4.1 Social benefits

4.1.1 Green education

As the extracurricular classroom for primary and middle school students in Haiyan, Haiyan "zero carbon house" has expanded the practical ways of energy conservation and low carbon popularization, which improved students' innovative and practical ability, and guide the whole society to for education of zero carbon. Zero carbon house holds all kinds of science exhibitions and technological activities all year round, and has won the titles of " Green practice education base", "Lifelong learning experience hall", "Jiaxing Science Education Base" and so on, becoming the window and portal to spread the concept of "zero carbon".

The Nuclear Power Science and Technology Museum (see figure 9) in the Nuclear Power Town is currently the largest nuclear power science popularization platform in China with the most advanced facilities and the richest public experience activities. The exhibition hall has received more than 170000 visitors in total.

Figure 9 Nuclear power science and technology museum

4.1.2 Development of industries to improve employment

By the end of 2021, 314 enterprises had launched in the town, and 96 nuclear power related enterprises had been successfully cultivated. The cumulative tax revenue exceeded 500 million yuan, the average tax revenue per mu was 431,100 yuan. The total output value of nuclear power related industries in the town reached 29.1 billion yuan, providing nearly 20000 employment. The nuclear power related enterprises has become an important part of the industrial economy of Haiyan, and has formed two complete industrial chains: the nuclear power construction & transportation industry chain and the whole process of nuclear power operation & maintenance industry chain. With 4 national (provincial) skill masters' studios, 3 provincial enterprise research institutes, 5 provincial technology centers, and 13 provincial research & development centers, The high-quality industrial development of nuclear power town is gradually emerging.

4.1.3 Develop a zero carbon village with common prosperity and beauty

Xueshuigang village actively guided the relocation and agglomeration of small and micro enterprises into small and micro industrial parks, introduced professional tutors to provide courses to villagers, and integrated folk experiences such as making rice wine, Qingtuan and sachet into the culture and tourism industry. A series of measures were explored to improve the kinetic energy of Rural Revitalization and the function of beautiful villages. With the help of digital energy conservation and carbon reduction, Xueshuigang is exploring the route to develop the local industries in a smart and green way. Furthermore, Xueshuigang village provide multiple energy services such as energy efficiency diagnosis and energy-saving transformation for rural residents, developing a zero carbon path of "beautiful village, rich residents, prosperous industry and harmonious people". The village has been successfully selected into the list of the first batch of pilot villages for Future Rural Development in Zhejiang Province.

4.2 Economic benefits

4.2.1 Industrial economic benefits

At present, 32 industrial enterprises above the designated size have launched in the town, achieving a total output of 1.774 billion yuan. In these enterprises, five service enterprises achieved a total output of 545 million yuan; five retail enterprises achieved a total output of 15 million yuan; 18 high-tech enterprises with a revenue of 1.848 billion yuan. In addition, 27 technology-based small and medium-sized enterprises achieved a a revenue of 1.808 billion yuan.

Some enterprises have gained extra benefits from the "green economy" by building roof distributed photovoltaic. Taking the 397.98kw distributed photovoltaic project of Zhejiang Chengmei Technology Company, which was connected to the grid at the end of 2021 as an example, 1060 tons of carbon emissions can be reduced every year. Through generating power for their own use, about 400000 yuan of electricity costs can be saved for enterprises.

4.2.2 Rural economic benefits

In 2021, the collective economic income of Xueshuigang village increased from 660000 yuan in 2006 to 2,456,900 yuan. The per capita income of farmers increased from 8,520 yuan in 2006 to more than 41,000 yuan, and the car ownership of 100 households increased from 20 in 2006 to 212.

Xueshuigang village has significantly reduced the consumption of firewood by promoting the conversion of firewood to electricity in 537 households, increasing the villagers' income by 138,900 yuan per year.

The collective economic income of Xueshuigang village increased by more than 2 million yuan through the reclamation of construction land. Through the development of cultural tourism, it attracts about 300,000 tourists every year, and the tourism income reaches 15million yuan. By guiding small and micro enterprises to relocate and build small and micro industrial parks, 7 large-scale enterprises have

launched in the village, with an annual output value of 300 million, providing over 90 job opportunities to villagers.

4.3 Environmental benefits

4.3.1 Energy construction layout to improve carbon emissions

In the past three years, with the continuous growth of nuclear energy and photovoltaic power generation, the average annual growth rate of carbon emissions in the nuclear power town is 3.85%, and the average annual decline of carbon emission intensity is 2.6%.

At present, the installed photovoltaic capacity in the nuclear power town has exceeded 20 MW, and the annual power generation is about 20 million kwh, equivalent to 11600 tons of carbon emission reduction per year. In addition, after the full completion of Haiyan nuclear heating demonstration project by 2025, the annual heat supply is expected to reach 1.7 million GJ, which means 58000 tons of standard coal can be saved every year. The corresponding emission reductions include 139000 tons of carbon dioxide, 4279 tons of sulfur dioxide and 2138 tons of nitrogen oxides. The benefits of energy conservation and carbon emission reduction are significant.

4.3.2 Environmental improvement and development of Beautiful Village

Under the policy incentives, Xueshuigang village reduced firewood consumption by about 8.53 tons and carbon emission by 15.64 tons by promoting the conversion of firewood to electricity, which increased the income of villagers and was selected as a typical case of Rural Revitalization in China.

Xueshuigang village vigorously promoted distributed photovoltaic projects, with a cumulative installed photovoltaic capacity of 16 MW, and an annual power generation of about 17.28 million kwh, equal to 16600 tons of carbon emission reduction. In 2022, it is planned to add 3 sets of wind power generation, with an annual power generation of 20000 kwh.

4.3.3 The green development indicators showed healthy growth

As per the *Evaluation indicators of green development in Haiyan county* and the Green Development Index (GDI) from 2018 to 2020, the green development of Haiyan is constantly improving (see table 1), showing a positive trend of development.

Table 1 Green development indicators of Haiyan

Fields	2018	2019	2020
Green production	202.68	205.32	286.77
Green life	151.00	167.88	135.64
Green ecology	105.20	111.28	128.98

V. Problems and Suggestions

5.1 Comprehensive management and supervision shall be further strengthened

The zero carbon development needs a comprehensive management system, involving many government departments and covering a wide range of fields. It requires not only the joint efforts of multiple government departments, but also the practice of social responsibility by enterprises and institutions, but also the recognition and participation of the majority of residents. Meanwhile, the capability and efficiency of administrative supervision also need to be further improved in order to treat zero carbon development as a long-term task.

5.2 Utilization of nuclear energy and industrial layout need to be further optimized

As a clean, safe and zero carbon energy, nuclear energy has significant advantages in energy conservation and emission reduction, and achieving the goal of carbon emission peak and carbon neutrality. Theoretically, nuclear energy can achieve multi-purpose supply of heating/cooling, hydrogen production, compressed air production and seawater desalination. However, the current nuclear heating demonstration project has not make full use of waste heat resources. For example, large quantities of thermal effluent used in the cooling system of nuclear reactors is directly discharged into the sea, and the heat has not been recycled.

The nuclear industries in the nuclear power town have made certain achievements, but on the whole, traditional manufacturing is still the main industry. The improvement of industrial quality, the elimination of unqualified enterprises and other special rectification actions need to be further strengthened.

5.3 Promotion and reproduction of Xueshuigang village

The experience of xueshuigang village provides a model for the zero carbon development path of nearby villages. However, each village has its own characteristics, simple replication of the xueshuigang village won't make sense. For example, Fengyi village in Qinshan Sub-district is close to a wasted mine. The village needs to find its own way on how to make good use of this resource and develop in their own way.

VI. Future Work Plans

6.1 Establish a long-term management mechanism for a zero carbon development

Under the guidance of the *Development plan for the economic and social development of Haiyan County and the outline of the long-term goals for the year 2035*, Haiyan will further improve the

efficiency of resource utilization, speed up the optimization of the energy structure, and develop a long-term management mechanism for the zero carbon development of the county. Haiyan will prepare the follow-up construction plan of the zero carbon development, continue to promote and consolidate the achievements, exchange experience on the mature models and achievements among cities, and accelerate the promotion and application of the pilot experience.

Meanwhile, Haiyan will integrate the management of the zero carbon development into the daily work of government and improve the cooperation & liaison between departments. Haiyan will strengthen the capability and efficiency of administrative supervision, and take multiple measures to promote zero carbon development in the whole region.

6.2 Expand comprehensive utilization of nuclear energy, and promote the quality and efficiency of industries

Relying on the nuclear heavy water reactor, Haiyan will vigorously develop the nuclear technology application (isotope) industry, and drive the upgrading, quality improvement and efficiency improvement of traditional industries in the region with isotope industry. Domestic and foreign enterprises on isotope products, nuclear drugs, new irradiation modified materials and irradiation devices will be introduced and launched in the county. Together with radiation therapy, health care and other service industries, Haiyan will build a national isotope industry demonstration base. In addition, Haiyan will continue to promote and develop nuclear heating demonstration projects, expand the scope of comprehensive utilization of nuclear energy, and focus on the application of nuclear heating in industrial, agricultural and other scenes.

6.3 Promote the experience of Xueshuigang village and build a "zero carbon village" zone

Regarding the characteristics of each village, the Haiyan government will help them to find a zero carbon path suitable for their own characteristics. Haiyan will make full use of land, water and other resources, innovate diversified photovoltaic development models, and focus on promoting eco-friendly "photovoltaic plus" projects. The government will accelerate the application of the new generation of information, science and technology in agriculture, and cultivate a "zero carbon village" zone in Haiyan based on the policy of "one village, one policy".

1.3 Regional Transformation Breaking the "Resource Curse"

I. Exploring the Path of Ecological Transformation

1.1 Basic information

Shanxi Province is a province of coal in China, accounting for more than one third of the country's coal resources. The development of resource-based cities in Shanxi has long depended on coal resources. As a typical resource-based economic region, Shanxi is in the critical period of transformation and development. Under the current situation of China's economic development, the transformation of resource-exhausted cities is an inevitable choice for social development. The smooth transformation and development of resource-exhausted cities is not only a process of transforming from a single mode of production to a diversified production structure, but also directly affects the development path of the country.

Xiaoyi is one of the first batch of resource-exhausted cities in Shanxi. Facing the dilemma of "resource curse", the city actively seeks change, breaks the "turning difficulties" of resource-based cities through innovation, takes industrial transformation and structural adjustment as the main direction of development, pursues green development, and achieves a transformation from "coal city" to "beautiful city".

1.2 About Xiaoyi

Xiaoyi is located in the central part of Shanxi Province, at the foot of Luliang Mountain, on the bank of Fenshui River, and on the southwest edge of Taiyuan Basin. It is a key city for the integrated development of urban cluster in the central basin of Shanxi Province. Xiaoyi has been rated as one of the top 100 counties (cities) in China for many times, and is at the top level of the county economy in Shanxi Province. The total area of the city is 937.57 square kilometers, with a total population of 477,000. There are 8 towns, 3 villages, 5 districts, 1 provincial economic development zone, 224 hamlets and 81 communities in Xiaoyi.

With a long city history, Xiaoyi also has profound culture. Guayan county (ancient Xiaoyi) was set up in 594 BC, with a history of more than 2600 years. It is one of the nine earliest counties in China. In

the first year of Zhenguan in the Tang Dynasty (A.D. 627), Zheng Xing, a resident of the county, was known to the court for his filial piety, and Taizong Emperor granted the name "Xiaoyi" (filial piety) to the county.

Xiaoyi enjoys superior location and convenient transportation. It is located in the gateway of Jinzhong and Luliang. It has always been the logistics hub of Shanxi and the transportation hub of western Shanxi. It is an important part of the core area of Shanxi merchants, and also the material distribution center of Luliang and Northern Shaanxi. It is 120 kilometers away from the provincial capital Taiyuan. The total mileage of the city's roads has reached 1725 kilometers, and it is accessible to the surrounding counties and cities in 15 minutes.

Xiaoyi is one of the first 50 key coal producing counties in China. Over the years, the rich mineral resources and the rapid development of coal coking industry have brought rich economic benefits, forming an industrial structure based on coal, coke and aluminum. The tax revenue of resource-based enterprises in the city once accounted for more than 70% of the total fiscal revenue. As a resource-based city, coal has brought a lot of wealth myths to Xiaoyi. Xiaoyi thrives on coal and is strong on coal. In 2001, there were more than 360 coal mines with complete "four license"[9] in Xiaoyi. Large and small coal mines were all over the mountain gullies of the city. While coal brings great economic benefits, it also brings serious pollution and ecological deterioration. Xiaoyi is thus labeled as "pollution city". In 2006, the Environmental Protection Bureau of Shanxi Province presented Xiaoyi with the province's first "yellow card" for regional approval restriction. Xiaoyi, which ranked first in the province in terms of economic output and entered the top 100 counties (cities) of the country for the first time, was cancelled for the reward by provincial government.

Figure 1 Xiaoyi City

In March 2009, the State Council of China identified the second batch of 32 resource-exhausted cities,

9 Mining license, Coal safety production license, Coal production license, Mine manager qualification certificate

Xiaoyi was among the list. The list was formulated as per following procedures: first, determine the list of resource-based cities; second, select resource-exhausted cities according to the reserve indicator, and finally determine the rank according to the resource reserves, financial and economic indicators.

Table 1 List of resource-exhausted cities

Batches	No	List of resource-exhausted cities
1	12	Fuxin, Yichun, Liaoyuan, Baishan, Panjing, Shizuishan, Baiyin, Gejiu, Jiaozuo, Pingxiang, Daye, Daxing'anling
2	32	Zaozhuang, Huangshi, Huaibei, Tongling, Qitaihe, Wansheng, Fushun, Tongchuan, Jingdezhen, Tongren, Yumen, Qianjiang, Lingbao, Heshan, Leiyang, Lengshuijiang, Beipiao, Shulan, Huaying, Jiutai, Zixing, Zhongxiang, **Xiaoyi**, Wudalianchi, A'ersha, Dunhua, Yangjiazhangzi Development Zone of Huludao, Yingshouyingzi Mining Zone of Chengde, Nanpiao District of Huludao, Dongchuan District of Kunming, Gongchangling District of Liaoyang, Xiahuayuan District of Zhangjiakou
3	25	Jingxing Mining Zone, Huozhou, Wuhai, Shiguai, Erdaojiang, Wangqing, Hegang, Shuangyashan, Jiawang, Xinyu, Dayu, Xintai, Zichuan, Puyang, Songzi, Lianyuan, Changning, Shaoguan, Pinggui, Changjiang, Nanchuan, Luzhou, Yimen, Tongguan, Honggu

1.3 Ideas on transformation from resource dependence to green and low carbon

The policy makers of Xiaoyi have realized in practice that it cannot be a long-term plan to relying too much on resources for development, and it is also not a wise choice to completely abandon the existing industries. In the process of transformation and development, the abundant coal resources can be directly used for the rational transformation of capital, technology and projects, so as to realize the multiple expansion of resource advantages. In 1998, Xiaoyi took the lead in raising the banner of economic restructuring in Shanxi Province, cultivated two industrial chains of coal coking and coal-electricity-aluminum, and established three industrial groups of coal-electricity, coking and aluminum industry. In 2002, Xiaoyi shut down all the traditional coke ovens. In 2003, Xiaoyi took the lead in ending the production of modified coke in Shanxi. In 2008, Xiaoyi launched the economic transformation strategy of a resource-based city, completely closed down the coal mines with small scale, low technology and production capacity. Focusing on the goal of building a "world-class coal chemical base"and construction of 13 modern coal mines with an average production capacity of more than 900000 tons, the coal mining in Xiaoyi entered the "Time of big mining".

Since 2001, the sustainable development of resource-based cities with the transformation of resource-exhausted cities as a breakthrough has achieved initial outcomes. The policy system has been improved, the working mechanism has been initially established, and the economic and social development of resource-exhausted cities has regained vitality and vigor. According to the *Chinese national plan for sustainable development of resource-based cities (2013-2020)*, resource-based cities are classified according to their resource guarantee capability and economic and social sustainable development ability. Resource-based cities are divided into four types: growth, mature, recession and regeneration.

The development direction and key tasks of different types of cities are clarified, and various cities are guided to explore their own development modes. Xiaoyi is listed as one of the 23 regenerative cities.

Table 2 List of regenerative cities in China

Regenerative cities	
prefecture-level administrative area	Tangshan, Baotou, Anshan, Panjing, Huludao, Tonghua, Xuzhou, Suqian, Ma'anshan, Zibo, Linyi, Luoyang, Nanyang, A'ba, Lijiang, Zhangye
County-level city	**Xiaoyi**, Dashiqiao, Longkou, Laizhou
County	Anyang, Yunyang, Shangri-la

II. Measures for industrial transformation and ecological development

As early as 2002, Xiaoyi put forward the idea of resource-based city transformation. In 2012, Xiaoyi took the lead in preparing and completing a series of pilot action plans such as the *Pilot action plan for comprehensive transformation of Xiaoyi* at the city and county levels of Shanxi, and was the first to obtain approval, becoming a model for other pilot counties and cities. Through many years of exploration, Xiaoyi has embarked on a green, low-carbon, diversified, efficient and smart transformation path of resource-exhausted cities. It has taken a series of measures from the optimization and upgrading of traditional industries, the construction of modern industrial parks, urban modernization, and the promotion of employment and entrepreneurship. In recent years, Xiaoyi is integrating its development advantages and national policies to focus on building several major industrial clusters, promoting the urban sustainable development and industrial upgrading under the carbon emission peak and carbon neutrality goal, and making efforts to build a national first-class green modern coal and coke chemical base. In 2022, Xiaoyi was awarded by the Shanxi provincial government as the pilot of comprehensive transformation and traction integrated reform in the province.

2.1 Green high-tech modern industrial construction

(1) Modern coal chemical industry cluster

Figure 2 Coal-electricity-aluminum-material integrated industrial cluster

Xiaoyi modern new coal chemical industry park is listed as one of the four coking concentrated development areas in Shanxi Province. The city's existing coking capacity is 18.67 million tons, accounting for 13% of Shanxi and 50% of Luliang. On the basis of the formed industrial capacity of 18.67 million tons of large machine coke, supporting dry quenching and waste heat power generation, Xiaoyi will extend the development of high-end products in the fields of photovoltaic, military industry and aviation, such as olefin, nylon series, carbon fiber and engineering plastics, and build the world's largest production base of 500,000 tons of degradable plastics to create a national first-class modern coal chemical new material industrial park.

(2) Coal-electricity-aluminum-material integrated industrial cluster

Adhering to the high-end guidance and cluster development, Xiaoyi promotes the transformation and upgrading of the aluminum industry, and successively implement six aluminum oxide projects including Xing'an and Xinfa. At present, the aluminum oxide production capacity has reached 8.7 million tons, accounting for 56.9% of Luliang and 33.7% of Shanxi Province. Xiaoyi has been included in the aluminum industry cluster in the central part of Shanxi, focusing on the extension and development of new aluminum based powder materials, aluminum profiles, high-quality magnesium alloys and so on. Xiaoyi is actively developing aluminum magnesium alloys for aviation, aluminum for automobiles, aluminum die-casting products and other high-end products to foster a aluminum magnesium new material industrial cluster of national competitiveness.

(3) Agricultural deep processing industrial cluster

Xiaoyi developed ten characteristic agricultural industries such as walnut, livestock and poultry, and agriculture facilities, launched a large number of agricultural product processing projects, cultivate and develop agricultural leading enterprises, developed six characteristic industrial chains of livestock and poultry, walnut, corn, Baijiu, small grains, and medicinal tea. Xiaoyi havs developed more than 280 products, 33 of which have filled the domestic gap.

(4) High-tech industrial cluster

Taking strategic emerging industries such as new energy, big data and new materials as the main direction of development, Xiaoyi is actively introducing domestic advanced high-tech industrial projects. The 30MW photovoltaic power generation project and the 30MW distributed wind power generation project were completed and on grid. New breakthroughs were also made in the three emerging industries of hydrogen energy, new materials and Baijiu. The 20,000 ton hydrogen production project of Pengwan hydrogen port was completed to production. Two hydrogenation integrated energy stations were built. Xiaoyi is developing an equipment manufacturing base for 300,000 hydrogen energy vehicles. The Phase I project of 20,000 heavy trucks, 3,500 hydrogen fuel electric reactors and hydrogen power systems is under development. The Phase I of Ruituofeng biodegradable polyester

project was completed and put into operation and the carbon based new material industry was further consolidated. The 20,000 ton original liquor base project of Fenqing distillery is located in Xiaoyi Economic Development Zone, which promotes the revitalization and development of Baijiu industry.

Meanwhile, Xiaoyi aims at specialization and innovation, give full play to the subjective initiative of enterprises, and release the source of vitality through innovation. Xiaoyi has established a technological innovation system with enterprises as the main body, universities and scientific research parks working together and integrating industry, university, research and application. The city has developed 6 innovation and entrepreneurship carriers, 18 innovation capacity platforms, 7 high-tech enterprises, 1 national level "small giant" of special and new technology enterprise, 5 provincial-level "specialized and new" small and medium-sized enterprises, 1 provincial-level smart manufacturing demonstration enterprise, 1 industrial product green design demonstration enterprise, 5 green factories, 1 provincial science and technology enterprise and 3 studios. Multiple measures were take to motivate the innovation enthusiasm and creativity of the scientific and technological workers in the region.

(5) Modern service industry cluster

Efforts were made to promote the trade industry to take the road of refinement, characteristics and branding. Wanda Plaza, Walmart, Huamei Xintiandi, Yiwu Eommercial Expo City, Xiguan Shopping Plaza and other business complexes were put into operation, and more than 50 Chinese first-line brands such as Yonghui and Wanda were launched. Xiaoyi promoted the deep integration of cultural and tourism industry, implemented leisure tourism projects such as Dream Sea and Caoxi River, and created four National 4A level tourist attractions. The total tourism revenue has increased by more than 20% for many consecutive years. Xiaoyi has deeply explored scarce tourism resources, launched three research and tourism routes of wine culture and vinegar culture, coal chemical industry and intangible cultural heritage culture, and successfully created 7 provincial-level rural tourism demonstration sites and 2 provincial-level 3A level rural tourism demonstration villages. With these achievements, Xiaoyi has won the honorary titles of *National cultural advanced city* and *Shanxi provincial leisure agriculture and rural tourism demonstration county*.

2.2 Measures on ecological environment improvement

While promoting industrial cluster and urbanization, Xiaoyi has also effectively promoted ecological improvement.

(1) Implementation of ecological governance

With the implementation of national "Three North" project, Tianbao afforestation project and the project of returning farmland to forest and dry fruit economic forest, Xiaoyi is strengthening the ecological governance and restoration around the mining area and other ecologically vulnerable areas. 3000 mu of land has been under the ecological governance. Focusing on the green belts on both sides of urban

suburbs, towns and villages, national highways, provincial highways and municipal and township roads, Xiaoyi has carried out supplementary planting, construction, management and protection, effectively enhanced the greening quality of the roads, and improved the greening of the roads by 50000 mu. For developing the urban landscape, Xiaoyi has implement the construction of large parks and shelter forests around the city, and speed up the greening of urban roads, street gardens, and courtyards. In recent years, a total of 25 new and reconstructed roads and urban landscape greening have been completed. The green coverage area of the city's built-up area is 11.74 square kilometers, the green area is 10.21 square kilometers, the park green area is 2.89 square kilometers, the coverage rate is 43.8%, and the green rate is 38.1%, forming a modern urban garden pattern of "transparent green space system, excellent and comfortable environment, and distinct cultural characteristics".

(2) Implementation of comprehensive treatment project of coal mining subsidence area

The residents affected by coal mining subsidence areas were relocated and resettled, and the relocated villages were subject to all-round geological disaster treatment and ecological restoration. The coal resource of the villages was released, and the resource income provided a financial guarantee for the local ecological restoration and new rural construction, which effectively promoted the ecological improvement. Xiaoyi protects and restores the geological environment of mining mountain areas. At present, Fenxixinyang, Xinyu, Xinliu and Liliu companies have carried out ecological restoration and treatment projects according to the *Ecological environment restoration and treatment plan of mining mountain areas*. There are 32 treatment projects in total, 28 projects have been completed, and 4 projects are under treatment construction. The ecological environment assessment quarterly report system has been carried out. Xiaoyi formulated and completed the *Ecological environment damage control plan for non coal mine mountains* to further promote the ecological environment function evaluation.

Figure 3 Ecological transformation in Xiaoyi

III. Industrial Transformation and Upgrading

3.1 Development of hydrogen energy industry

(1) Low-carbon transformation of key enterprises

After more than 20 years, especially in the past five years, the transformation of the coke industry in Xiaoyi has been successfully achieved in accordance with the industrial structure layout of "simultaneous development of coking and focusing on chemical industry" and the concept of innovation leading, high-end industry and circular development. In 2022, the key enterprises in the regional integrate industries including raw coal mining, clean coal washing, coke smelting, methanol, LNG, synthetic ammonia production, hydrogen energy and big data industrial development to develop key enterprises in the whole industrial chain with digital smartness, recycling and green concepts, forming a leading advantage in practicing the carbon emission peak and carbon neutrality goals.

In recent years, focusing on the goal of green and low-carbon development, Xiaoyi has accelerated the transformation of the traditional coal and coke industry into an innovative, high-end intensive and green environment-friendly type by planning and building a number of key enterprises. With the successful commissioning of phase I 20,000 t/a coke oven gas hydrogen production project, it marks that Xiaoyi has taken a solid step in strengthening and extending the industrial chain, and has achieved a magnificent turn from the traditional coal coke industry to the new energy hydrogen production industry.

(2) Development of emerging strategic pillar industries

After nearly three years of innovation and development, Xiaoyi has taken the hydrogen energy industry as an emerging strategic core industry, and has initially achieved phased outcomes. While the phase I of the 20,000 t/a coke oven gas hydrogen production project is completed to production, hydrogen energy storage and transportation, hydrogen energy equipment manufacturing and hydrogen energy application are simultaneously promoted. The phase I of the hydrogen fuel cell vehicle manufacturing project with an annual output of 30,000 vehicles has been launched. The purchase order of 100 hydrogen fuel heavy truck tractors, 5 hydrogen fuel hazardous chemical transport vehicles, 5 hydrogen fuel commuter buses, and 2 hydrogen fuel reception minibuses will initially form a new pattern of development of the whole industrial chain of gas-station-transportation-vehicle.

Focusing on the goal of building a pioneer for the Northen China hydrogen energy industry base, Xiaoyi is deeply participated into the hydrogen energy development plan of "one body, two wings, three ports and four chains" of Luliang city, and fully builds the whole industrial chain of gas-station-transportation-vehicle. For hydrogen production, 200,000 t/a coke oven gas hydrogen production and photovoltaic power generation electrolytic hydrogen production projects will be implemented. By 2025, the scale of hydrogen production will reach 100,000 t/a. For hydrogenation station, Xiaoyi will build

four energy stations integrating LNG, refueling, hydrogenation and charging. For storage and transportation, based on the existing technologies, Xiaoyi will carry out development of high-pressure hydrogen storage, pure hydrogen pipeline transportation and key equipment. Multiple hydrogen storage and transportation systems such as gas storage and transportation, liquid storage and transportation and solid storage and transportation will be established. With above work, the whole vehicle production and application scenes will be realized. From 2022 to 2030, the production line of 300,000 vehicles/year will be built in three phases, supporting 15,000 sets/year hydrogen fuel power reactors and 10000 sets/year hydrogen fuel power and other hydrogen energy equipment manufacturing projects.

3.2 Green development against white pollution

Biodegradable plastic is a kind of fully biodegradable material with great development potential and is easy to modify. It is suitable for making various disposable film materials, such as packaging bags, shopping bags, garbage bags, express bags, plastic films and food packaging. It is widely used in the downstream of industrial chain. In recent years, with the implementation of national plastic restriction policy, Xiaoyi has actively distributed the degradable plastic industry, successfully cultivated the leading enterprises in the industry, and advanced the green and high-quality development.

PBAT phase II project (annual output of 2×60000 tons of biodegradable plastic) is one of the representative projects of new material industry in Xiaoyi. At present, the project has entered the stage of equipment commissioning and trial production. After completion, it will become the largest bio-degradation base in North China and the only enterprise of similar products in the province and the world. The fully biodegradable packaging bag produced by the project can be decomposed into carbon dioxide, water and organic fertilizer within 180 days. It is the best product to effectively solve the white pollution at present and has a broad market prospect.

3.3 High-quality development of coking industry

Coking industry, one of the core industries of Xiaoyi, has become a synonym for pollution due to extensive development. In the face of the severe situation of environmental protection and energy consumption constraints, Xiaoyi has implemented the concept of green and low-carbon development, followed the advanced technology of the industry, accelerated the implementation of the transformation of dry quenching technology in the coking industry, and led the transformation and upgrading of the coking industry in Shanxi.

Dry coke quenching is a coke quenching method that uses inert gas to cool the red coke. The coke quenching process is operated in a closed space. Compared with the traditional wet coke quenching, it has a significant effect on reducing the total energy consumption of the coking industry, saving resources and reducing environmental pollution. Taking the dry coking quenching project of the current

key enterprise as an example, it can dry quench 2.6 million tons/year, the waste heat of red coke can produce 1.6 million tons/year of high-temperature and high-pressure steam, generate 376 million kwh/year of power, and increase the annual output value by more than 200 million yuan. With the dry quenching, the coking cost can be reduced by about 10%, the water content of coke can be reduced by about 8%, and the steam containing harmful substances can be reduced by about 1.3 million tons/year. It can replace the corresponding coal-fired and gas-fired boilers, saving energy and reducing pollutant emissions.

Up to 2022, among the 8 coking enterprises in Xiaoyi, 6 have been put into operation, and the remaining 2 are under construction. By the end of 2022, all coking enterprises in Xiaoyi will complete the transformation and upgrading of dry coke quenching, and fully enter the time of dry coke quenching. It is estimated that 2.2 billion kwh of waste heat power generation can be increased annually, and the new output value is more than 2 billion yuan. The economic, ecological and environmental benefits are obvious.

IV. Achievements in Transformation and Development

Through a series of transformation and development, Xiaoyi has been transformed from a resource-exhausted city with serious pollution into a green low-carbon city with beautiful ecology and suitable for living and working, and has achieved great social benefits for sustainable development.

Figure 4　Green Xiaoyi

Xiaoyi is dedicated to business promotion, inclusiveness and openness. A good investment and business environment, coupled with a significantly improved ecological environment year by year, has opened up a broad path for a virtuous circle of sustainable development for Xiaoyi. In 2021, it ranked 77th among the top 100 counties and cities with comprehensive strength in China, and was the only county level city in Shanxi. Meanwhile, Xiaoyi ranks 28th among the top 100 counties and cities with investment potential and 89th among the top 100 counties and cities of scientific and technological

innovation.

Xiaohe National Wetland Park, Shengxi Lake Forest Park, Jinlong mountain scenic area and Sanhuang Temple scenic area have been rated as national 4A scenic spots, and the establishment of 5A scenic spots is being vigorously promoted. Xiaoyi was rated as the county with basically balanced development of compulsory education in China. As a key incentive and support county for national public hospital reform, Xiaoyi was commended by the State Council of China, and the medical treatment rate in the city reached more than 90%.

In the process of achieving positive outcomes in transformation and development, Xiaoyi has won the titles of *National ecological civilization advanced city*, *National garden city*, *National health city*, *National greening model city*, *National safe construction advanced city*, *National cultural advanced city*, *National science popularization demonstration city*, and *National civilized city*.

V. Problems and Suggestions

5.1 It is difficult to change the status of coal as the main energy

Shanxi Province is an important energy base in China. In terms of industrial structure, Xiaoyi and Shanxi have the same industrial structure that both the secondary industry and heavy industry account for a high proportion. In terms of energy consumption structure, Xiaoyi and even Shanxi's economic development still rely heavily on coal. Coal consumption still occupies a dominant position in energy consumption The development of renewable energy power such as photovoltaic power generation is difficult to support the effective transformation of energy structure. At present, the high energy consumption industries in Xiaoyi have a far greater pull on carbon emissions than on GDP and industrial added value. There are still some difficulties in the adjustment of such high-carbon energy and industrial structure. With the increase of energy structure adjustment, and due to the constraints of resource endowment, economy, technology and other factors, the substitution of renewable energy for coal is still weak in the short term.

5.2 The shortage of relevant indicators restricts the extension of the industrial chain and high-quality development

Due to the high concentration of coking, alumina and other industries in Xiaoyi, there are not enough energy consumption plans for new projects. Restrictive indicators such as coal consumption and environmental capacity limit the extension and high-quality development of these industrial chain projects. The actual circumstance of special industrial assembling development areas, including the development dilemma of Xiaoyi should be fully considered, and the energy consumption, emissions, water consumption and other indicators of the city should be decomposed and allocated.

5.3 The scientific and technological innovation foundation is difficult to support and control the demand for greenhouse gas emission reduction

Carbon dioxide emission reduction is a long-term and arduous task. In the near future, Xiaoyi can carry out the work through development of the internal emission reduction potential of enterprises and focusing on energy consumption optimization, production and energy conservation, development and utilization of clean energy. However, to achieve long-term and effective emission reduction, Xiaoyi need more means of carbon dioxide emission reduction and utilization, that is, "post-treatment" technology. Therefore, it is necessary to arrange the research and development of carbon emission reduction and utilization technologies as soon as possible. The city should make full preparations for emission reduction technologies and schemes, improve the core competitiveness of enterprises while fulfilling the national requirements, promote the low-carbon transformation of enterprises, and advocate the sustainable development of enterprises.

IV. Future Plan for Low Carbon Transformation

6.1 Industrial upgrading and development for the carbon neutrality goals

Focusing on the strategic goal of carbon emission peak and carbon neutrality, Xiaoyi will implement the "two-wheel drive" strategy of upgrading traditional industries and cultivating and expanding emerging industries, and accelerate the development of a green and low-carbon modern industrial system.

(1) In terms of new material industry, Xiaoyi will further research on carbon based new materials and accelerate the development of degradable plastics, antibacterial agents, carbon fibers, graphene and other industries.

(2) In the pharmaceutical industry, Xiaoyi will promote Luliang Traditional Chinese Medicine Factory to move into Gaoyang Modern Agricultural Park to fill the gap in the pharmaceutical industry of Xiaoyi.

(3) Xiaoyi will guide and promote consumption, and actively cultivate digital consumption, health consumption, green consumption and service consumption among residents.

(4) Xiaoyi will develop modern logistics industry and fully support mature logistics enterprises such as Logistics Warehousing Center to create national modern service industry cluster. Xiaoyi will also accelerate the development of rural delivery logistics, make up for the shortcomings of rural delivery logistics infrastructure, and ensure the full coverage of delivery logistics in hamlets within 2022.

6.2 Ecological development for a beautiful Xiaoyi

Xiaoyi will dedicated to tackling key problems of ecological and environmental protection, taking good ecology as the "green engine" for accelerating transformation, providing more high-quality ecological products for residents and constantly build a beautiful Xiaoyi.

(1) Xiaoyi will promote the ecological protection and high-quality development of the Yellow River Basin to achieve high-quality and high-level coordination of the city's economy, society and ecology.

(2) Xiaoyi will promote carbon emission peak and carbon neutrality. An action plan for peaking carbon dioxide emissions by 2030 was formulated. We will implement the goal of dual control of energy and energy consumption. We will focus on promoting energy efficiency in the six traditional high energy consuming industries, including power, coking, building materials, steel, nonferrous metals and chemical industry, and resolutely reduce and eliminate backward production capacity.

(3) Xiaoyi will continue to fight against pollution. The pollution in the city will be under control from the source, and Xiaoyi will also promote the "one license" supervision of pollutant discharge permits for fixed pollution sources. Xiaoyi will continue to advance the treatment of black and odorous water bodies in cities, and promote the designation of centralized drinking water source protection zones. Xiaoyi will strengthen soil pollution control and remediation, and strictly prevent and control soil pollution sources. The institutionalization of the "two positive lists" of environmental assessment approval and supervision and law enforcement will be consolidated.

(4) Xiaoyi will further promote scientific pollution management. The city will carry out coordinated control of multiple pollutants, accelerate the management of mobile source pollution, and establish a grid management and refined control mechanism for ecological environment protection. Xiaoyi will also consolidate the management of mountains, forests, fields, lakes and grasses, implement the "forest manager system", make full use of advanced technology, continue to carry out artificial afforestation, close mountains for afforestation, restore wetlands and lakes, and constantly enhance the regeneration capacity of environmental resources.

Chapter 2 Community

2.1 Carbon Neutrality and Sustainable Development of Sino-Singapore Tianjin Eco-city

I. Developing Circular Ecology with Green Buildings

1.1 Background

Since its launching in 2008, Sino-Singapore Tianjin Eco-city (SSTEC) has taken green building as an important part of the top-level design of urban development. After more than ten years of development, SSTEC has made excellent achievements in green building. According to the research of the overall action plan of carbon emission peak and carbon neutrality of SSTEC, green building is an important starting point and way for SSTEC to implement China's "3060" strategy[10].

The development of green building in SSTEC has been highly praised by Chinese national ministries, Tianjin City and Binhai New Zone, consecutively won the honors and certificates as follow:

C21 international sustainable development cities and communities solution award

National green development demonstration zone

National green ecological urban area

National green building demonstration base

Green building base of northern China

National demonstration city of renewable energy building

Three-star transportation management certificate for national green ecological urban area

Three-star design certificate for national green ecological urban area

1.2 Significance of implementation

SSTEC is a landmark cooperation project between China and Singapore in the development of ecological city, which shows the determination of the two countries to combat with global climate change, strengthen environmental protection, and save resources and energy. The development of SSTEC is a significant demonstration of developing an ecological city with limited resource, and it provides a model for the sustainable development of other cities.

[10] At the general debate of the 75th session of the United Nations General Assembly in September last year, China announced that it would aim to achieve peak CO_2 emissions before 2030 and carbon neutrality before 2060.

SSTEC is fully implementing the dual development strategies of "upgrading of eco-city" and "innovation of smart city". While carrying out the piloting of Chinese national green development demonstration zone, SSTEC is advancing the development of a low-carbon and recycling green building system, leading the regional green and low-carbon development with comprehensive standards, and supporting the high-level environmental protection and high-quality economic development of SSTEC.

1.3 Innovative ideas

"100% green building" is the initiative aim since the beginning of planning and construction of SSTEC. The implementation of the green building development strategy is an indispensable means for SSTEC to achieve successful development. The development of a comprehensive management system of green buildings is a decisive and important process for SSTEC to achieve its original aspiration - to build a fantastic, eco-friendly and livable new city.

1.4 Implementation objectives

SSTEC always adhere to the thought of ecological civilization as its guide. While deepening the development of low-carbon city, waste-free city, sponge city and resilient city on the concept of sustainable development, SSTEC strives to make continuous upgrading for the city, and provide a demonstration for development of a resource-saving and environment-friendly society.

Under the guidance of the 2.0 indicator system, SSTEC will further promote the full process management of green buildings, continue to develop standards on green buildings, accelerate the promotion and application of new technologies of green buildings such as passive buildings, near zero energy consumption, zero energy consumption buildings, and promote the upgrading of technical standards and the industrialization of technology application system. SSTEC is also exploring ways to improve the efficiency of building energy consumption to ensure the development goal of 100% green buildings. By 2035, SSTEC will increase the proportion of renewable energy from 20% to 32%, which is the same as the EU target for the same period. At the same time, SSTEC will increase the carbon emission intensity per unit of GDP from 150 tons of CO_2 per million US dollars to 100 tons of CO_2 per million US dollars.

II. Plan for Innovative Development

2.1 Technical proposal

Top-level designing	Architectural designing	Construction	Completion acceptance	Operation and maintenance
Full process management system on green building				
Policy innovation on full process verification of green building				

SSTEC indicator system	Application of green building technology	Green finance	Development of information platform
Recyclable resource planning			Promotion of demonstration

Figure 1 Route map of SSTEC's full process management system on green building

2.2 Overview

2.2.1 Standardization development of full process management system on green building

On the basis of developed standards, regulations and guidelines, SSTEC developed standards such as *Guideline for green building evaluation in SSTEC*, *Designing standard for green building in SSTEC*, *Guideline for designing of green building in SSTEC*, *Regulations on management of green construction technology in SSTEC*, *Guideline for operation and management of green building in SSTEC, Guideline for development of smart community in SSTEC, Completion acceptance standard for green building in SSTEC.* These standards have formed a full process system through top-level planning, architectural design, construction, completion acceptance, operation and maintenance, and vigorously promoted the all-round development of green buildings in SSTEC. In 2017, SSTEC was awarded as the first city in China where the evaluation standards of green buildings can benchmark with Chinese national standards.

Planning	Designing	Construction	Completion	Operation
DB/T29-195-2016 Guideline for designing of green building in SSTEC				
DB/T29-192-2016 Guideline for green building evaluation in SSTEC		DB/T29-198-2016 Regulations on management of green construction technology in SSTEC		Guideline for operation and management of green building in SSTEC
		Completion acceptance standard for green building in SSTEC (under development)		

Figure 2 Diagram of SSTEC's full process management system on green building

On the whole process of top-level planning, architectural designing, construction, completion acceptance and operation and maintenance, SSTEC strictly follows the standards, regulations, guidelines and approval procedures on construction of green buildings. Integrating the existing indicator system of eco-city, renewable energy planning, green building technology, green finance and other means, SSTEC has developed a full process management system on green building.

2.2.2 Planning for renewable energy

SSTEC carried out a special plan for renewable energy. By optimizing the renewable energy structure, innovating the forms of development and utilization, and improving the supply and operation mode, SSTEC established a safe, efficient and sustainable comprehensive renewable energy utilization system based on solar energy, geothermal energy, wind energy and biomass energy.

In terms of photovoltaic power generation, the total installed capacity is 11.69 mw, and the annual cumulative power generation is 12.726 million kwh. In the field of utilization on light and heat, the solar water heating system covers all residential areas in SSTEC, with a guarantee rate of 80%. The cumulative installed area of solar water heater collectors is 111,000 m², which can save 38% of household electricity throughout the year. In terms of geothermal energy utilization, 32 ground source heat pump projects have been completed, with an application area of more than 1.2 million m². As for wind power, the Jiyunhekou wind farm project has been completed, with an installed capacity of 4.5 mw and an annual power generation of 3.351 million kwh. For biomass energy, the construction of kitchen waste, catering waste, sewage treatment plant sludge treatment system and related supporting facilities has been launched. It is estimated that the waste treatment capacity is about 100 tons per day, and the output of biogas is about 4,738 m³ per day. In 2020, the utilization rate of renewable energy in SSTEC has reached 15%, which is in the leading level in China.

2.2.3 Application of green building technology

(1) Demonstration and application of zero energy consumption building

SSTEC zero energy consumption cabin project is the first zero energy consumption building in Tianjin, with a construction area of 135 m². The project applies a variety of technologies such as photovoltaic building integration, zero energy consumption building operation system management platform, new building materials and AC/DC micro-grid distribution system. The energy consumption level of the building is reduced by more than 85% compared with the Chinese national standard. While fulfilling its usage as apartment, it can also provide the surplus electricity to the grid and become a regional distributed power supplier.

The zero energy consumption renovation project of the SSTEC Real Estate Registration Service Center is the first zero energy consumption renovation project of SSTEC, with a construction area of 3,467 m². With systematic and smart improvement on the existing projects, the project has formed the demonstration of the zero energy consumption building technology system of "green production capacity, flexible energy storage, energy consumption as per demand, smart energy control, high efficiency and energy conservation". The zero energy consumption renovation project of the SSTEC Real Estate Registration Service Center has won the three-star certificate of the Chinese national green building design and the first prize of Chinese Green Building Innovation Award, realizing the demonstration and upgrading from a zero carbon cabin to a zero carbon building. It is estimated that the renovated SSTEC Real Estate Registration Service Center can save 172000 kwh of electricity every year, the energy self-sufficiency rate can reach 112%, and the annual carbon dioxide emission can be reduced by 329 tons, equivalent to planting 3,000 trees, which is a significant environmental benefits. In June 2021, Tianjin Low Carbon Development Research Center awarded the Zero Carbon Building

Medal to SSTEC Real Estate Registration Service Center, which is also the first zero carbon building demonstration project in Tianjin.

The fourth community center of SSTEC is the first "zero carbon" community commercial project in Tianjin. The center adheres to the low-carbon path from design to construction and operation, and widely uses building energy-saving technology. According to the *Guideline for green building evaluation in SSTEC*, the center has reaches the silver medal level of green building design, and the carbon emission generated in the operation of the project is lower than that of other buildings of the same scale. In February 2022, the fourth community center of SSTEC obtained the Carbon Neutrality Certificate issued by Tianjin Emission Rights Exchange Center.

(2) Demonstration and application of ultra-low energy consumption building

The ultra-low energy consumption public apartments phase II project is the first high-rise ultra-low energy consumption residential project in Tianjin. This project has won the certification from the Passive Housing Institute (PHI) in Germany, China's ultra-low energy consumption buildings, and the platinum certification of SSTEC green buildings. Based on the implementation of the project, SSTEC has issued the *Guideline for the design of ultra low energy consumption residential buildings in SSTEC* and the *Technical specifications for the construction of ultra low energy consumption residential buildings in SSTEC.* These two standards is developed to guide and promote the construction and implementation of ultra-low energy consumption buildings. At present, 14900 m² of passive ultra-low energy consumption buildings have been built in SSTEC, the energy-saving rate can reach 90%, providing a demonstration and model for reducing urban building energy consumption.

(3) Demonstration and application of wood structure building and prefabricated building project

On the premise of meeting the national and municipal requirements on for prefabricated buildings, SSTEC has carried out relevant study on prefabricated buildings, and is working on demonstration projects of wood structure buildings and modular buildings.

With regard to the wood structure building, SSTEC adopted the cutting edge technology and concept of Canada in low-carbon ecological city, and built and developed the Fengshuyuan project. This project covers an area of 4.7 hectares and a construction area of about 56000 m², of which all low-rise buildings adopt wood structure technology. The Fengshuyuan project, with the aim of low-carbon and environmental protection, is an important practice to develop resource-saving buildings.

The modular building demonstration center in SSTEC covers a land area of 116 m² and a building area

of 221.58 m². The center is composed of six standardized box modules. This project highly integrates various green technologies, and all the standardized boxes are produced and installed in the factory then assembled on site within three days. The building of modular building demonstration center achieved energy conservation and environmental protection in the construction process.

2.2.4 Development of information platform

In order to ensure the applicability of the operation and maintenance system, SSTEC has developed an urban solar energy water heating system monitoring platform, a comprehensive energy management platform and a green building energy consumption monitoring platform, which fully covers residential and public construction projects in the urban area. The monitoring platform of solar energy water heating system can supervise the operation and energy consumption of system in real time, which is an important point for energy conservation and emission reduction. The platform is equipped with small meteorological stations located in SSTEC to provide local indicator information and meteorological parameters. Meanwhile, the platform can collect and analyze data at the project level and single system level. It has a complete calculation and alarm function module to cooperate with the on-site inspection work to form a real-time continuous tracking of project operation and ensure the effect of professional operation and maintenance. The green building energy consumption monitoring platform can track the energy consumption of public construction projects, master the energy consumption characteristics of public construction projects in SSTEC, find energy consumption problems in time, and explore the energy consumption potential. SSTEC builds a green building energy consumption monitoring platform to achieve the collection of regional conventional energy and renewable energy data, and carries out regular project evaluation based on actual data to improve the overall energy consumption efficiency of the whole region.

2.3 Development of indicator system of SSTEC

Since the initial stage of construction, SSTEC has creatively designed the world's first eco-city indicator system, which was jointly developed by experts from China and Singapore and implemented after being approved by the Ministry of Housing and Urban-rural Development of China and the Ministry of National Development of Singapore. In the 2008 version of indicator system 1.0, 22 quantitative indicators were established, of which 6 indicators are directly related to carbon neutrality as follow:

(1) proportion of green buildings;

(2) proportion of green travel;

(3) wast recycling rate;

(4) proportion of renewable energy;

(5) utilization rate of non-traditional water resources;

(6) carbon emission intensity per unit of GDP.

In order to follow the progress of city development, SSTEC organized a group of experts from China and Singapore to prepare and complete the upgraded indicator system 2.0 according to the evaluation results and research progress in 2018, which was officially approved by the Ministry of Housing and Urban-rural Development of China in 2020. In the field of carbon neutrality, the intensity indicator of heat island effect in city was added to the indicator system, and the original six indicators are all retained and the standards are all strictly enforced.

The SSTEC indicator system can help to meet the requirements of carbon neutrality practice in the city, promote sustainable and high-quality development, and assist to top-level design for the development of green buildings.

III. Experience and Practice

3.1 Innovation of green building full process approval system

In 2010, SSTEC formulated the *Interim Provisions on the Management of Green Buildings in SSTEC*. Integrated with the existing planning and approval process, SSTEC formed a full process approval process for green buildings covering planning, operation and maintenance, This process, transforming management of green buildings from post declaration to pre-presentation, approval control, process supervision and post evaluation, which helps city management to reach all indicators of green buildings, realize electronic examination and approval, and step up the implementation of the development strategy on smart city innovation.

3.2 Development of green finance

SSTEC actively explores the route to promote the high-quality development of green buildings. Based on the local circumstance, SSTEC formulated the design idea of "one main insurance + n additional insurance" for the performance liability insurance of green buildings in the region. The insurance has passed the review and filing of the China Banking and Insurance Regulatory Commission and has become the first green insurance product in Tianjin. In November 2021, SSTEC Jianbin Real Estate Development Company signed an insurance agreement with the Tianjin Tanggu Branch of the People's Insurance Company of China on the Lanhaijinyu project. The insurance for this project is not only the first green building performance liability insurance in Tianjin, but also the first residential green building performance liability insurance combining main insurance and additional insurance in China.

In order to further improve the proportion of high star green building projects in the SSTEC, the management of SSTEC resolutely implements the *Incentives for green buildings and passive buildings*

in Tianjin Binhai New Area. This incentive plan advocates an energy-saving and low-carbon lifestyle, and encourage all relevant companies to actively participate in the construction of green buildings in SSTEC. At present, SSTEC has completed the pilot work of building area award for four projects, which plays an important role in promoting the high-quality development of green buildings in Binhai New Area[11].

3.3 Publicity and promotion of demonstration achievements

SSTEC has successively hosted the Youth Competition on "Ecological imagination & Green action" for Environmental Protection for 10 years, and has participated in the International Conference on Green Building and the China Building Science Conference for many times. In these activities, the development and construction experience of SSTEC, together with the green ecological development concepts, was successfully shared to all participants.

In order to demonstrate the progressiveness and high-end development of green buildings in SSTEC, the city management has published the *SSTEC Green Building White Paper 2020-2021*. The book focuses on the development of SSTEC on green building in the past ten years, summarizes the achievements of SSTEC on green building from 2020 to 2021, introduces innovative cases made by SSTEC, and expounds the future prospect of SSTEC on green buildings under the background of carbon neutrality.

IV. Economic and Sustainable Benefits

4.1 Green economic benefits

The proportion of green buildings in SSTEC is 100%. By 2021, SSTEC has built a total of 20.488 million m² of green building projects and 379 green buildings. 125 projects with a total construction area of 7.43 million m² awarded Chinese National Green Building Certificate, including 63 three-star projects, accounting for 50.4%.

From 2020 to 2021, 30 new green building projects with National Green Building Certificate launched in SSTEC, including 16 three-star and 14 two-star projects. The "SSTEC 12-year school" project won the first batch of three-star certificate of the national standard for green buildings, and it is also the only approved project in northern China.

[11] SSTEC is located in Binhai New Area of Tianjin.

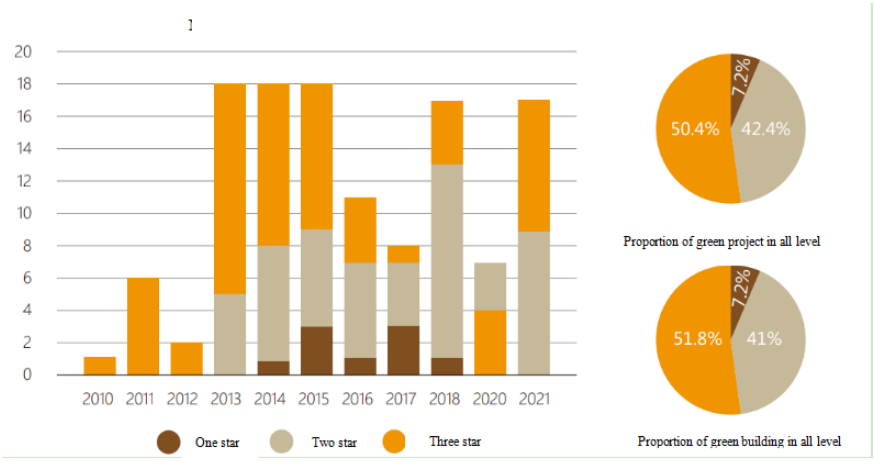

Figure 3 New green building projects by year in SSTEC

4.2 Environmental benefits

According to statistics, there were 77 public building projects in operation in SSTEC in 2019, with a total consumption of 131million kwh of electricity, 193500 GJ of heat and 4.693 million m³ of natural gas. In 2020, 77 public building projects were in operation in SSTEC, consuming 119 million kwh of electricity, 161300 GJ of heat and 3.352 million m³ of natural gas.

Through the investigation of public buildings in SSTEC, it is found that the average energy consumption of various types of buildings in 2020 showed a downward trend compared with that in 2019, and the energy consumption of individual projects increased slightly due to the expansion of business scale and the increase of users. SSTEC has paid great attention to building operation and maintenance for many years, The average energy consumption of buildings has been reduced by developing relevant energy-saving requirements, technical standards and specifications, evaluating the operation effect, and promoting the improvement of the project management.

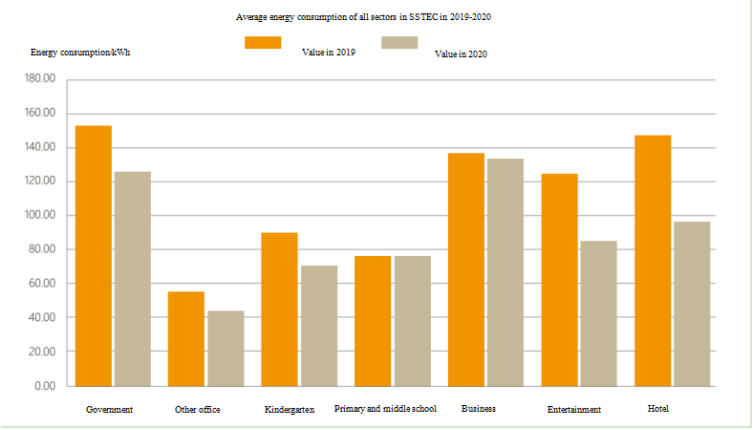

Figure 4 Average energy consumption of all sectors in SSTEC in 2019-2020

4.3 Sustainable development benefits

Focusing on the practice of carbon neutrality, sustainability and high-quality development, SSTEC actively participates in Chinese and international pilot demonstration projects, and vigorously contributes its own experience cases. Since 2017, SSTEC has participated in the development of six international standards, among which the ISO37106 *Sustainable development and communities guide to establishing strategies for smart cities and communities* has just been published at the end of October 2021, which can provide city developers with guidance for the implementation of smart city strategy and promote urban sustainable development. The relevant work has been highly recognized by the International Organization for Standardization (ISO).

In addition, SSTEC National Grid Customer Service Center North Base (phase I) won the "International Special Nomination Award for Green Building Solutions" in the eighth C21 international "Green Solutions Award" in November 2021. By wining the award, this project promotes the concept of people-oriented and environment-friendly green, healthy, smart low-carbon buildings and ecological urban areas, and provide excellent and practical experience that can be adopted and implemented in development of other ecological cities.

V. Future Work Plans

5.1 Promote the application of high standard green building technology

According to the municipal development plan of Binhai New Area, SSTEC should achieve the target of building 500,000 m² of ultra-low energy consumption buildings by 2025. To achieve this goal, SSTEC encourages the development of composed pilots on PEDF[12], ultra low energy consumption[13] + three stars green building, near zero energy consumption[14] + three stars green building[15] and zero energy consumption[16]+three stars green building. By using zero carbon building technology, SSTEC has incubated demonstration projects such as zero carbon building + zero carbon community, Zero carbon building + zero carbon park and zero carbon building + zero carbon island. These projects are playing a leading role in the implementation of high-standard green building construction in Binhai New Area. Through studying and summarizing the experience of green building, the Green Building Technology Library of SSTEC has been established.

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[12] PEDF: the abbreviation of the four technologies of solar photovoltaic, energy storage, direct current and flexibility.
[13] Ultra low energy consumption: the level of building energy consumption is reduced by more than 50% compared with indicators in the relevant Chinese national standards and industrial standards.
[14] Near zero energy consumption: the level of building energy consumption is reduced by more than 60-75% compared with relevant national standards and industrial standards.
[15] Three stars green building: green building three stars. According to the *Evaluation standard for green buildings* (GB/T 50378-2019), green buildings are divided into four levels: basic, one star, two star and three star, which mainly evaluate five indicators: safety and durability, health and comfort, convenience of life, resource conservation and livable environment.
[16] Zero energy consumption: the annual energy supply of renewable energy is greater than or equal to the total energy consumption of the building in the whole year.

5.2 Further develop the renewable energy system

SSTEC will use the Internet, big data and other information-based means to strengthen the collection, sorting, analysis and feedback of building information, promote the deep integration of green buildings and renewable energy systems with interconnected information, and achieve refined development. In the future, SSTEC will further expand renewable energy application scenes, increase the proportion of non fossil energy in total consumption, achieve sustainable and healthy development, and carry out the implementation route and scheme for the development of renewable energy and green buildings in SSTEC.

5.3 Consolidate management of green buildings and elevate urban soft power

In the next stage, SSTEC will continue to implement the incentive policies on development of green buildings, guide and encourage more social capital to invest in the development of green buildings through government subsidies, plot ratio incentives, green finance and other forms, These policies will help to enhance the sense of social gain and happiness of enterprises and residents, promote quality and efficiency of green buildings, benefit people's livelihood, and improve the city's soft power.

2.2 Carbon Neutrality Experimental Community with Biosphere Concept

I. Concept of Carbon Neutrality Community

1.1 Significance of implementation

Vanke Center in Dameisha launched a green and low-carbon upgrading and transformation project in September 2021. With this project, Vanke dedicated to responding to the strategic goal of Chinese national carbon emission peak and carbon neutrality and the action plan of Dameisha carbon neutrality demonstration area in Meisha Sub-district, Yantian District, Shenzhen. This construction project consists of office, exhibition and activity area. Integrated with the future industrial development positioning and cultural and tourism supporting facilities of Dameisha community, through the technical iteration of the project itself, fully considering the functions of industrial investment attraction, innovation incubation, project visits and industrial activities, the Vanke Center in Dameisha will be developed into a cultural exchange platform and technological innovation platform for urban carbon neutrality communities.

Figure 1 Vanke Center in Dameisha

1.2 Innovative ideas

In the first phase of the project, a development and operation framework is cultivated from seven dimensions: clean energy, green building, low-carbon transportation, resource recycling, biodiversity, carbon asset management, lifestyle advocacy. The project proposes the concept of "carbon neutrality community" to develop it with business partners, park users, and community residents.

In terms of technological transformation, the project adheres to the concept of climate friendly design

and low impact development. The facilities and equipment of the existing buildings are comprehensively evaluated and maintained. Through energy audit, the project will implement energy consumption diagnosis and operation carbon emission verification, and then formulate practical energy conservation and carbon reduction strategies and implementation paths, including building energy conservation transformation and renewable energy utilization, roof ecological garden transformation, smart operation and maintenance system construction, reduction of hidden carbon emissions, practice and display of innovative technologies.

Regarding the operation and management, the project establishes a carbon emission management system and a carbon asset management system. A green and low-carbon property management mode and a zero waste park management mode is developed for operation of activities in carbon neutrality community.

1.3 Implementation objectives

The project will achieve a comprehensive energy-saving rate of 83% and a carbon reduction rate of 92% in the operation process (compared with the base year data). Carbon neutrality of the project will be achieved through technological transformation combined with multiple paths of operation management, continuous and rigorous carbon emission management in the operation process, a small amount of green power procurement and carbon sink development of the projects. Through the application of a series of green building technologies with demonstrative significance, Vanke can publicize and promote the concept of sustainable development and enhance people's awareness of environmental protection.

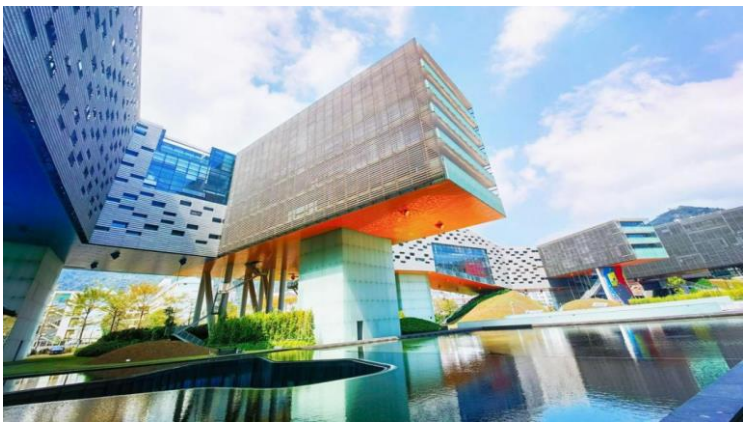

Figure 2 Vanke Center in Dameisha

As the first office building to obtain LEED platinum certificate in China, Vanke Center will further apply for LEED OM platinum certificate, LEED Net Zero Waste certificate, Three-star Green Building certificate and Near Zero Energy Consumption Building certificate of the Chinese Ministry of Housing and Urban-rural Development.

II. Development Contents and Characteristics

2.1 Main contents of development

2.1.1 Utilize the existing buildings through comprehensive evaluation and in-depth maintenance

The first phase of the project, which is planned to be completed in October 2022, is positioned as a science and innovation office park with the theme industries of life and health, carbon neutrality technology and sports technology. In the future, through the integration of the resources within the park and surrounding areas, a series of activities around the theme industries will be held, such as Dameisha Carbon Neutrality International Forum, Carbon Neutral Community Innovation Plan, rock climbing competition, water sports and so on.

(1) Building energy conservation transformation and renewable energy utilization:

The project improves energy efficiency through energy-saving measures such as reconstruction of high-efficiency machine room and lighting system. The photovoltaic power generation system is optimized on this basis, so as to improve the proportion of renewable energy.

(2) Reconstruction of ecological garden on roof:

While creating an experimental scene for the biodiversity of the park, the project explores the design concept of integration of architecture, landscape and energy.

(3) Development of smart operation and maintenance system:

The project develops an energy management system on Internet of things and Clouding, This system can help achieve the traceability, disclosure, analysis and application of energy data, and promote the operation and maintenance goal of "reducing carbon emissions, optimizing operation performance and improving user experience".

(4) Reduce implied carbon emissions:

The project advocates the concept of resource recycling. In the project, professional companies help to recycle some dismantled materials and equipment. The project uses system to calculate the implied carbon emission of newly purchased materials & equipment and construction process.

(5) Practice and display of innovative technology:

The project introduces innovative technologies such as micro-grid, PEDF, and 3D printing of recycled materials to provide occasions of technology application for supply chain partners and help the development of the industry.

2.1.2 Establish a low-carbon management operation and maintenance system to ensure the sustainable

development of the community

Technological transformation provides green and low-carbon infrastructure for the park, and operation management is an important support for realizing the sustainable development of the park and creating a better life for park users and community residents.

(1) Foster a carbon emission management system:

The project develops carbon emission management strategies, carries out standardized and digital management of carbon emission data in the park in the three stages of development, construction and operation, and open relevant data to users in park.

(2) Cultivate a carbon asset management system:

Through carbon indicator development business, the project helps the enterprises launched in the park to achieve carbon neutrality.

(3) Management of green & low-carbon property :

The demonstration project of green and low-carbon property management is co-developed by Vanke and Wanwulianghang, the management of the park.

(4) Management of zero waste park:

Led by the community member Vanke public welfare fund, the project will continue to carry out programs such as zero waste office, black soldier fly kitchen waste treatment, organic composting, and jointly develop the zero waste Park demonstration project.

(5) Operation of carbon neutral community activities:

The project organizes project visits, industry exchanges, innovation incubators, community open days, large international forums and other activities to publicize and promote the concept of green and low carbon development.

2.2 Functional features

The first phase of the project is a pioneer demonstration project on green & near zero carbon community with education as its main function and integrating innovation incubation, exhibition, conference exchange and other functions.

2.3 Technical indicators

Function and area		Building energy consumption indicator	
Total building area	15789 ㎡	Energy consumption indicator per unit area (design value)	66kwh/ ㎡
Among them, square meters of headquarters office		Energy-saving rate	28.64% (220%)

Shared office		comprehensive energy-saving rate	82.96% (260%)
		Reduce carbon emissions	851tCO_2e (compared to the base year)
		Carbon reduction rate	91.6% (≥ 40%)

2.4 Specific methods

2.4.1 Carbon sink

(1) Local plant landscape to maximize ecological benefits

In terms of landscape, Vanke Center strives to restore the original ecosystem in the site to the greatest extent and obtain the best ecological benefits by maximizing the application of local plant species with low water consumption and maintenance needs, so as to form a carbon sink landscape with local characteristics. The circling architectural design of the anti-tsunami of Vanke Center has created a porous microclimate and a landscape green space with free shade. Among them, the 52000 square meter tropical landscape design plan includes complex and diverse spaces, activities and plants. Some kinds of grass seeds in the original site are sown on the hills in the landscape park. Without artificial intervention such as fertilization, watering and pruning, it is completely in a wild state. Most of the garden plants in the whole landscape are drought tolerant species with low maintenance need. Various measures are imposed for the landscape, such as shallow vegetation ditches, infiltration ditches, and biological retention. These measures are used to reduce rainwater erosion, maintain the local water and soil environment and reduce irrigation water.

(2) Recycling of organic waste

The use of black soldier fly (Hermetia illucens L.) to treat kitchen waste can not only effectively realize the reduction, harmlessness and recycling of waste, but also have a significant greenhouse gas emission reduction effect through carbon capture and utilization. Larvae of black soldier fly mainly feed on kitchen waste, which can efficiently convert kitchen waste into their own nutrients, and such larvae can inhibit the reproduction of housefly adults and avoid environmental health problems. In addition, the mature larvae after treatment of kitchen waste are rich in lauric acid, antibacterial peptides and other substances, which can be used as high protein feed for poultry and fish. The odorless black soldier fly dung formed from kitchen waste after treatment by the insects can be directly used as organic fertilizer.

The greenhouse gas accounting of black soldier fly's treatment of kitchen waste applies the method of life cycle assessment, including the generation of waste, the pretreatment of kitchen waste, the cultivation and transportation of black soldier fly, the stage of black soldier fly's treatment of waste, the stage of product collection, and the stage of product utilization. Using black soldier fly to treat kitchen waste can realize on-site treatment and organic transformation of kitchen waste in the community.

The black soldier fly treatment station in the park has been normalized. The kitchen waste supplied to the black soldier fly mainly comes from the restaurant, and the daily amount of kitchen waste is about

2-3 barrels (100-120kg), which can be used for the normal operation of the black soldier fly treatment station. From the kitchen waste produced in the restaurant, to the kitchen waste feeding larvae of black soldier fly, from the black soldier fly dung as organic compost to nourish plants, and then to the insect body as feed to organisms. As a practical application of small-scale biological treatment technology of organic waste, the station has formed an organic cycle chain with composting and soil return in the park and community co-developed garden.

The kitchen waste in the office area of the building is composted through the small composting box and the experimental station of the earthworm tower on the outer stairs of the fourth floor. The materials in the composting box have been anaerobic. The resident personnel take out all the materials for ventilation and aeration, and the viscosity of the compost body is reduced after ventilation.

2.4.2 Carbon Asset Management

During the transformation and later operation and maintenance of the project, a carbon asset management system will be established. Among them, based on the working methods and carbon reduction of building energy conservation transformation and organic waste recycling (black soldier fly), relevant methodologies will be developed demonstratively, and VCS carbon emission indicators will be applied through Verra system. In the future, carbon sink trading will be carried out in a more efficient and transparent way with the help of blockchain technology.

2.4.3 Other technical fields

(1) Building energy saving technology:

A. Building energy conservation transformation: transformation of high efficiency machine room and lighting system to improve energy efficiency;

B. Utilization of renewable energy : Roof solar photovoltaic panels are deployed;

C. Reconstruction of roof ecological garden: while creating an experimental scene for the biodiversity of the park, the project explores the design concept of organic integration of architecture, landscape and energy. Using the dehumidification and cooling functions of the solar system, a sun shading roof landscape is formed through a special "roof parasol";

D. Electric sunshade system, double-layer glass curtain wall with hollow plated Low-E glass[17] and heat break bridge aluminum alloy window frame: porous louvers provide the main sunshade effect when closed. They can reduce the solar energy heat collection by 70% under the maximum sunlight, and still provide 15% light transmittance through the holes;

E. Natural ventilation: the louvers have a double-layer appearance, in which the hollow part of the gap can produce a convective chimney effect, cold air flows in from the bottom of the building, and then hot air is discharged through the top of the building near the roof;

[17] Along with the arising of general public's concern about environmental issues,Low-E glass has received the attention both at home and abroad because of its high-efficient energy-conservation and low radiation.

F. Water recycling system: Vanke Center forms a rich three-dimensional landscape through sinking courtyards, green spaces, water and wetlands, and creates a sustainable water environment system closely integrated with landscape design. The optimal design of rainwater, reclaimed water and landscape water is achieved by using rainwater resources with good water quality and using reclaimed water resources as a supplement;

G. Water saving measures: Vanke Center adopts the most advanced water-saving appliances to reduce the consumption of tap water and pipes;

H. Fresh air floor supply VAV system: the air supply outlets of all air conditioners in the building are hidden in the floor. The air sent out from the ceiling must be covered to a height of at least 2.5 meters, and it only needs to cover about 18 meters from the floor for people to feel comfortable;

I. Permeable climate public space: according to the principle of adjusting measures to local conditions, Vanke Center makes full use of the characteristics of local wind direction to make the main facade of the building intersect with the dominant wind direction, which is conducive to increasing the pressure difference on the windward side of the building and creating a good indoor ventilation environment. The bottom layer is raised, which can adjust the local microclimate.

(2) Classified waste carbon reduction strategy:

In the project, all recyclables are recycled, including collecting all receivables, enriching recycled products, introducing social enterprises, promoting circular economy, establishing recycling banks, flea markets, and advocating the concept of resource regeneration.Organic waste is treated with biological resources, decentralized in-situ composting, black soldier fly pilot test, and community garden soil improvement. For the reduction of other garbage from the source, on the one hand, the management of project should strengthen the advocacy of residents on the accuracy of garbage classification, on the other hand, he management should strengthen the advocacy on the reduction of domestic garbage from the source.

III. Experience and Practice

3.1 Technological innovation

3.1.1 Structural design

With the idea of "Build a house like a bridge", Vanke Center is constructed with a maximum connected span of 50m and a cantilever of 25m. Vanke Center interprets the architectural design concept with its unique "hybrid frame + cable structure system", which not only provides a broad vision for the use space, but also achieves "greening the public" to the greatest extent: if counting on the greening of the roof, the greening rate of the whole site is greater than 100%.

3.1.2 Micro-grid system

Vanke Center is the first commercial construction project using Schneider micro-grid system in China. The building load power consumption and renewable energy power generation in the next 24 hours are predicted by the model, and the load is scheduled by multi-objective strategy through the algorithm, so as to realize the peak cut of the daily power consumption curve and improve the renewable energy consumption rate. It can directly reduce the carbon emission of operation and the cost of municipal electricity.

The project will use the local energy storage of the building, dispatch the air conditioning load, and improve the consumption rate of renewable energy. Meanwhile, the project will actively participate in power grid demand side response and virtual power plant transactions in the medium and long term.

3.1.3 PEDF demonstration area

This project will be developed with the integration of PEDF[18] and prefabricated wood structure technology to create a zero carbon cabin operating in the energy micro-grid scene.

3.1.4 Regeneration and localization of materials

(1) Renewable and localization

Vanke Center uses a large number of Chinese local traditional building materials - bamboo, instead of wood, for the production of concrete formwork, wall decoration and furniture;

(2) Cradle to cradle products

InterfaceFLOR carpet is used in the open office area of Vanke Center, which is made of recycled materials, thus the damaged and worn carpet can be recycled by the manufacturer for the production of other products;

(3) Health care

All paints, wooden poles and adhesives used in the decoration of Vanke Center do not contain or only contain a small amount of volatile organic compounds (VOC, such as formaldehyde), and sunshade materials do not contain VOC.

3.1.5 Organic composting of landscape plants

The Vanke Fublic Welfare Fund as community user carries out composting in the community and invite the professor workstation of China Agricultural University to conduct on-site research and technical

[18] PEDF is the abbreviation of the application of four technologies in the construction field: photovoltaic, energy storage, direct current and flexibility.
PEDF is an important pillar for the development of zero carbon energy, which is conducive to the direct consumption of wind and solar power.
What flexibility should solve is the collaborative relationship between the municipal power supply, distributed photovoltaic, energy storage and building energy consumption.

guidance. Together with the black soldier fly station, composting demonstration area, community garden and roof garden, a circulated operation of organic composting is formed, which also provides an excellent place for public science popularization and staff leisure.

The resident technicians are familiar with the garbage generation and circulation chain in the park, and optimize the facilities and technology of the composting points in the park. The optimization is carried out mainly by adjusting the proportion of composting raw materials, and using the recycling compost method developed by the research team from China Agricultural University to promote composting. The maximum temperature of composting is nearly 80 ℃ (previously not more than 45 ℃), which helps to improve the decomposition process. Meanwhile, the temperature is recorded every day and samples are collected for tracking analysis, which is used to make the operation guidance manual of composting points in the park.

3.2 Industrial optimization

The project industry investment attraction takes the basic industrial resources and future industrial planning of Dameisha community as the foothold, and introduces the industrial resources of Biosphere III in the field of carbon neutrality, so as to create a carbon neutrality industry innovation community with theme, diversification and high value as the core. At present, the users who have checked in include enterprises, scientific research institutions, public welfare organizations, and industries involving life technology, environmental protection, cultural tourism, and so on. Leading enterprises such as MGI Tech, Vanke Agriculture, small and medium-sized enterprises such as Deep Dive and Shenshi Zero Carbon Tech, well-known scientific research institutions such as the professor workstation of organic recycling of China Agricultural University, and public welfare institutions such as Vanke Public Welfare Fund has launched in the center.

IV. Implementation and Effectiveness

4.1 Green economic benefits

(1) The project reduces the operation cost of building energy. By adopting advanced technical measures, the comprehensive energy-saving rate of Vanke Center phase I can reach 82.96% compared with that before the transformation, and the annual electricity cost can be saved by about 1 million yuan;

(2) The project increases revenue from building energy operation. By cooperating with a third party to invest in rooftop photovoltaic power stations, the project will earn about 170000 yuan a year;

(3) The project promotes the transformation of industrial structure. Listed enterprises, professor workstations and other enterprises and institutions are attracted to launch in the center. This brings fresh industrial vitality into the region. On the one hand, it improves the rental income, on the other hand, it

also enlivens the catering, accommodation and other service supporting facilities inside and around the project.

4.2 Environmental benefits

4.2.1 Energy saving and carbon reduction

The 1400 square meter photovoltaic panel installed on the roof of the building has a verified solar power generation of 266.7 TWH, which can provide about 12.5% of the power requirements of the entire Vanke Headquarters every year. The utilization rate of renewable energy has increased from 18% to 82%. Through energy conservation and emission reduction measures, the annual carbon dioxide emissions will be reduced by 851 tCO_2e.

4.2.2 Biodiversity

The concept of natural integration is fully considered in different stages of design, construction and operation, so as to minimize the impact of human activities on the environment and organisms. For example, measures such as building glass curtain walls with anti bird impact films effectively ensure the stability of the number and species of birds. Landscape adopts local plants as much as possible to maintain local species diversity. Meanwhile, natural experiments on urban farms in the roof garden, such as bee and BGI crop experiments, have improved the integration of urban architecture and nature.

4.2.3 Efficient utilization of water resources

The project makes full use of water-saving appliances, such as the water outlet nozzle with induction water saving of 19 L / min. The water consumption is less than 1/4 of the ordinary domestic water output, which can reduce the daily water consumption. Meanwhile, the landscape water consumption is also greatly reduced due to the selection of drought tolerant plants.

4.2.4 Demonstration of on-site organic waste treatment technology

On the basis of scientifically setting garbage classification rules and effectively advocating and promoting garbage classification in the park, Vanke took the lead in using black soldier flies, earthworm towers and other technologies to create a unique organic waste treatment scheme in the office park. The daily kitchen waste treatment capacity can reach 100-120kg, exploring a new technical route for the treatment of organic waste in urban communities.

4.3 Benefits of sustainable development of the whole society

4.3.1 Demonstration and guidance

As the first batch of near zero carbon emission pilot projects in Shenzhen, Vanke Center has explored and tried from the aspects of building energy conservation transformation, renewable energy utilization, roof garden transformation, waste resource utilization, reduction of implied carbon emissions and community co construction, providing an experimental site for CO creation and co-construction of

carbon neutrality technology and green low-carbon concept, and providing a model for the transformation of industrial parks and office buildings and the transformation of operation mode.

4.3.2 Science education

The process of project transformation and operation is participated by the government, enterprises, research institutions, public welfare institutions, experts, schools, community residents and other stakeholders, many of whom are first exposed to the concept of carbon neutrality. In the process of practice, both technicians and community residents have more in-depth knowledge of carbon neutrality communities, and their overall environmental awareness has also been significantly improved. Several schools in the community also applies the Vanke Center as a learning venue to provide students with roof garden ecology courses and other related learning content, which greatly improves students' interest in environmental issues;

4.3.3 Increase employment

The transformed Vanke Center has been updated and upgraded in terms of technical hardware and operational software. Therefore, the property management team has higher requirements on scale and skills of technical team. On the one hand, it brings new employment opportunities to local residents. On the other hand, it also urges employees in the traditional property management industry to learn new technologies and skills and become future-oriented carbon neutrality community management and operation and maintenance experts.

V. Problems and Suggestions

5.1 Supporting support of corresponding policies and regulations

According to the needs of carbon neutrality communities, the corresponding policies and regulations on technology and management should be developed. For example, clean energy technologies such as hydrogen energy have made great progress, and the safety performance of related products has also been verified by the market. However, due to regulatory restrictions, they still cannot be applied in communities. For pilot demonstration projects, the most important thing to explore new technologies and products is the operation experiment and demonstration role in the difference scenes. Therefore, setting up a series of policies and regulations specifically for carbon neutrality communities to encourage innovative applications can bring great practical significance to further promote the transformation of community towards carbon neutrality.

5.2 Support of green finance

The carbon neutrality renovation of buildings involves the application of new ideas and the practice of new products. Therefore, the incremental cost generated needs certain incentives for market-oriented

entities to drive more property owners to join the carbon neutrality renovation. The support of green financial instruments can bring social and economic benefits to enterprises by reducing the cost of green transformation, which is undoubtedly a path worth exploring.

5.3 The industrial chain needs to be improved.

The carbon neutrality transformation of buildings needs not only good concepts as guidance, but also well operated industrial chain to provide technology, products and services. For example, in order to reduce carbon emissions during the transformation, the demolished buildings and decoration materials should be recycled as much as possible in principle. However, due to the imperfect development of the recycling industry chain, there are few enterprises that can really cooperate to achieve the recycling of construction waste. Furthermore, the technical capability of most enterprises cannot meet the requirements, so that some of the renovation plans can not be implemented.

VI. Experience for Sharing

6.1 Continue to promote the implementation of later projects

Under the successful demonstration of the first phase transformation of Vanke Center, Vanke Group will continue to complete the relocation and transformation of the second phase of Museum and Conference Center and the third phase of Education Park.

6.2 Promotion and reproduction of successful experience

Figure 3: Seashore of Dameisha Community

Vank will promote the successful experience of Vanke Center to Dameisha community and help Dameisha community successfully build a pilot community with near zero carbon emissions in Shenzhen.

6.2.1 Promote community garden

In the construction of the roof garden of Vanke Center, through many community activities, the enthusiasm of community residents to jointly develop and improve environmental quality has been fully driven. In the next step, Meisha Sub-district plans to promote the model of community garden, select sites in the community and encourage residents to develop community gardens together, enhance the awareness of environmental protection, and form a harmonious neighborhood.

6.2.2 Promote garbage classification and organic composting

Vanke will further promote carbon sink and achieve 100% on-site treatment of kitchen waste and garden waste in the community. Vanke will also improve the recycling system in Dameisha, establish a second-hand flea market, and help community residents improve their environmental awareness and daily living habits. The company will also take the innovative action of "charging by bag, who produces, who pays", refer to the Taiwan model, and implement the strategies of "special bag and investment" and "measuring by bag" for other garbage, so as to improve the accuracy of garbage classification.

Chapter 3 Heavy Industries

3.1 Development of Comprehensive Carbon Flow Management System

I. Basic Information

1.1 Significance of the case

In 2022, the "carbon emission peak and carbon neutrality" goal was once again written into the *Annual work report of Chinese central government*. The report points out the following contents regarding China's 3060 goals[19]:

(1) China should promote carbon emission peak and carbon neutrality in an orderly manner, implement the carbon emission peak action plan;

(2) Advance the energy revolution, ensure energy supply, based on resource endowments, and promote the low-carbon transformation of energy as per the the overall plan;

(3) Promote the research, development and application of green and low-carbon technologies;

(4) Resolutely curb the rough development of high energy consumption, high emissions and low-level projects;

(5) Accelerate the transformation from management of energy consumption to management of total carbon emissions and intensity, improve the incentive and restraint policies for reducing pollution and carbon emission, develop green finance, and carry out the development of a green & low-carbon production and lifestyle.

With the strong support of the government and enterprises in the pilot district, a research team with members from administration and industries is established to study the carbon emission control methods and measures, and solidify them through the management platform, so as to effectively implement the research outcomes.

1.2 Technical significance

"Carbon emission peak and carbon neutrality" is an extensive and profound economic and social systematic change. The realization of the 3060 goals cannot be achieved without the support of key

[19] At the general debate of the 75th session of the United Nations General Assembly in September last year, China announced that it would aim to achieve peak CO_2 emissions before 2030 and carbon neutrality before 2060.

technologies and technological innovation. The research and development team of carbon emission management has been continuously deepening the layout of the domestic market, exploring technological reform, focusing on the monitoring and calculation difficulties of carbon sources and sinks, improving the quality of carbon emission data, seeking the value of carbon emission data, providing technology and ideas for the realization of the 3060 goals, supporting the improvement of relevant key technologies, developing new technologies, enhancing the research and development, promotion and utilization of green and low-carbon technologies, and forming a series of experience that can be used for reference and promoted, and thus provides a scientific and reasonable technical route for developing a complete comprehensive carbon flow control scheme and developing a carbon flow management platform.

1.3 Social significance

The platform can assist the local government in analyzing and managing the social operation, and perceive the social, economic and livelihood status. For instance, the prediction model can be used to calculate the coupling relationship between each reduction rate of energy consumption intensity per unit of GDP and carbon emissions in the region, and quantitative sensitivity calculation can be carried out accordingly. By calculating the relationship between the cleanliness of local power supply and the proportion of carbon emission reduction, the quantitative analysis can be conducted and put forward emission reduction countermeasures accordingly. By calculating the coupling relationship between terminal electrification rate and carbon emissions, the results of quantitative analysis can support the government's accurate policy implementation and scientific regulation. The application of these analysis results can make social governance smarter and greatly improve the management effect.

The platform can help government agencies to implement process and grid management, and become a practical tool for government's energy management department. Through the convergence and integration of the city energy production and consumption data of the energy big data center, a three-level government-enterprise linkage mechanism is developed to support the government to carry out online supervision of enterprise energy efficiency benchmarking, environment protected production, capacity expansion and reconstruction, energy review and verification. The platform can help to enhance the transparency of production costs, service quality and other information in the energy industry, promote the improvement of the quality and efficiency of industry supervision, explore potential energy conservation and emission reduction projects, and thus reduce costs.

Focused on the low-carbon energy transformation of industrial enterprises, this system use big data to calculate carbon assets for enterprises, issue evaluation reports of transformation projects, help enterprises to calculate potential greenhouse gas emissions, and make decisions on how to deal with the challenges brought by climate change. The study is dedicated to improve the ability of accurate

analysis in carbon emissions, provide a series of solutions for enterprises, especially small and micro enterprises, promote the precise docking and complementary advantages between the upstream and downstream of the industrial chain, cultivate new businesses and models, create greater development opportunities for all enterprises in the industrial chain, and foster a wider market.

In all, this study and the subsequent development of this platform can effectively promote the transformation and upgrading of green development in the industry, popularize the concept of green production and low-carbon environmental protection, and create a good environment for the whole society to jointly promote carbon reduction in the industry.

1.4 Innovation

At present, China's energy transformation is largely relying on the promotion of policies. The macro and micro dynamics of the transformation are insufficient as a whole. Policy is the starting point of transformation and can continue to play a boosting role, but it cannot be used as the core driving force for a long run. Therefore, it is necessary to conduct an in-depth analysis of the relationship between the energy consumption structure, output value and carbon emissions of the energy industry, cut into the vital points of industry emission reduction, estimate the transformation results, and develop the core driving force of energy transformation.

Meanwhile, the energy industry to which the power industry belongs has not been organized and implemented from the energy supply side, energy consumption side and policy side to build a carbon reduction system. Therefore, there is an urgent need to explore the potential of data-driven carbon emission control for key energy consumption industries, carry out research in energy evaluation and comparison, energy use right approval, carbon emissions measurement, carbon electricity trading and other related aspects, establish a carbon management system, give priority to the admission of energy suppliers with emission intensity higher than the industry's advanced value and renewable energy with small carbon emissions, and also give priority to preferential power supply to energy users with low carbon emissions and sufficient energy use rights.

This study makes up for the lack of carbon emission calculation and prediction models at the district and county levels, and contributes more localized improvements on the basis of the general model. By incorporating the carbon emissions of energy suppliers and users, the trading of energy consumption rights and the performance of carbon trading into the data platform, a localized fusion algorithm is explored to help realize the adjustment of energy supply structure on the grid side.

1.5 Implementation objectives

According to the requirements of development in energy industry, the research team established a data resource system at the district and county levels to explore local carbon emission measurement methods,

and take total energy consumption, total carbon emission, energy consumption intensity and carbon emission intensity as the core indicators, with the goal of accelerating the green and low-carbon transformation in the six major fields of industry, energy, construction, transportation, agriculture and livelihood as the goal, to achieve the dynamic measurement of carbon emissions.

In order to realize all-weather online monitoring, the research team focus on key areas, conduct policy sensitivity analysis, study and judge future trends, and put forward feasible green transformation plans. Jointly with the Zhejiang Energy Big Data Center (ZEBDC), the team give full play to the means of digital smart empowerment, deeply develop energy budgeting algorithms, flexibly allocate quarterly energy consumption indicators of enterprises, guide over 3600 enterprises within the scope of energy consumption management to use energy in a standardized and orderly manner, form scientific budget control, and achieve real-time data monitoring by governments at all levels.

On the basis of the original energy consumption and intensity management framework, the research team build three-level application modules at the district level, department level and enterprise level, form a carbon emission management mechanism, and complete the full closed loop of enterprise carbon emission monitoring process. This can help enterprises transform energy into low-carbon and build a long-term mechanism for energy conservation and carbon emission reduction, thus to realize the carbon emission peak goal of the pilot district in multiple ways, at multiple levels and in multiple dimensions.

Furthermore, the research team explore and study the applications of carbon inclusion, carbon finance, carbon technology, effectively encourage emission entities to complete carbon emission reduction targets at low cost, encourage enterprises to use new energy to reduce the demand for carbon emission rights, help enterprises efficiently produce green and low-carbon products and develop technologies, thus promote the development of green and low-carbon economy.

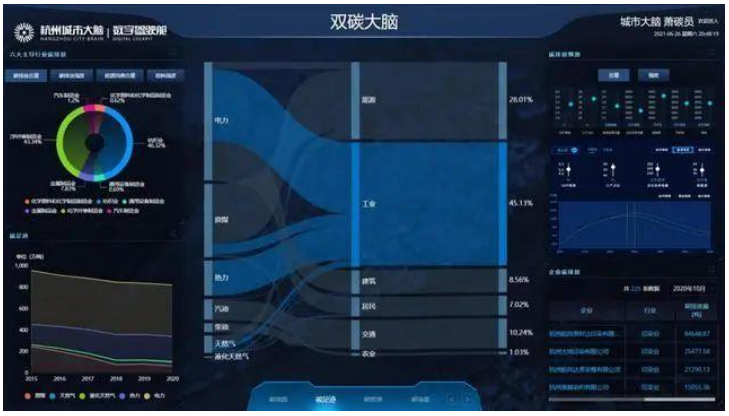

Figure 1 Carbon Management Online Platform

II. Technical Route and Functions

2.1 Overview

The research team established an algorithm model suitable for local characteristics to predict energy consumption and carbon emissions in key energy industries. Using the model construction method of combining bottom-up and top-down models, the prediction model of energy consumption and carbon emissions in key energy industries is established. Under the current development situation, the research team predict and analyze the total energy consumption and carbon emissions under different scenarios, and study the carbon consumption and intensity control potential of key energy industries. The study is focused on following aspects:

(1) Research on carbon management system of key industries for energy consumption. Based on big data, starting from the demand of government on process management of carbon control and the need of enterprises on carbon reduction as per assigned goals, the research team develops a carbon budget management application system with the government's carbon control and feedback. With this system, enterprise's carbon reduction can proceed with goals, positioning and effectiveness, so as to realize the transformation of carbon emission data from post accounting to real-time monitoring, and the transformation of carbon control mode from extensive management to whole process budget management, the progress of carbon emission reduction change from post evaluation to online tracking statistics, thus to ensure precise carbon control, orderly carbon reduction and comprehensive benefits;

(2) Build a data platform and complete the basic data research for carbon on typical products in key industries for energy consumption. The research team studies the carbon emission attributes of typical products in key industries for energy consumption, build a carbon basic credit database for key industries for energy consumption, and provide data support for potential excavating of carbon control and carbon electricity trading in key industries for energy consumption. In addition, it is vital to integrate data standards and develop a complete data resource system;

(3) Develop financial services in the industrial chain and establish a green ecological chain. Based on the connection and sharing with the provincial and municipal integrated smart governance data platform, the local government develops a data module system with energy big data as the core, expands the value-added services of energy, carbon and electricity data, explores industrial chain financial services, and aims at guiding the low-carbon transformation of economic and industrial structure.

2.2 Functions of the platform

The development of carbon flow management system is a digital system integrating carbon monitoring, analysis, management and emission reduction in combination with digital reform. It focuses on the

three core elements of carbon monitoring, carbon analysis and carbon reduction to achieve "one-screen overview, one-way tracking, one-stop intelligent governance and one-stop application", promote the overall process of regional carbon emission peak and carbon neutrality and illustrate the development process of low carbon in the whole region.

2.2.1 Data analysis and tracking the "carbon footprint"

Based on the "four indicators", this platform is developed to realize the comprehensive collection of carbon data. The Comprehensive carbon flow management system, based on the four indicators of "total carbon emission, carbon emission intensity, total energy consumption and energy consumption intensity", through collaboration between government departments, enterprises and agencies and through the carbon management platform, collect carbon related information in an all-round way, gather important data such as electricity, gas, coal and oil within the region, and realize data connectivity and application connectivity. So far, more than 20000 pieces of data have been collected, laying a solid foundation for the analysis and use of data. The data collected is from 3600 enterprises in the pilot district, achieving full coverage of industrial enterprises above designated size[20] and key enterprises for energy consumption in the region. In addition, the platform focuses on the "six areas" to achieve full traceability of carbon emissions. Focus on the six carbon consumption fields of energy, industry, construction, transportation, agriculture and livelihood, the platform draws a carbon flow traceability map guided by the characteristics of the industry. For some enterprise data that cannot be collected for the time being, three sets of correlation algorithms such as "energy-carbon", "energy-electricity" and "electricity-carbon" are established to build carbon emission calculation models in six major areas on the consumer side. Taking the industry as an example, the carbon management platform can achieve the end carbon source tracking of enterprise consumption, obtain various energy consumption data of enterprises with the help of the smart energy integrated service platform, and summarize them level by level from street and town to the whole district, forming a logical carbon flow map, and finally realize the penetrated analysis and accurate control of the whole process of industrial carbon flow. Furthermore, the platform builds a localized carbon emission prediction model. Carbon emission peak is intertwined with economic growth, security of energy supply, affordable social costs and other factors, which is a balanced system with constraints from multiple objectives. In view of this situation, the platform builds a carbon emission prediction model with "economy, energy, electricity and environment" as the content, comprehensively analyzes the coupling relationship between the four, works on the prediction and analysis of carbon emission peak under three scenes: natural scene, benchmark scene and enhanced

[20] Industrial enterprises above designated size: In China, this term refers to industrial enterprises with product sales revenue of more than 20 million yuan (including) in the current year.

scene, and provides advice for rational governance.

Figure 2 Control modules at all levels of carbon management

2.2.2 Digital empowerment and optimizing "carbon management"

First, the system advocates multi-cross collaboration for "smart governance in one". According to the goal of "data can be seen, different levels can be connected, tasks can be achieved, and outcomes can be checked", three-level mechanism of districts, governmental departments, and enterprises are developed to achieve the overall smart governance of carbon management. Among them, the district level control module can timely grasp the double control indicators, the completion progress and the carbon emissions of towns, streets, fields and enterprises, so as to provide a basis for the rational decision-making of the government. The department control module has the functions of energy use approval and information management, guiding enterprises to optimize the industrial structure, and urging enterprises to reduce emissions and carbon. The control module of the enterprise has the functions such as data reporting of facilities and energy consumption, energy consumption warning, so as to assist enterprises to independently carry out carbon emission management. Second, on this platform, the decomposition of indicators is "clear at a glance". According to the carbon indicator system and the actual situation of industries in the region, each department will establish three lists of "scenes, systems and reforms" according to the key points, and take this as a breakthrough to implement system remodeling and process redeveloping, so as to achieve the goal that indicators of towns, streets, enterprises can be checked, ranked and summarized. Third, the management of energy consumption and intensity on one map. Enterprises are the key points to achieve the carbon emission peak and carbon neutrality goal. In this study, 3600 enterprises above designated size, public institutions and other enterprises with key energy consumption are connected through the platform. With the functions of energy consumption monitoring, evaluation and analysis, enterprises will get proposals for carbon emissions and reduction. Through the platform, government can calculate and issue budget management indicators to key controlled enterprises, the calculation of energy consumption data is changed from post accounting to real-time monitoring, the monitoring mode is transferred from

extensive management to whole process budget management, and the emission reduction progress turned from post evaluation to online tracking statistics, so as to ensure accurate governance and orderly emission reduction.

2.2.3 Digital smart applications and building "carbon scenes"

"Specific energy consumption code" and "District carbon code" are integrated to ensure orderly power consumption and promote energy conservation and emission reduction. "Specific energy consumption code" is the latest carbon application under the carbon management platform. Enterprise users can identify the daily energy consumption ranking of their category by scanning the code, learn their annual remaining energy consumption limit, and grasp the energy consumption and intensity management plan for orderly power consumption and energy consumption issued by government, so as to help the government and enterprises achieve orderly power consumption, orderly production and effective consumption control. Meanwhile, "District carbon code" integrates the energy consumption data of regional and enterprise production and operation, calculates the carbon energy efficiency in combination with the output value, compares the enterprise's carbon efficiency with its industry average value by cycle, and divides it into five grades according to the energy efficiency level, accurately positioning the enterprise's energy consumption level, which not only provides a quantitative basis for the classification and implementation of government departments, but also provides reference data and reference route for the low-carbon transformation of enterprises.

2.3 Technical indicators

This study has formed a set of technical indicators for carbon emission control, and through the carbon management platform to achieve macro calculation and route analysis for carbon emission reduction , including six major areas in the pilot district. The enterprise energy consumption and carbon emission calculation, monitoring, prediction and analysis covers all 1503 power consumption enterprises above designated size and more than 2100 small and micro enterprises in the region (key enterprises for energy consumption).

Data presentation, indicator calculation and application management are carried out in four parts: carbon map, carbon footprint, carbon management and carbon scene.

Carbon map

The carbon map clearly presents the proportion of carbon emissions, total carbon emissions, carbon emission intensity, total energy consumption, energy intensity, consumption side energy structure,

provincial and municipal GDP, the proportion of three industries[21] and other information in the region. All data is updated every half a year or once a year.

The above carbon emission data is tracked and refined to towns, sub-district, enterprises and communities, so as to make the data source traceable, and realize the selection and switching of different regions and time dimensions through the overall map.

The overall map is drawn according to the administrative division of the region, and the carbon emissions of 26 towns and streets in the region are subdivided according to the carbon emission intensity with a five-color map.

Carbon footprint

The Sankey diagram is used to trace the proportion of six fields in the region's carbon emissions, and analyze the energy consumption structure of a single field. The evolution process of energy consumption in this field from 2012 to 2021 is presented by using the stacking diagram. Through the prediction model, the carbon emissions in this field are predicted in three scenes.

All data includes three sources. Data from different sources have their own processing methods and update frequencies:

Data collection: data collection mainly refers to all kinds of power data that the smart energy integrated service platform accesses to the site. There are corresponding enterprises and sites on the smart energy integrated service platform. This data is the basis for calculating the power consumption of the enterprise, and the update and storage frequency is 15 minutes.

Collected data: including the information of output value and added value for all enterprises in the pilot district. For instance, energy consumption information including raw coal, natural gas, liquefied natural gas, gasoline, diesel, heat, electricity, basic information of the enterprise including name of enterprise, credit code, region, national standard industry, address, contact person, contact information. The data update frequency is determined by the data department in charge.

[21] Three industries: According to the Regulations on the Division of Three Industries, the primary industry refers to agriculture, forestry, animal husbandry and fishery; the secondary industry refers to mining, manufacturing, power, heat, gas and water production and supply, and construction; the tertiary industry is the service industry, which refers to other industries except the primary industry and the secondary industry.

Input data: for all kinds of comprehensive data that cannot be collected and out of the "city brain"[22] data catalogue. This part of data is input into the platform system through the exclusive entry interface provided by the platform. The update and storage frequency can be entered once a month or once a year accordingly.

By collecting and integrating data resources, clarifying energy consumption data by varieties, industries and locations, the platform can provide data evidence for carbon indicators (total carbon emissions, carbon emission intensity, total energy consumption, energy consumption intensity), carbon emission structure, carbon footprint, consumption side energy structure and other modules.

Through the comprehensive analysis and refinement of a large number of original data, the function of predicting the future short-term, medium-term and long-term carbon emission trend through historical data is achieved.

Carbon management

To foster the carbon management platform, it is required to develop three-level control modules of districts, departments and enterprises.

The district control module focuses on serving the whole process of government monitoring, early warning and precise implementation, help to grasp the energy consumption and intensity management indicators in time, complete the progress, and assist macro analysis and strategic planning of energy.

The departmental control module focuses on the management of whole process and approves the data submitted by enterprises. The departmental control module carries out enterprise energy consumption monitoring, realize the dynamic accounting of the whole process of enterprise energy consumption, real-time early warning of energy consumption progress, emission reduction analysis and display. They also analyze the abnormal energy consumption, identify the sudden change of enterprise energy consumption level through industry benchmarking and historical comparison, ensure the authenticity and reliability of enterprise energy consumption data, and assist in the research and judgment of the development trend of the industrial chain.

The enterprise control module focuses on serving enterprises to save energy and reduce consumption

[22] City brain: A smart city management system originated from Hangzhou.

and improve integrity of clients. First, the enterprise control module launched a “specific energy consumption code”, so that service enterprises can grasp their own energy budget progress, energy efficiency level and industry ranking in real time, and make appeals, feedback and energy right transaction applications accordingly. Second, the enterprise control module provides energy toolbox services, generate the estimated values of enterprise energy consumption, energy efficiency, total carbon emissions and carbon emission intensity with one click, and output the evaluation report of energy-saving transformation projects. Third, the enterprise control module accurately promotes comprehensive energy solutions, and provides a package of energy rights solutions such as photovoltaic, energy storage, cascade utilization of energy, green power trading according to user’s demand.

Meanwhile, the platform module is extended to the mobile terminal to connect the mobile phone and platform, so as to achieve interoperability and make carbon emission management more efficient and convenient.

Carbon scene

This module mainly explored the applications of carbon inclusion, carbon finance, carbon technology and so on. At present, it provides enterprises with "specific energy consumption code" and "district carbon code".

"Specific energy consumption code" is the exclusive energy consumption account book of the enterprise, which includes the information of industry of the enterprise, energy efficiency ranking, power consumption amount, power consumption plan, energy consumption calendar and energy consumption indicators. Industry and energy efficiency ranking ranks enterprises by industry to achieve industry benchmarking. The power consumption amount should cover the amount of electricity used and the remaining amount for the enterprise. The power consumption plan can predict the production suspension and restriction arrangement of the enterprise within a week. The energy consumption module displays the enterprise's energy consumption and exceeding the limit in multiple dimensions, helping the enterprise to better understand its own energy consumption and arrange production plans.

"District carbon code" aims at developing indicators such as average energy consumption per mu[23], average energy efficiency per mu, average carbon emissions per mu, rating the carbon efficiency of enterprises, recommending emission reduction plans for enterprises. "District carbon code" also establishes Carbon Asset Management System for enterprise, tracking the total amount of carbon

[23] Mu (亩): a unit of area (=0.0667 hectares)

emission accounts and actual carbon emissions, and monitor the progress of carbon emission indicators in real time. By making comparison with leading enterprises in the industry, the "Xiao carbon code" encourages enterprises to develop green and low-carbon mode with continuous transformation and upgrading. From the monthly and annual statistics on the energy consumption structure and carbon emission data on the "Xiao carbon code", management of enterprises can master their own energy consumption.

Figure 3 Carbon Effect Code

2.4 Methods for carbon asset management

For carbon asset management, the first thing in need is to establish a carbon monitoring system, quantify carbon emission factors and carbon emission reduction data of enterprises, integrate the initial carbon allocation, trading allocation, voluntary emission reduction and other factors of enterprises, form an enterprise "carbon account", help enterprises clarify carbon emissions, promote enterprises to actively participate in the carbon trading market, have better management on carbon assets, provide support for China's carbon pricing, and reduce the risk of carbon assets.

Second, it is important to integrate the government, research institutions, enterprises, energy-saving manufacturers, residents and other subjects, to build a "carbon mall" platform with carbon trading as the main function, so as to achieve trading of carbon emission indicators, which means to use carbon indicators to engage in financial activities or technology trading. This will cultivate new business forms and new models, and form a ecosystem for the whole society to participate in carbon reduction action. Meanwhile, according to the development of the national carbon finance market, applications like carbon credits, carbon benefits, carbon finance, carbon technology can be launched in the "carbon mall", which can not only effectively encourage emission entities to complete carbon emission reduction goals at low cost and achieve the total greenhouse gas emission control, but also guide funds to low-carbon industries and gradually increase the production cost of high-carbon emission industries through the market-oriented price operation mechanism, thus promote these enterprises to carry out low-carbon transformation.

Third, it is vital to form a research team including senior experts on energy and researchers from university to give full play to the intellectual and professional advantages of talents, pool excellent knowledge, information and technology resources at home and abroad, and provide technical support and theoretical guidance for the research. The key spirit for this team will be adhering to strategic demand orientation and problem orientation, dedicated to technical research of carbon asset management analysis, and maintain the progressiveness of the research.

III. Experience and Practice

3.1 Localization of algorithm model

This system, on the basis of the data from provincial energy big data center, integrates the existing carbon emission prediction algorithms, forms an algorithm model that fits the local characteristics, and achieves the prediction and research of energy consumption and carbon emissions in key industries for energy consumption. The method of combining bottom-up and top-down models is adopted for this system, establishing the prediction model of energy consumption and carbon emissions of key industries for energy consumption, predicting and analyzing the total energy consumption and carbon emissions under different scenes under the current industrial development process. In view of the local circumstance, the system builds a 4E[24] all factor balance and deduction model for carbon emission monitoring, and thus to study the further carbon deduction potential of these key industries for energy consumption. Based on the LEAP (long-term energy substitution planning) econometric model and referring to the 4E model of electric power company, the study is making effort on more detailed, practical and localized improvements:

(1) Align with local circumstance and oriented to district level. The carbon management platform shall better adapt to the actual circumstance in the region, the study team is using the energy big data centers at all levels and the emission distribution of six major fields to establish the first carbon emission environment model that integrates all factors of 4E;

(2) Optimize the algorithm and make it more practical. The carbon management platform is working on detailed and comprehensive calculation on secondary energy in the pilot district, and the carbon emissions of power are decomposed and calculated according to the policy of local zero carbon contribution, local carbon emissions calculation, unified carbon emission regulation from provincial government;

(3) Highlight features and make thematic analysis. The calculation focuses on the total energy consumption, current circumstance and prediction of emission structure of high energy consumption and high emission industries in the regional, such as textiles, printing and dyeing;

[24] 4E: economic,efficiency,effectiveness,equity.

(4) Keep updating and improve the system. Align with the decisions from national economic work conference in December 2021, the policy adjustment of "new renewable energy and raw material energy are not included in the total energy consumption control" is included in the model calculation.

The model coordinates the upgrading of industrial structure, the improvement of energy efficiency, the adjustment of energy consumption structure, policy guidance, technological progress and other factors, and provides theoretical support for the formulation of carbon emission peak and carbon neutrality schedule and road map.

3.2 Improvement of the data resource system

The study is dedicated to expanding the district and county-level data platform, and complete the basic carbon data research on the typical products of key industries for energy consumption. The study also focuses on the carbon emission attributes of typical products in key industries for energy consumption, build a basic carbon credit database for key industries for energy consumption, and provide data support for potential exploring of carbon management and carbon electricity trading in those industries with high energy consumption demand. It is also important to integrate data standards and develop a well-operated data resource system.

Based on the core business, the system sorts out and prepares the list of data resources, and determines the collection methods and approval departments of macro data and carbon emission calculation data items in six fields. It is vital to define each data item: data definition, data structure, data range, update frequency and data source system.

A data resource system with smooth operation cannot be achieved without the help of data modules and energy big data center of higher level. Working with the energy big data center, this system provides open data interfaces and generate calculation data through the data calculation engine.

Guided by the decarbonization and carbon reduction of economic and social development, and taking the low-carbon transformation of regional industries, the development of low-carbon energy, and the improvement of carbon sink capacity as the main guideline and breakthrough, the whole community shall work together to improve the low-carbon capability in the fields of transportation, construction, agriculture, livelihood, scientific and technological innovation, and spare no effort to promote regional green and high-quality development. Together with digital reform, the pilot district is developing China's first digital platform on carbon neutrality, integrating functions of carbon emission reduction, monitoring, analysis and management. Focusing on the three core elements of carbon, carbon analysis and carbon reduction, carbon management platform will realize the visualization and whole process

control of "carbon governance", and help the government make scientific decisions, digital smart city development, energy conservation and carbon emission reduction of enterprises , and thus pursuing the precise social governance.

3.3 Establishment of accurate carbon budget management application system

(1) Scientific decomposition and allocation of carbon emission targets. Based on the data resources of industries and key industries for energy consumption, and the carbon emission characteristics of enterprises, the carbon emission reduction targets are decomposed and distributed industry by industry and enterprise by enterprise, thus to maximize the scientific rationality of target decomposition.

(2) Monitoring and early warning of carbon emission process. It is necessary to establish an smart analysis and application system for enterprise's carbon emission monitoring and accounting. Supplemented by remote quality control and smart operation and maintenance, it will be feasible to achieve the follow:

(i)dynamic calculation of the whole process of carbon emission from enterprise;

(ii)real-time warning of the profit and loss of the target amount;

(iii)analysis and display of carbon emission reduction;

(iv)Peer comparison within industry;

(v)historical comparison.

With this function, it will be able to track the progress of the enterprise's carbon emission peak goal in real time, and give early warning if necessary.

(3) Prediction and analysis of carbon emissions. Using the prediction model, the impact of multi-dimensional carbon emission factors such as time, space and industry can be considered. By analyzing the trends and rules of historical and recent enterprise data such as carbon emission behavior, carbon emission composition, energy consumption, time cycle, the future emission reduction potential of enterprises can be predicted, thus to improve the accuracy of prediction and analysis of future carbon emissions of enterprises.

(4) Evaluation of carbon emission reduction outcomes. For evaluation of outcomes, the study team determined the evaluation scope and evaluation factors of carbon emissions, developed an evaluation model of the effectiveness of enterprise carbon emission reduction according to the relevant data of

enterprise carbon emissions, economic output value, carbon emission intensity of the industry, target value of enterprise carbon emission reduction, and conduct a more comprehensive, focused, scientific, accurate, objective and fair evaluation of the enterprise, especially on the scale of carbon emissions, the effect of carbon emission reduction, and the completion rate of carbon emission peak goals.

(5) Feedback for management on carbon emission reduction. The study team establish a feedback improvement mechanism between enterprises and the government. After obtaining the phased carbon emission reduction effect evaluation, enterprises can give feedback on the adaptability, acceptance, implementation difficulties and other issues of the carbon emission peak goal through the budget management platform according to their own conditions. The government judges and analyzes the feedback of enterprises align with the carbon emissions. Based on the judgment, the government either improve the target decomposition and distribution method, or urge enterprises to improve the capability to fulfill the target.

IV. Analysis of Effectiveness

4.1 Economic benefits

This research and the development of the platform have helped the regulators from government to save time and labor costs in management of energy consumption and carbon emission. Before using the carbon management platform, this management work needs to be carried out with dozens of people. After the implementation of the project, the online calculation of results and supervision of the online process can be completed by one person.

The platform saves time for the government to calculate the energy indicators of enterprises. It takes half a month to calculate the indicators required by the government before the implementation of the project, and now it only takes a few minutes to calculate the indicators after the implementation of the project.

The platform saves the economic costs for enterprises to obtain the energy evaluation report. Before the implementation of the project, the enterprise needs to spend hundreds of thousands of yuan and wait for half a month before obtaining the energy evaluation report. After the implementation of the project, it only needs tens of thousands of yuan to obtain it in one day.

The platform saves the time for the approval process between government and enterprises. Before the

implementation of the project, the process of enterprise applying for capacity expansion and transformation is complex and cumbersome. The information between government departments is not interconnected, and the verification of enterprises is time-consuming and labor-consuming. The content of the application business form submitted by the enterprise is mostly repeated. After the implementation of the project, multi cross collaboration between departments can be achieved, and the approval process only requires one time online application, thus greatly reduce the waiting time.

4.2 Environmental benefits

Through all-weather online monitoring, the platform focuses on key areas for policy sensitivity analysis, studies and judges future trends, puts forward feasible green transformation plans, assists decision makers in introducing a series of means such as technology, market and environmental protection projects to 'offset' the negative impact of carbon dioxide and other gas emissions, so as to reduces the adverse impact and losses of climate change on agriculture, people's livelihood and health of residents.

With the application of carbon management platform, enterprises eliminate old facilities, optimize workflow, develop green manufacturing processes, and complete the transformation and upgrading of enterprises, which not only reduces production costs, but also cuts down the cost of green governance. This can greatly decrease the impact of production and consumption on the environment, save resources for production, reduce or eliminate pollution from the origin.

4.3 Social benefits

By exploring the core driving force of energy transformation and doing research on emission reduction paths which are closer to local characteristics, the platform can help developing new business models, help local governments form a complete green industry ecological chain, activate the vitality of green industry development, promote industrial green transformation, and provide an industrial foundation for high-quality development .

The implementation of the carbon management platform not only breaks the existing segmented management system in urban energy management and explores new energy business models and mechanisms, but also fully exploits the potential of low-carbon supply and demand, optimizes the structure and mode of supply and demand, coordinates the multi-resource energy environment, improves the using proportion of renewable energy, reduces energy consumption and pollutant emissions, and improves energy efficiency, thus to help realize the optimization and adjustment of energy and its related industrial chains.

V. Problems and Suggestions

5.1 Problems encountered in implementation

This research largely relies on the carbon management platform, and the platform itself is a outcome from this research. Currently the platform encountered the following problems in terms of data:

First, collection for part of the data is difficult. The current energy data statistics focus on the energy production and consumption of industrial enterprises above the designated size. For small and micro enterprises, the statistic agencies do not have detailed energy statistics specifications, so it is impossible to systematically grasp the energy consumption and development trend of the whole society. In addition, some enterprises still do not taking it seriously when filling in the energy report, and even has a certain motivation of misconduct. In this circumstance, the the accuracy of energy data will be disturbed, and the most accurate analysis of energy consumption and energy conservation of all industries and enterprises cannot be achieved.

Second, there are difficulties for data to be deeply integrated. While ensuring the safety and stability of data, it is also necessary to be open-source and consistent with standards. The collected data comes from various enterprises and departments, with different statistical boundaries and cycles. With huge diversity in information attributes and data characteristics, the explanation of data sources can be unclear.

Third, in the process of connecting the platform with carbon trading and power trading platforms, it is necessary to consider the integration of trading data. The research team lacks experience in liaison with the trading platform, and more detailed policy guidance is needed.

5.2 Suggestions on realizing the goal of carbon emission peak and carbon neutrality

5.2.1 Promote industrial restructuring

In the future, the emission reduction potential of adjusting the tertiary industry structure and optimizing the internal structure of the industrial industry are indispensable. The focus of low-carbon development lies on accelerating the transformation of industrial structure. The emission reduction goals of industrial structure can be achieved through the following ways:

(1) Increase the upgrading and transformation of traditional industries, especially high energy consuming industries, and improve the technical and management capability. The development of contract energy management mode, energy audit, and the implementation of energy-saving objectives to workshops and individuals will contribute to energy conservation and carbon reduction.

(2) Explore energy consumption access and carbon emission assessment systems. First, a strict energy access system shall be established, controlling the registration of high energy consuming enterprises from the very start. supplemented by equal or reduced replacement of energy consumption, and improve the low-carbon level of regional enterprises. Second, for newly introduced projects, technologies and industries, the whole process and long-term energy and resource consumption and carbon emission evaluation system should be implemented. Through the prediction and evaluation of energy consumption and carbon emission in the whole life cycle, the long-term energy consumption and total carbon emission control should be reasonably planned, and the relationship between emerging industries, energy consumption and carbon emission should be well coordinated.

(3) Accelerate the development of modern service industry. The rapid development of information technology has facilitated the integration of modern service industry into advanced manufacturing industry. Accelerating the integration of advanced manufacturing and modern service industry is in line with the overall development goals of China and the demand of social and economic development. It is conducive to enhancing market competitiveness, optimizing the industrial chain, forming a new growth pole, improving the efficiency of resource allocation, and finally forming a modern industrial development system led by strategic emerging industries and supported by advanced manufacturing and supported by producer services.

5.2.2 Develop a low-carbon industrial system

In order to achieve carbon emission peak in the industrial field, it is significant to optimize the industrial structure, reduce the energy consumption intensity of key industries, and establish a well-operated low-carbon industrial system. The following implementation methods can be referred to:

(1) Advance the transfer and shutdown of major projects. Government shall carry out reasonable evaluation on the necessity of transferring major projects such as steel, explore the development mode with transformation of steel industry and high value-added industrial base. For the pilot district, government departments speed up the shutdown of old assembling units in the power industry, pursue the relocation, entry, shutdown and rectification of chemical enterprises, eliminate backward energy

production in the chemical industry, explore the possibility of process chain transfer in the cement industry, and achieve the low-carbon development of the industrial system through the transferring and transformation of industries with high energy consumption.

(2) Promotion and application of energy-saving technology. The city management can carry out its work by means of keeping close liaison with enterprises, providing energy-saving technologies and energy-saving diagnosis by experts. In order to improve the industrial energy efficiency level of the city, funds such as energy conservation (circular economy) special projects and green credit shall play the leading role, and energy-saving service institutions shall be actively motivated. Enterprises should be supported to implement the application and transformation of key energy-saving technologies, give priority to the energy-saving transformation projects that meet the conditions and have remarkable performance.

(3) Increase the recycling rate of resources. First of all, the city management should develop resource recycling policies, establish and improve recycling management systems, and require all agencies and enterprises to promote resource recycling in their production process. Secondly, a sound waste classification and recycling system shall be established, together with the development of technical specifications. Meanwhile, technical development and staff training shall be enhanced for the standardized recycling process, so as to improve the recycling rate, and prevent secondary pollution. In addition, publicity and education are indispensable to consolidate the awareness of waste classification and resource recycling in enterprises.

(4) Accelerate the implementation of standards, identification and certification systems for low-carbon products and low-carbon enterprises, for the development of a green and low-carbon industrial system. The city management should develop the energy consumption allocation and product energy efficiency standards for major energy consuming products, increase the promotion of energy-efficient household appliances, automobiles, motors and lighting products, stimulate the demand for low-carbon products, advocate low-carbon consumption, and formulate corresponding incentive measures to encourage enterprises to produce green and low-carbon products for the transformation to low-carbon production mode. In addition, the city management should promote industrial green manufacturing, develop the list of green parks, green factories, green products and green supply chains in the city, and carry out the integration of green manufacturing systems.

(5) Strengthen the publicity of energy-saving technology. The city management can organize training, exchange and discussion activities themed on carbon management among enterprises.

5.2.3 Develop a low-carbon energy structure

(1) The city management should constantly control the total coal consumption and strengthen the source control of energy consumption. First, they should strictly control the excessive growth of high energy consuming industries, seriously abide by the industry access threshold, and strengthen the binding role of indicators such as energy conservation, environmental protection, land and safety. In the pilot district, for areas that have been ranked as the first level warning and have lagged behind in the completion of the "double control"[25] goals, the approval of new and reconstruction projects with high energy consumption will be suspended. For high energy consumption projects that have been completed in the areas ranked as first and second level warning, the power connection will be suspended, and the development of enterprises with high energy consumption and low output will be restricted. Secondly, the city management should optimize the utilization of coal, improve the quality and efficiency of coal utilization. An efficient, clean, low-carbon and circular green manufacturing system shall be developed. Finally, the city management should continue to promote key energy-saving projects. Focusing on key industries such as steel, chemical industry and electric power, the city management should promote the development of whole process and systematic low-carbon energy conservation.

(2) The city management should continue to promote the upgrading of existing power plant, make comparison with the advanced technology from other countries, promote energy-saving technology, and reduce coal consumption for power generation and power supply.

(3) The city management should develop clean energy and renewable energy. Take the industrial plant area as the key pilot, it will be a good opportunity for promotion of distributed photovoltaic power generation technology. For management of small cities and tows, it is feasible to improve the transmission capacity of clean electricity outside UHV areas, and actively introduce foreign clean hydro-power.

5.2.4 Introduce advanced low-carbon technology

The introduction of advanced low-carbon technology from other countries is of great significance for controlling carbon dioxide emissions and achieving "net zero" emissions. The city management should actively advocate the development of the industrial chain of green new materials and research on carbon capture and storage (CCS) technology.

[25] "double control": management of energy consumption and intensity.

5.2.5 Develop green and energy-saving buildings

(1) It is suggested that the city management should promote the requirements on construction of green building. For instance, increasing the proportion of green buildings in new buildings by using green and low-carbon building materials in construction.

(2) City management should think of expanding the energy-saving transformation market of existing buildings. Based on energy-saving technologies such as wall insulation, energy-conservative exterior-protected structure and energy-conservative lighting system, the numerous existing buildings can be transformed, and the market scale of energy-saving transformation of existing buildings will be boosted.

(3) City management should increase the use of renewable energy in the construction sector and strengthen the management on energy consumption of building operation. In new projects and renewable energy application projects, the city management should vigorously advocate developing of solar photovoltaic and solar thermal systems, guide enterprises to increase the utilization of clean energy such as ground source heat pumps and wind power, monitor the energy consumption of buildings, establish recycling of building energy, and thus achieve a great improvement in building energy efficiency.

(4) The city management is suggested to strengthen statistics of energy consumption data and monitoring on energy consumption. According to the study, the city management should strengthen the statistics, publicity and management of energy consumption in the operation of public buildings, establish and maintain the energy consumption statistics, energy audit, energy efficiency publicity and energy consumption allocation management system of public institutions, enhance the development of energy consumption monitoring platform and energy conservation supervision system. For buildings with energy consumption exceeds the allocated level, city management shall impose order of compulsory transformation.

(5) The city management should enhance energy consumption supervision and performance management in the process of buildings operation. In the pilot district, after the completion of the building, some of them did not play a full role in energy conservation, and part of their energy-saving functions and energy-saving equipment were idle. In view of this, the government will strengthen the development of supervision mechanism for the use of building energy-saving functions, align building energy efficiency with the work performance of building managers and principals, establish an effective reward and punishment mechanism, so as to improve the management of building energy efficiency.

5.2.6 Develop a low-carbon transportation system

(1) The city management can consider of controlling the growth of motor vehicle ownership and introduce incremental control policies for motor vehicles. Measures on this including vehicle license plate restriction, traffic restriction, limited license plate registration and limited validity of license plates.

(2) The city management may strengthen the promotion of new energy vehicles. The promotion of new energy vehicles can reduce the consumption of fossil fuels and help alleviate the pressure of traffic gas emission.

(3) In order to develop a low-carbon transportation system, the very most thing is to develop a well-operated urban public transport system. It is also advised that city should vigorously develop urban metro system and improve the travel sharing rate of public transport. Furthermore, city management should work on the improvement of the public transport system, especially for pedestrian, bus and bicycle. It is important to establish the leading role of public transport in urban transport.

VI. Routes for Future Development

On the existing basis of carbon management platform, the study team will further improve the data collection of government departments and enterprises, improve the energy big data warehouse in the pilot district, upgrade on the framework of information basic system, business system, management system and application system, and achieve the following goals:

6.1 Budgeting of energy consumption integrated in one QR code

(1) Use of specific energy consumption code. With the use of “specific energy consumption code”, the pilot district will deepen the existing energy budgeting outcomes on the carbon management platform, and improve the energy budgeting process under the district-town-enterprise three-level framework. The government departments will carry out the whole process management and closed-loop assessment from the calculation, issuance, appeal, audit and supervision of indicators. The “specific energy consumption code” will help to achieve the dynamic tracking of the implementation of the budgeted energy consumption of towns and enterprises, and timely deliver the early warning notice of enterprises that exceed the level.

(2) Information platform for reallocation of energy consumption. The research team will develop an

energy reallocation information platform in the energy budgeting scenes, where relevant enterprises can upload the supply and demand information of energy transfer or purchase. This platform will strengthen the interaction of energy reallocation information resources, and improve the convenience and sense of access of enterprises.

6.2 Management of energy consumption and intensity integrated as lists

(1) List of the whole region. The research team will further improve the data resource system to improve the data collection frequency of real-time acquisition of power data, monthly submission of gas data, regular update of coal-fired oil data and other statistical data. With big data analysis, it is possible to regularly generate the regional carbon emission energy consumption report, develop a "five color chart of energy consumption" with total energy consumption and energy consumption per enterprise of industrial added value as the algorithm model, and making evaluation according to the chart.

(2) List of key industries. The research team will continue to analyze the development trend of the industry, develop an analysis model according to the characteristics of the local industry, analyze the change trend of energy consumption based on the industrial chain for the key industries of the pilot district such as chemical fiber and textile through statistical tools. The research team will also follow the latest energy-saving and carbon reduction technology trends of the industry, and issue a more in-depth and detailed monthly analysis report on key industries.

(3) List of key enterprises. The research team will develop evaluation standards for enterprise energy consumption. These standards will help to achieve dynamic accounting of the whole process of energy consumption and carbon emission for all enterprises above designated size in the region, provide real-time warning of energy consumption progress. Based on historical and peer comparison, enterprises of the same industry will be ranked according to their carbon emission intensity. The research team will also issue proposal for enterprises on energy saving and emission reduction.

6.3 Management of energy supply on one map

(1) Operation diagram of thermal power enterprises

The carbon management platform will help to mark the distribution of thermal power enterprises in the region on the map, and display the online power of each enterprise in real time. Meanwhile, the data submission channel of coal reserves of thermal power enterprises will also be established on the system, counting the coal reserves and consumption of thermal power plants on a monthly basis. The supply methods of thermal power and coal in the whole region in combination with the fluctuation of coal

market price will be analyzed, so as to ensure the sustainability and stability of energy supply in the whole region.

(2) Renewable energy distribution map

For renewable energy plants such as photovoltaic power plants and biomass power plants, the research team will design the distribution map for development of renewable energy in the region. The map will include information of location, installed capacity, output capacity, power generation characteristics, etc. The historical power generation will be imported in the map, together with the function of collecting real-time power generation data.

(3) Trend chart of refined oil, natural gas and electricity consumption

The carbon management platform will regularly count the consumption of refined oil, natural gas and electricity in the region to analyze the subsequent consumption trend, compare the predictable subsequent supply, and achieve the early warning of energy supply protection.

(4) Diagram for early warning of power supply

The research team will establish a regional and local power supply protection and early warning mechanism on the carbon management platform. This mechanism will dynamically track the development of regional and local power demand, regularly analyze the development of power demand, constantly evaluate the adaptability of power demand growth and power protection measures. The research team will promote the development of a long-term mechanism to ensure the smooth development of the power system, and make every effort to ensure the power supply for the healthy and stable development of economy and society.

6.4 Mechanism for overall management

(1) The research team will help government departments to form an online data notification mechanism. The government departments shall conduct real-time accounting for indicators such as enterprise's energy consumption budgeting progress and energy consumption intensity. For enterprises with warning signs, the person in charge of the enterprise and the local government will get notification from the system.

(2) The government of pilot district will establish an offline "assistance + law enforcement"

management mechanism. The management department will set up an on-site management working group gathering officers from departments of development and reform, environmental protection, statistics, municipal supervision and sub-district to ensure the precise management of carbon management platform on the demand of enterprises with high energy consumption. This working group will carry out on-site assistance to enterprises above designated size with early warning, assist enterprises in energy conservation and consumption reduction analysis, so as to improve energy consumption efficiency.

(3) The research team will establish a set of standards and specifications to provide support for policies and regulations. In view of the role of carbon management platform has played in urban energy conservation and emission reduction, industrial transformation, and the achievements of pilot demonstration in the pilot district. The research team is proposed to develop national and international standards for the sustainable development of smart cities on carbon management platform.

3.2 Zero-carbon Industrial Park of Danfoss Haiyan Factory

I. Zero Carbon Development with High Efficiency

1.1 Background

At the UN General Assembly held on September 22, 2020, Chinese President Xi Jinping pledged that China's carbon dioxide emission will peak by 2030, strive to achieve carbon neutrality by 2060 (hereinafter referred to as "3060 carbon goals"), and make greater efforts and contributions to achieve the goals set in the Paris Agreement for the response to the climate change. Under the background of carbon neutrality, China is promoting the integration of power source, grid, load and storage, and multi-energy complement development. In 2022, the National Development and Reform Commission and the National Energy Administration of China issued the Guidance on promoting the integration of power source, grid, load and storage, and multi-energy complement development. The document points out that, through optimizing and integrating local resources of power supply, power grid and load, supported by advanced technological breakthroughs and institutional innovation, the implementation of the integration of power source, grid, load and storage will explore a new development path of power system.

Danfoss is one of the largest industrial groups from Denmark and a global leader in climate change, electrification, digitalization and smart manufacturing. The company focuses on clean technology and is committed to providing partners with energy-efficient solutions. Denmark is famous with its green development. In the past 50 years, the country's GDP has doubled, but energy consumption has remained basically unchanged, while water consumption and carbon emissions have been halved. Denmark has already taken the lead in achieving carbon peaking, and is making steady progress towards the goal of carbon neutrality by 2050. As the main promoter and contributor of green development in Denmark, Danfoss has long shared green development experience and best practices in China to promote low-carbon development and green transformation of the industry.

In June 2022, the International Energy Agency (IEA) held the 7th Global Energy Efficiency Conference in Sonderborg, the southern city of Denmark, where Danfoss is headquartered.

Danfoss is the only corporate partner of this world-class energy efficiency conference and made an introduction of the zero-carbon project of its plant in Haiyan, China.

Danfoss Haiyan Factory is one of the main production bases of Danfoss in China. In 2021, it won the title of "Green Factory" issued by the Zhejiang Provincial Government. Green and low-carbon development is the core value of Danfoss. In order to further promote Danfoss Group's goal of achieving carbon neutrality in its global business by 2030, Danfoss and Shanghai Electric will cooperate to carry out integrated innovation and integration of zero-carbon technologies under the guidance of "3060 carbon goals". The project focuses on improving the efficiency of energy utilization, actively implements renewable energy alternative actions, builds a new power system with new energy as the main body, and promotes the application of pollution reduction and carbon reduction technologies. Through cooperating with Shanghai Electric, Danfoss Haiyan Factory will be the first zero-carbon industrial park of Danfoss in China.

The micro DC grids, maglev compressors, frequency converters and other products produced by the Danfoss Haiyan Factory will all be applied and lay a solid foundation for building the zero-carbon industrial park. It is expected that in the next 5 years, the successful implementation of this project will promote the rapid development of the enterprise, and the annual output value of Danfoss Haiyan Factory will increase from 3 billion yuan to 6 billion yuan.

1.2 Innovation

Danfoss Haiyan factory covers an area of about 39,333 square meters, with an annual power consumption of 26.21 million kWh, 50t of diesel for heating in winter, and an annual output of about 7 billion yuan. Danfoss Haiyan Factory Comprehensive Energy Pilot Project plans to use 4 workshops, 3 of which are color steel tile roofs with an area of 28,400 square meters, and 1 is a concrete structure with an area of 5,000 square meters. Through the construction of a 3.2MW rooftop photovoltaic, 9.3MW distributed wind turbine, 1MWh energy storage and other power projects, as well as new technologies and products of Danfoss, such as ground source heat pump, inverter air conditioner transformation, Danfoss DC micro-grid, maglev compressor, dynamic control management technology of "power source, grid, load , storage and complement" can be done.

1.3 Implementation goals

The implementation of this project will achieve a self-sufficiency rate of 84.1% in clean energy power supply, which can reduce carbon emissions in the area and make contribution to GDP. In the later stage,

according to the planning and design, the development and construction of new energy will be increased, and finally the zero-carbon operation of the factory will be achieved.

II. Solution of High Efficiency

Project construction content: considering the renewable resources of the project site, land resources and the load of the park, after on-site survey and analysis of noise and safety, the zero-carbon industrial park of Danfoss Haiyan Factory is planned to be constructed in the park as follows:

No.	Equipment Name and Specification	Quantity (set）
1	9.3MW wind power system（2*WH4.65-182）	1
2	3.2MW photovoltaic	1
3	250kW/1MWh energy storage system	1
4	micro grid control system	1
5	Intelligent energy scheduling management platform	1
6	Dc distribution network system	1
7	Chilled water storage system	1
8	Waste Heat Recovery and ground source heat pump	1
9	Charging pile	8
10	Environment and energy consumption monitoring system	1

2.1 Wind turbines:

According to the wind speed data measured by the wind tower, it is determined that the turbines meeting IEC standard IIC type and above can be used in the project site. According to the wind resources of the wind farm and the wind measuring tower, as well as the wind speed in the field, Shanghai Electric WH4.65N-182 wind turbines will be selected for this project.

Specification		W4.65-182
Rated Power	MW	4.65
rotor diameter	m	182
Hub height	m	105
Safety level		IEC S
Cut-in wind speed	m/s	3
Rated wind speed	m/s	9.1
Cut-out wind speed	m/s	20

Extreme wind speed	m/s	52.5
Design lifetime	year	20

Figure 2-1 Main parameters of wind turbine

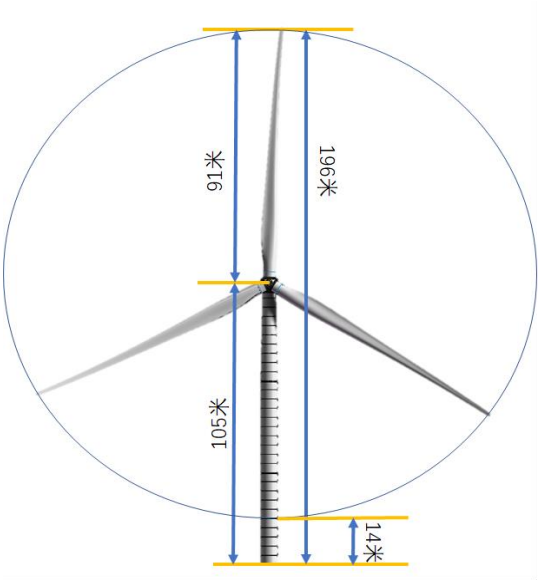

Figure 2-2 Schematic diagram of the height of the turbine (unit: m)

In addition, the noise and other impacts on the environment are fully considered, and the turbine location selection is shown in Figure 2-3. The distance from the noise sensitive point meets the IEC/GB double standards. The wind turbine position and the electrical wiring of the park meet the requirements.

Figure 2-3 Site selection

Figure 2-4 Schematic diagram of land occupation

2.2 Rooftop photovoltaic in the park

Taking into account the power generation and the usable area of the roof, 144 half-piece 450Wp high-efficiency monocrystalline silicon cell modules are selected for this project. The photovoltaic modules are arranged on the roof with fixed brackets, the photovoltaic modules on the concrete roof are installed with fixed brackets, and the optimal photovoltaic inclination angle is 20 degrees. The total capacity of the system is 3.2MW, and a total of 7110 photovoltaic modules need to be installed.

The specific arrangement of PV modules is shown in Figure 2-5：

Figure 2-5 Arrangement of PV modules in rooftop

2.3 Energy Storage System

The energy storage system of this project adopts a containerized layout scheme. 1 set of 250kW/1MWh energy storage system is configured in the plant area, and a 20-foot 250kW/1MWh container energy storage system of Shanghai Electric is used. The container energy storage system adopts the design concept of all-in-one, and organically configures multiple subsystems such as lithium iron phosphate battery module, battery management system, energy storage bidirectional inverter, fire protection

system, and environmental control system in a standard container. It can implement the functions of valley power consumption, demand control, power distribution capacity expansion, backup power supply and other functions.

Figure 2-6 Schematic diagram of a 20-foot battery container

2.4 DC distribution network system

By using the DC distribution network equipment produced by Danfoss Haiyan Factory, the flexible smart DC micro grid system is optimized to integrate modular rectifiers and hybrid output AC-DC converters. New energy, green energy and storage energy are directly connected to the public DC bus system, eliminating the commutation link of DC to AC and the synchronization risk of AC grid connection. The regenerative energy can be transferred and recycled directly on the DC bus.

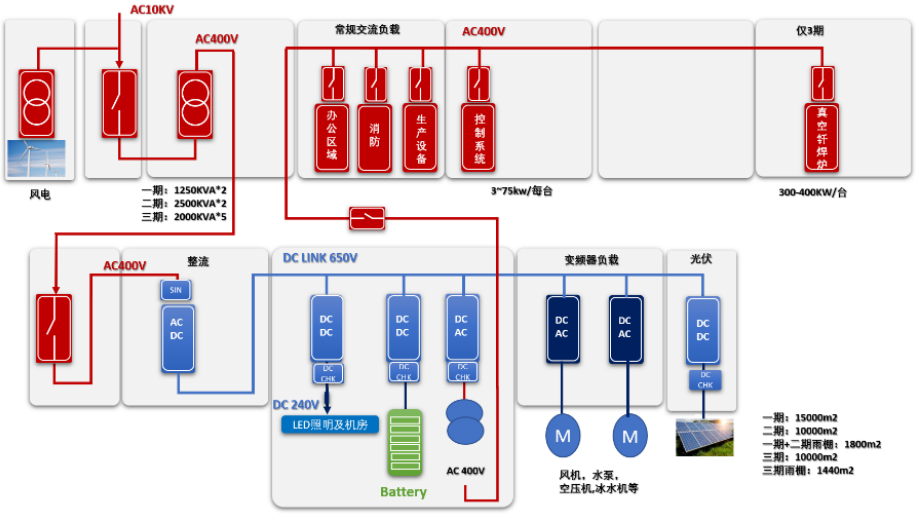

Figure 2-7 Electrical topology diagram after reconstruction

2.5 Chilled water storage system

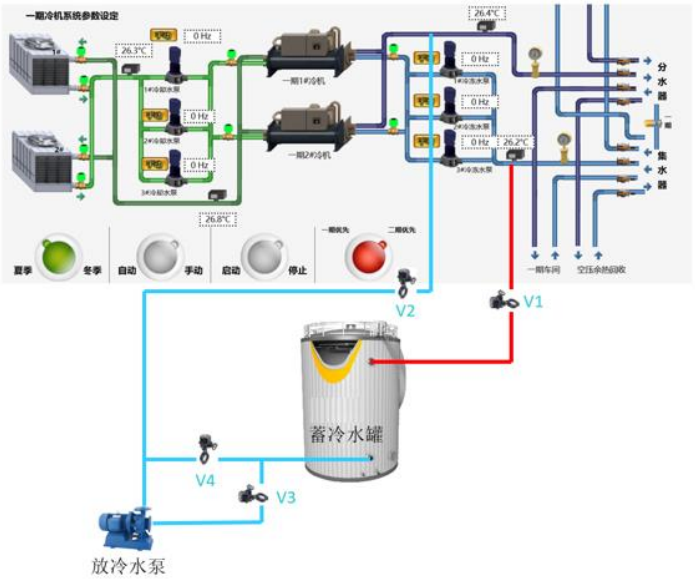

Figure 2-8 Schematic diagram of chilled water storage system

Chilled water storage technology is used for time-of-use pricing. During the peak power consumption phase, the chilled water storage system provides the required cooling capacity for the factory. It can not only increase the cooling load range of the refrigeration unit, but also stores cooling energy in the valley power consumption phase, saving the operating cost of the refrigeration unit.

Figure 2-9 Schematic diagram of the photovoltaic carport

2.6 Photovoltaic carport

This project includes 8 sets of charging piles, 4 sets of fast charging and 4 slow charging, and also includes the outdoor cabinet of energy storage to operate with the charging piles. The carport is also

equipped with floor locks, cameras and other monitoring equipment. The overall appearance of the carport is beautiful and has a strong sense of technology.

2.7 Smart energy dispatch management platform

The smart energy dispatching management platform is the core of the entire project system. It is a platform for managing and controlling the entire life cycle of "power source, grid, load, and storage" and the entire life cycle of carbon assets. It can take full use of scientific scheduling and complementary advantages among various energy sources, cascade utilization of various energy sources, highly-efficient utilization of comprehensive energy, as well as overall carbon footprint tracking, management and transaction of carbon asset.

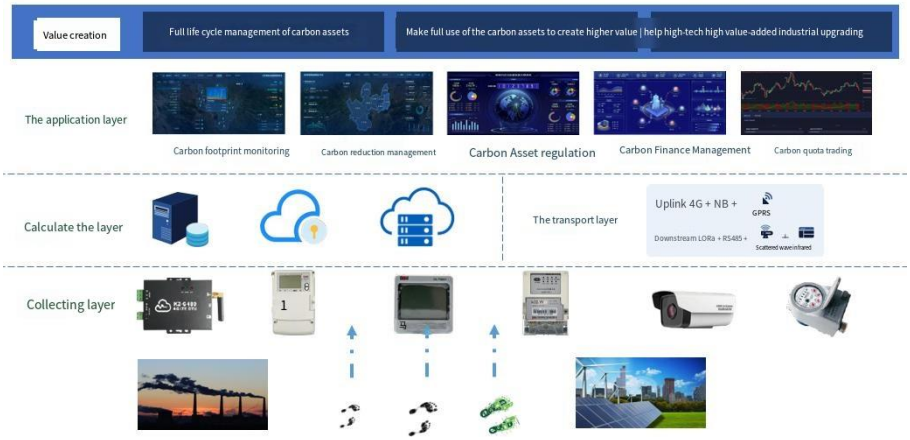

Figure 2-10 Schematic diagram of the carbon asset management

III. Experience and Practice

3.1 Establish a pilot project integrating wind power,photovoltaic power and power storage

Fully considering the impact of new energy development on the safe and stable operation of the power system and reliable power supply, and adjusting the power grid planning and construction in time to meet the development needs of wind power and photovoltaic power, the "zero carbon project" of Danfoss Haiyan Factory is an integration of wind power, photovoltaic power and power storage. It is deeply in line with China's "3060 carbon goal", implement the new energy security strategy of "four revolutions and one cooperation", fully implement China's green development concept, and accelerate the construction of a new power system with new energy as the main body. In addition, the project promotes the concept of high-quality development of new energy based on maritime wind power and photovoltaic power generation.

3.2 Promote the cooperation and complementation of domestic and foreign advanced technology

The cooperation mode of Shanghai Electric investment and Danfoss products, will expand future energy market by trillion yuan. Shanghai Electric, as a large domestic energy equipment and automation control equipment manufacturers, has highly technological complementarity with Danfoss in the process of energy transformation. The two parties can make full cooperation in promoting "power source, grid, load and storage, and multi-energy complement development" related pilot projects, making deep coupling in power generation and power consumption.

IV. Low Carbon Effectiveness

The implementation of this project provides 23.32 million kWh of new energy for Danfoss Haiyan Park every year, achieving 84.1% self-sufficiency rate of clean energy power supply. At the current level of electricity fee, it can save about 32.97 million yuan for the whole life cycle of Danfoss Haiyan Factory, and save about 11.14 million yuan of electricity fee for the maximum demand. In addition, considering the carbon price of 40 yuan/ton, the annual carbon value of Danfoss Haiyan Factory will be about 850,000 yuan. According to the coal consumption of thermal power (standard coal) of 305.5g/kWh, the project can save 0.84 million tons of standard coal every year, and correspondingly reduce the emission of various air pollutants every year, including 27,377.62 tons of carbon dioxide (CO_2), 823.8 tons of sulfur dioxide (SO_2), 411.9 tons of nitrogen dioxide (NO_2) and 7,469.12 tons of soot, making contributions to low carbon emission in Haiyan and low energy consumption per unit GDP. In the later stage, according to the planning and design situation, the project will enhance the development and construction of new energy, and finally achieve the zero-carbon operation of the factory.

The successful implementation of zero-carbon industrial park of Danfoss Haiyan Factory will also bring great social benefits, demonstrating that industrial enterprises can quickly achieve carbon neutrality by making full use of existing energy efficiency and new energy technology. The project is also expected to be a nationwide even worldwide model project for the development of zero carbon factories.

V. Problems and Suggestions

In the current advancement process, there are no relevant design standards and specifications for the DC micro grid. As for the design stakeholders and reviewers, they are facing new issues in system simulation, relay protection, transient analysis, etc. In the design and approval process of the access system, more detailed communication and innovative thinking are required. In the future, Danfoss and Shanghai Electric will jointly develop the group standard for the DC distribution network and upgrade it to the industry standard, laying the foundation for the promotion of this new technology.

In terms of implementation, the approval and filing should be carried out according to the requirements of each element because the project involves various energy forms such as wind power, photovoltaic, and energy storage. It’s suggested that the unified package approval of the project can not only meet the needs of technological development, but also simplify the procedures and facilitate management.

VI. Future Work Plans

The project has started construction since June 2022, up and running in 2023.

The two parties will work together and strive to make the project a model project in the field of carbon emission peak and carbon neutrality, and actively share experience with all sectors of society to jointly promote the achievement of China's “3060 carbon goals”.

3.3 Delingha 10MW+50MW Tower Concentrating Solar Power Station

I. Technical Breakthrough

Delingha 10MW tower Concentrating Solar Power (hereinafter referred to as “CSP”) station of Qinghai Zhongkong Solar Energy Corporation is located in Delingha City (as known as the city of sunlight on the Qinghai-Tibet Plateau), Haixi Prefecture, Qinghai Province. It was invested and constructed by Xizi Clean Energy in 2013 and put into operation in 2016. The installed capacity of the power station is 10MW, and the tower-type water/molten salt binary refrigerants technology is adopted. The solar field contains 21,500 helioscopes of 2 ㎡ and 1,000 helioscopes of 20 ㎡. It is the first large-scale thermal storage CSP station successfully put into operation in China, and the third in the world.

Based on the outstanding performance of the 10MW tower molten salt CSP project, Xizi Clean Energy has invested in the construction of Delingha 50MW molten salt tower CSP station in Qinghai Province, and undertook the research, design and manufacture of the molten salt heat absorption system and molten salt heat exchange system. The project was connected to the grid for power generation successfully in 2018. Xizi Clean Energy’s energy storage technology (high-power molten salt heat absorber and molten salt steam generation system suitable for solar thermal and thermal storage systems), was shortlisted as the first major technology equipment project in energy field in 2021 issued by the National Energy Administration.

Figure 1 Delingha 10MW Tower Concentrating Solar Power Station

Delingha translates as “golden world” in Mongolian. Thirty years ago, there was a desolate gobi. Today, under the brave and arduous struggle of Xizi Clean Energy and other engineers, the city of sunlight

shines even more brightly.

Table 1 Main technical parameters of Delingha 10MW CSP station

Installed capacity	10MW
Thermal storage time	2h
Covers an area of	250,000M^2
Lighting area of solar field	63,000M^2
Number of heat absorption towers	2
Refrigerant	Water and molten salt
Design point (vernal equinox day) photoelectric efficiency	15.9%
Salt temperature of molten salt heat absorption outlet	568℃
Main steam parameter	8.83MPa，510℃

Table 2 Main technical parameters of Delingha 50 MW CSP station

Installed capacity	50MW
Thermal storage time	7h
Covers an area of	2.47 KM^2
Lighting area of solar field	542,700M^2
Center height of absorber	200M
Usage of molten salt	10,093Ton
Main steam parameter	8.83MPa，510℃
Annual power generation in typical weather	146 million kWh

II. Construction and Operation

Delingha 10MW tower CSP station was officially put into operation in July 2013. With the adoption of

direct steam generation (DSG) technology, it is the first tower-type solar thermal power station successfully put into commercial operation in China and the sixth tower-type CSP station in the world. In August 2016, the power station's molten salt heat absorption, heat storage and heat exchange system was put into operation, making it the first commercial tower-type CSP station with large-scale energy storage system in China and the third in the world.

In September 2014, the power station was approved by the Chinese National Development and Reform Commission for the feed-in tariffs of 1.2 yuan /kWh, which was also known as the "first price of solar heat" in China at the time.

The power station is located in Delingha, Haixi, Qinghai Province, with an installed capacity of 10MW and currently operates with tower DSG/ molten salt binary refrigerants. The lighting opening of the power station's solar field covers an area of 63,000 ㎡, including 21,500 helioscopes of 2 ㎡ and 1,000 helioscopes of 20 ㎡. The designed point power generation efficiency is 15.7%.

After the molten salt energy storage system was put into operation on August 21, 2016, the power station were soon in stable operation. According to the cumulative power generation curve of the power station, the cumulative power generation curve is very consistent and in a continuous rising state, which proves that the power station didn't experienced long-term shutdown caused by major equipment failure. As of February 28, 2018, the power station had been in stable operation for 18 months, with a total power generation of 384 days and a total power generation of 11.86 million kWh, completing 86.7% of the designed power generation (theoretical power generation predicted by the performance model).

III. Innovation of Design

3.1 Hot molten salt storage system with high temperature, high efficiency and large capacity

The project adopts tower molten salt energy storage CSP technology with independent intellectual property rights. Compared with similar projects built in China, the technical route, performance and reliability of the project remain in the lead, and more than 95% of the equipment has been localized.

The Delingha 50MW tower concentrating solar power station is equipped with a 7-hour molten salt heat storage system, which has achieved more than 24 hours of continuous power generation. From August 13 to 16, 2019, the power generation reached a maximum of 75 hours of continuous power generation, and the cumulative power generation of a single non-stop power generation reached 2.407

million KWH, which was equivalent to more than 48 hours of continuous power generation at full load.

3.2 Layout of compact modular power generation area with economical land use

The power generation area is mostly round, and the heliostat is arranged close to the heat collecting tower, so the utilization rate of the power generation area is more than 70%. The molten salt power generation area covers an area of 3.14 hectares with a diameter of 190 m. Meanwhile, the land for the central power generation area is much smaller.

The modular layout is mainly reflected in the turbine generator set is arranged in the turbine room, the steam generator is arranged in the heat storage and exchange area, the upper and lower high temperature pipes and air compressor room are arranged in the tower, and the heat storage and exchange distribution area and other equipment is set independently, What's more, the auxiliary factory buildings and ancillary buildings are merged and adjoined.

The compressed air room is arranged in the heat absorption tower, saving the project land. The 220-meter high heat absorption tower adopts independent steel structure for the inner support and concrete structure for the outer tower, which controls the construction progress to the greatest extent and indirectly saves the project cost. This concept is the first of its kind at home and abroad.

Figure 2 Close shot of the power station

3.3 Various operation modes and complex thermal system

The project switches the final high steam source to the higher pressure position of the high-pressure cylinder in the low load stage. When the system parameters are further reduced, the additional low-load preheater is put into operation. Compared with the traditional turbine that uses main steam as the heating steam source, this method improves the comprehensive and economical efficiency of the system.

A complete auxiliary steam system for start-up and shutdown is designed. The auxiliary steam source

is generated by the steam generation system in the short shutdown stage at night. These thermal systems are designed to allow the system to be out of service for several months in thermal backup mode.

3.4 Innovation of design on molten salt system

Considering the cold location of the power station, the wind and sand and other factors, the steam generator system is arranged in a simple workshop, with the arrangement of molten salt tank pit. All molten salt pipes and equipment are set up with electric heat tracing, so preheating and anti-condensation can be done.

The design of supports and hangers such as molten salt pipeline springs takes special working conditions into consideration, and reasonable models are selected to guarantee the safety of the molten salt pipe, and ensure that the slope of the pipeline can safely loose the molten salt in cold state, hot state and systematic hot standby state, avoiding problems such as excessive spring reaction force under special circumstances, and the invalidation of austenitic stainless steel welds in long-term high-temperature operation.

3.5 Development of control system and operation mode

The project adopts the automation network composed of solar field control system (SCS) and decentralized control system (DCS) to follow the design principles of decentralized control function and centralized information management.

Collaborating with local inspection personnel, the operators complete monitoring and control with LCD/ keyboard in control room. The control system can automatically complete the start and stop of the unit, normal operation monitoring and control, and abnormal working condition processing with a little intervention of the on-duty personnel.

Figure 3 Aerial view of power station

3.6 Core technology reaches international leading level

According to previous public reports, the power generation rate of tower molten salt CSP stations in other countries is generally about 50% in the first year, and about 90% in three or four years. During the period of one month from July 17 to August 16, 2019, the cumulative generating capacity of the Delingha power station reached 12.5823 million KWH, and the theoretical generating capacity during the same period was 13.8635 million KWH. The monthly generating capacity achievement rate was 90.76%, and the average generating capacity achievement rate of the week from August 9 to August 15 was 97.65%. After 3 months of full load operation, the power station achieved the monthly power generation rate of more than 90%, which was sufficient to prove that the core technology and the operation and maintenance had reached the international leading level.

IV. Economic and Social Benefits

4.1 Excellent design quality and advanced operation indicators

From August 6, 2021 to August 5, 2022, Qinghai Delingha 50MW molten salt tower photothermal power station has a total annual cumulative actual power generation of 158 million kwh, reaching 108% of the annual design power generation, achieving the world's highest operating record for power plants of the same type.

4.2 Green environmental protection and carbon reduction, win-win economic and social benefits

The calculation of the project's annual power generation is about 146 million KWH. According to preliminary calculation, it will replace coal by about 46,000 tons annually, SO_2 emissions by about 43 tons, NOx by about 43 tons, soot by about 13 tons, and CO_2 emissions by about 121,000 tons, contributing to the carbon emission work. In addition, it also reduces noise generated by coal-fired power plants, and the environmental and ecological impacts caused by transportation and disposal of fuel and ash. Furthermore, the project will transform the original gobi wasteland into industrial land, bringing considerable economic and social benefits to the local area.

V. Analysis of Problems and Rectification

According to the statistical analysis, the main factors of power generation failing to meet the full designing value include equipment failure, extreme weather and operational differences. Among them, equipment failure is the most important factor. Power generation deviation caused by equipment failure accounts for 68.96% of the total deviation; operation failure accounts for 20.44%; and extreme weather accounts for 10.6%. After adjusting for equipment failures, the power plant's operating rate for the most

recent year was 96.6%.

In terms of equipment, the failure rate of heliostat and conventional island is very low, especially the actual annual failure rate of heliostat was less than 5%, but there were many small failures of molten salt equipment at the beginning of operation, which affected the power generation. The causes of equipment failure include design, equipment selection, and lack of operating experience. With the gradual rectification, as well as the gathering of operation experience, the equipment operation had been stable, and the power generation deviation caused by equipment failure had been greatly reduced.

In the early stage of operation, because of the lack of molten salt storage system operating experience, the operation team chose a more conservative operation strategy. While with more operating experience, the team had done a lot of optimization in the preheating time, heating rate, cloud strategy, plant opening and closing and so on, therefore, the generating deviation was significantly reduced.

Extreme weather, such as snow, frost and wind, also has great impact on power generation, which is determined by the special natural environment of high altitude and cold in northwest China. In the future, the performance model can be modified according to the actual situation of different project locations to reduce deviation.

VI. Future Work Plans

Through the construction and operation of two CSP station projects in Delingha, it is proved that clean energy based on molten salt energy storage technology plays an important role in the development of modern new energy system. With formulation of the “new energy + energy storage” strategy, a series of adjustments will be carried out around it:

(1) The developer of CSP will carry out research with universities and institutes, cooperate with new energy enterprises, continue to make efforts in clean energy construction, and put the cooperation achievements into practice;

(2) On the basis of analyzing problems and summarizing experience, CSP will actively develop and improve relevant technical specifications and standards, and form a technical specification and standard system for the whole life cycle of design, construction, operation and maintenance, to provide a reliable normative basis for the promotion of achievements and experience;

(3) The developer of CSP improve the operation and maintenance, continuously enhance the operation quality of the station, give full play to the production benefits in a stable and efficient manner, to achieve the “3060 carbon goal”.

Chapter 4 Agriculture

4.1 Construction and Management System of Zhongcha Longguan Ecological Low-carbon Tea Garden

I. Innovation of Ecological Tea Garden

1.1 Background

Zhongcha Longguan is a leading agricultural enterprise integrating the cultivation, processing and sales of Longjing tea (a kind of green tea as well as the most popular tea in China). The Longjing tea of Longguan has been the designated tea for foreign affairs of the State Council of China, and become the assigned products in various international conferences. The company has high-standard clone tea gardens covering more than 200,000 m^2 in Chun'an County, one of the 74 national pilot counties with key ecological function and the first privileged ecological function zone in Zhejiang Province. The tea gardens drive the development of surrounding areas of more than 350 million m^2. Over the years, Zhongcha longguan has been committed to the construction and development of ecological low-carbon tea garden as an important way to implement the "30 60 carbon goals".

The work of ecological low-carbon tea garden was awarded the certification of the first batch "National Ecological Low-carbon Tea Garden" and highly recognized by governments at all levels in Zhejiang Province. The company's processing factories and tea gardens were recognized as the first batch of "Zhejiang Standardized Famous Tea Factory" and "Zhejiang Provincial Demonstration Tea Garden" by Zhejiang Provincial Department of Agriculture and Rural Affairs.

证书编号：ELCT-0001-2022

生态低碳茶认证证书

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认证范围：

基地名称	基地地址	基地面积	加工厂地址	产品名称	产量
下形源种植园	浙江省杭州市淳安县文昌镇潭头村	20.67公顷	浙江省杭州市淳安县文昌镇潭头村潭头 28 号	绿茶（龙井茶）	4.0 吨

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Figure 1　The Certification of the First Batch of National Ecological Low-Carbon Tea Garden

1.2 Significance of implementation

China has made it clear that it will strive to reach carbon peak by 2030 and achieve carbon neutrality by 2060, which is a major strategic decision made by the CPC Central Committee. The “3060 carbon goals” strategy has been incorporated into the overall layout of ecological development in China and it’s also the internal needs of China’s green and high quality development. To achieve the goals, not only puts forward new requirements for low-carbon emission reduction in fields such as industry and energy, but also in agricultural field such as tea industry.

At present, there are still some shortcomings in China’s tea industry in promoting green production and protecting ecological environment. First, the technical system for protecting and utilizing the ecological environment is not perfect. For a long time, due to the lack of ecological technologies and standard systems, some tea gardens aren’t committed to the philosophy of ecological priority and green development, resulting in single biodiversity, high risk of soil erosion and the fragile ecological environment. Second, the coverage of green production technology needs to be further expanded. Some tea gardens still rely on chemical inputs, and have problems such as excessive use of fertilizers or unscientific ratio, soil acidification and degradation, insufficient fertility, and excessive application of chemical pesticides and herbicides. Third, the single and imperfect implementation mechanism of

ecological value. In this context, Zhongcha Longguan took the lead in carrying out the construction and certification of ecological low-carbon tea garden according to relevant standards, which is of great significance to continuously increase tea farmers' income, promote the quality and efficiency of tea industry development, and support the "3060 carbon goals" and rural revitalization.

1.3 Innovative ideas

Research shows that the tea garden ecosystem is a high carbon flow system with high carbon input and output. Implement ecological low-carbon tea technology, limit the excessive and unreasonable application of chemical fertilizers and pesticides, guide rational planning and utilization, as well as carry out a series of carbon sequestration measures such as planting trees and grass, can enhance the carbon sequestration function of tea garden ecosystem by at least 12.1t CO_2 ha^{-1}. In addition, in the process of tea processing, by changing the use of traditional coal and other energy sources, tea companies are guided to use clean energy such as electricity and natural gas, so that each 1kg of dry tea produced can reduce 42.9kg of CO_2emissions. Therefore, through the construction of ecological low-carbon tea garden, greenhouse gas emissions in the processes of garden management and tea production can be significantly reduced, to achieve carbon sequestration and emission reduction.

Through ecological low-carbon tea garden management technology and reducing fertilizers and pesticides, Zhongcha Longguan has improved the disease and pest control and the quality and safety of tea products, created a demonstration model for green and low-carbon development of tea industry, and made its' own contribution to green and high-quality development of the whole industry.

1.4 Implementation objectives

The construction of ecological low-carbon tea garden will increase tea farmers' income, promote the quality and efficiency of tea industry development, and support the "3060 carbon goals" and rural revitalization.

II. Overview

2.1 Technical proposal

2.1.1 Scheme design

According to the *Guidance for Ecological Low-carbon Tea Garden Construction* and other relevant standards, the site conditions, soil, atmosphere and existing tea garden management technology scheme of the tea garden base are tested and evaluated, and on this basis, the ecological low-carbon tea garden construction scheme is formulated.

2.1.2 Main indicators

According to relevant statistics, the total annual CO_2 emissions of tea gardens nationwide reach 9.9

tons/ha (Chen et al., 2021). Based on the carbon emission calculation standards and methods formulated by the United Nations Intergovernmental Panel on Climate Change (IPCC), the carbon emission amount of tea garden is calculated, and the total annual CO_2 emission target in the process of tea planting and garden management is formulated according to actual situation. On this basis, the key technical indicators affecting carbon emissions, such as fertilization, pest control and other agronomic measures are listed, and technical indicators that meet the requirements of ecological low-carbon tea garden are formulated. The main control technical indicators are as follows:

The ecological land area shall not be less than 10% of the total area; plant trees around the tea garden or in areas not suitable for tea planting; plant street trees on both sides of main roads and ditches, with more than 50 trees per hectare;

The amount of nitrogen fertilizer (converted into pure nitrogen) should be under 15 kg/mu; potassium fertilizer consumption (equivalent to K2O) should below 3 kg/mu[26];

The amount of phosphorus fertilizer (equivalent to P2O5) should below 3 kg/mu, and the amount of nitrogen fertilizer should be no less than 30% of organic fertilizer;

Use green pest control technology, and the annual chemical control times should not exceed twice.

2.1.3 Establish technical systems

Centering on the technical indicators, taking the influencing factors such as the input and output of tea garden and the quality of raw materials into account, 6 standard systems have been established, and then a set of management standard system of ecological low-carbon tea garden has been completed.

2.1.4 Certification and management

The company applies for the third-party ecological low-carbon tea garden certification, improves the construction and management system through the certification, and further promotes sustainable development.

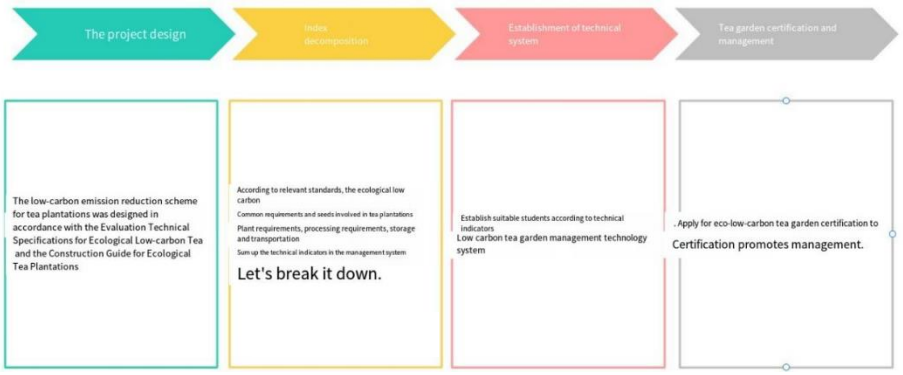

Figure 2 Technical Road Map of Ecological Low-Carbon Tea Garden Management System

[26] Mu: a unit of area (=0.0667 hectares)

2.2 Main construction contents

2.2.1 Standard systems of ecological low-carbon tea garden management technology

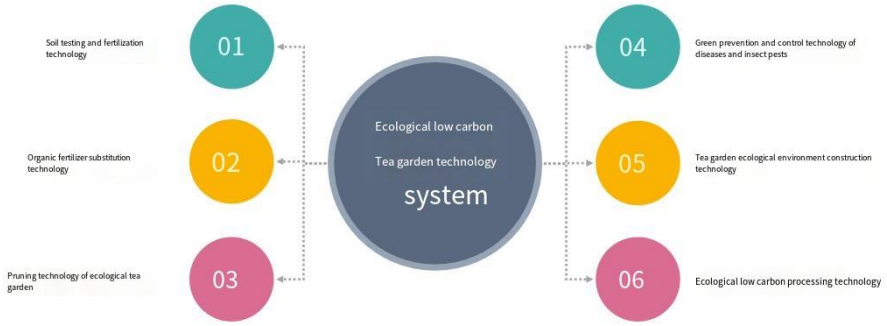

Figure 3 Standard systems of ecological low-carbon tea garden management technology

2.2.2 Development of smart management platform

Traditional tea garden agronomic management measures are combined with Internet of things technology to build an intelligent management platform in ecological low-carbon tea garden. Through the systematic integration of real-time monitoring of meteorological factors, soil moisture, nutrients and pest monitoring data, the monitoring data is uploaded to the backstage for statistical analysis, then targeted management plans for fertilization, pest control and so on are formulated, to achieve the precise control, cost-saving, high efficiency and ecological low-carbon goals.

2.2.3 Publicity and application of the standard systems

The publicity and promotion of the standard systems is carried out through regular training and other ways among more than 2500 households of tea farmers.

Figure 4 Ecological Low-carbon Tea Garden with IOT Intelligent Management Platform

III. Experience and Practice

3.1 Innovation of ecological low-carbon tea garden management and construction systems

According to the transformation of international carbon emission standards, with ecology and low-carbon as the main goals, the technical indicators and the first national technical standard systems for ecological low-carbon tea garden are formulated, and the related technologies and management system will be continuously improved through third-party certification.

3.2 Integration of ecological low-carbon and IOT technology

IOT technology can help make real-time monitoring and analysis of data such as meteorological factors, soil moisture, nutrients and pest monitoring, to achieve dynamic and accurate grasp of the relevant data, and timely assist the management personnel to formulate and adjust related technical measures.

3.3 Publicity and promotion of achievements

Tea industry plays an important role in promoting rural revitalization and common prosperity, especially Longjing tea, which has relatively high popularity and economic benefits in China's tea industry. Therefore, the publicity and application of ecological low-carbon technology in Longjing tea gardens has a strong publicity effect on carbon peak and carbon neutrality in agricultural field.

IV. Implementation and Effectiveness

4.1 Economic benefits

The input of fertilizer, pesticide and labor is reduced, the quality of tea products is improved, and the per mu income is increased by more than 15%.

4.2 Ecological benefits

The annual CO_2 sequestration reaches 6.4 tons/ha, and the carbon sequestration measures such as planting trees and grass around the tea garden achieve the annual CO_2 sequestration of about 2.5 tons/ha. Therefore, the annual CO_2 sequestration in the tea garden ecosystem reaches 8.9 tons/ha, bringing ecological benefits of carbon sequestration and emission reduction in the ecosystem.

4.3 Sustainable development benefits

The construction of ecological low-carbon tea garden can reduce carbon emissions, improve carbon sequestration level, and promote sustainable development of the tea industry.

V. Future Work Plans

5.1 Continue to improve the standard systems for ecological low-carbon tea garden

At present, the construction of ecological low-carbon tea garden is still in its initial stage, and the technology and management systems are not perfect enough. The adaptability of some technical indicators needs to be further verified. In the next step, combined with publicity and promotion,the technology and management standard systems will be continuously optimized.

5.2 Continue to strengthen the application of new technologies and equipment in ecological low-carbon tea garden

In the industry, related new technologies and equipment are emerging. With the help of the company's Chen Zongmao expert team, Tea Research Institute of Chinese Academy of Agricultural Sciences and other science and technology service platforms, the application of new technologies and equipment in ecological low- carbon tea garden will be enhanced.

5.3 Accelerate the publicity and promotion of ecological low-carbon technology

The construction and management of ecological low-carbon tea garden is an important method for promoting the high quality development of tea industry in China. Zhongcha Longguan strives to create ecological low-carbon tea product, publicize the awareness of ecological low-carbon production and consumption through labels and logos, promote the green and high quality development of the tea industry, and make contribution to "3060 carbon goals", rural revitalization and common prosperity.

Chapter 5 Service Sector

5.1 Certification of SGS Green and Low Carbon Management System

I. Certification of Management system on green & low carbon logistics and zero waste to landfill

1.1 Background

As one of the world's largest carbon emitter, comparing with developed countries, China is still in an important development stage of accelerating development and improving people's livelihood. Dr. Ding Zhongli, academician of the Chinese Academy of Sciences, once said that emissions are inevitable in the process of development, the problems of emission are essentially development issues, and emissions rights are the rights to development.

Despite this, China still made a commitment to the carbon emission peak and carbon neutrality 3060 goals[27] to the international community in September 2020. It reflects China's promise to addressing climate change from a global perspective, and to building a community with a shared ecological and human future.

1.2 SGS action

As a member of the World Business Council for Sustainable Development (WBCSD), SGS Group actively supports the Council's efforts to improve environmental protection industrial policies and behaviors. SGS China adheres to the concept of sustainable development and has always been committed to promoting green & low-carbon development. In early 2022, SGS China completed the development of green low-carbon management system standards for China's national conditions and current circumstance: *Green & low-carbon logistics management system* (Q/SGS-CSTC GLCL 01-2022) and *Zero waste to landfill management system* (Q/SGS-CSTC_ZWL_01). It is hoped that by promoting this work, SGS's support for achieving the carbon neutrality goal and commitment to

[27] At the general debate of the 75th session of the United Nations General Assembly in September last year, China announced that it would aim to achieve peak CO_2 emissions before 2030 and carbon neutrality before 2060.

environmental protection will be achieved.

1.3 Implementation significance

1.3.1 Low carbon logistics management system

Logistics is a key area for China to achieve the carbon neutrality goal. For China's logistics industry, the 3060 goal is not only a major challenge for the development of the industry, but also an important opportunity for the green transformation of the industry, which greatly enhances the urgency and enthusiasm of the industry to promote carbon emission reduction.

Logistics, as a link connecting all industries, have a significant impact on the environment. Green and low-carbon logistics is an important part of today's sustainable economic development. It is an inevitable requirement to cope with global economic integration and sustainable development, promote the construction of relevant standards for enterprises and groups, pursue green and low-carbon development by industries, and achieve the 3060 goals. It is of great significance to the continuous development of social economy and the improvement of human quality of life.

1.3.2 Zero waste to landfill management system

According to the statistics of 2020, the annual production of general industrial solid waste in China was 3.68 billion tons, the comprehensive utilization was 2.04 billion tons, and the disposal was 920 million tons. Among them, 19.6% of the waste was not disposed of environmentally, and 720 million tons of waste were stacked and stored. The accumulated solid waste stock in history is about 60 billion tons. In 2016, 33% of the global waste was dumped in the open air, which was not disposed in an eco-friendly way. A large amount of waste has not been properly disposed, such as temporary storage, open-air dumping and landfill, resulting in serious unnecessary land occupation and soil & groundwater pollution.

In December, 2018, General Office of the State Council of the People's Republic of China issued the pilot work plan for the development of Waste Free City. Waste Free City is a city development model guided by the concept of innovation, coordination, green, openness and sharing, which promotes the formation of a green development mode and lifestyle, continues to promote the source reduction and resource utilization of solid waste, minimizes the amount of landfill, and reduce the environmental impact of solid waste.

1.4 Implementation objectives

The standard of *Green & low-carbon logistics management system* is developed based on the aims of the 3060 goals and the needs of logistics enterprises for carbon emission reduction and sustainable development. The standard is developed to solve the multiple internal pressures faced by logistics enterprises, such as low energy efficiency, high operating costs and backward information technology. The standard also helps enterprises reduce energy consumption throughout their life cycle, promotes green & low-carbon enterprises, and assume corporate social responsibility.

The standard of *zero waste to landfill management system* is a comprehensive system based on optimizing the organization of waste management. The standard integrates the conventional experience of international waste management, development requirements of the Waste Free City, and national laws and regulations, as well as the best waste treatment practice.

The objectives of standards is to help enterprises and all stakeholders understand the risks of waste management and effectively control waste, find the best plan for waste management, reduce and eliminate enterprise costs, and promote the sustainable development of environment and economy.

II. Specific Contents of the Management System

2.1 Green & low carbon logistics management system (Q/SGS-CSTC GLCL 01-2022)

2.1.1 Scope

The standard stipulates the requirements for the organization to establish, implement, maintain and improve the green low-carbon logistics management system, aiming to enable the organization to integrate the development of green & low-carbon logistics into the organization's operation process through a systematic method, reduce the impact of all process in the logistics process on the environment, and make contributions to the sustainable development of society. The standard applies to organizations of any size, type and activity, and to activities that affect process logistics managed and controlled by the organization. This standard can be used alone, or coordinated & integrated with other management systems. This standard can be used in whole or in part to systematically promote green and low-carbon logistics activities. At present, there is no comprehensive standard for green & low-carbon logistics management system and certification evaluation at home and abroad. The only green logistics related standards are about the indicators and accounting method. As the logistics industry continues to pay more attention to sustainable development, the green and low-carbon management of the logistics industry needs the joint certification and improvement of the whole supply

chain. This standard will strive to establish the first set of green and low-carbon scoring standards consistent with the logistics industry, and achieve the comprehensive evaluation of green and low-carbon logistics management.

The standard includes the following contents:

(1) Contents and requirements of green & low-carbon logistics management system;

(2) The five aspects of evaluation indicator system of green & low-carbon logistics management: strategy and target indicators; environmental impact indicators; green & low-carbon logistics indicators; green facilities and equipment indicators; information management indicators;

(3) Certification content and requirements of green & low carbon logistics management system.

2.1.2 The enterprises carry out green and low-carbon logistics management system certification

The enterprise reviews and certifies according to the content of the green & low-carbon logistics evaluation indicator system.

2.1.2.1 Description of green & low carbon logistics evaluation indicator system

The evaluation indicators meet the following principles:

a) Comprehensiveness and systematization - the scope that the evaluation indicator should cover, and the evaluation indicators are comprehensive, systematic and clear in level;

b) Being quantifiable and measurable - the evaluation indicators should be quantifiable and measurable to meet the needs of quantitative analysis and objective evaluation of the organization's green and low-carbon logistics management capability;

c) Independence and representativeness - evaluation indicators should be relatively independent and representative. Indicators and weights should reflect the characteristics of products (or industries) and highlight the important green attributes of organizations (or industries).

2.1.2.2 Indicator framework and requirements of green & low-carbon logistics evaluation indicator system:

a) The evaluation indicators of green & low-carbon logistics management are divided into two levels, including a total of 5 first-level evaluation indicators and 33 second-level indicators;

b) The organization applying with the system shall monitor and manage the indicators with reference

to the description of evaluation indicators;

c) The indicator types are divided into current indicators and developing indicators. The current indicators are the indicators that must be met during the first certification cycle, and the developing indicators are the indicators that enterprises need to strive to achieve. The updated indicator types will be issued every year;

d) The types of indicators are divided into qualitative and quantitative;

e) The indicator units are for reference.

The specific indicators as follow.

Table 1 Green & low carbon logistics management indicators

First level indicator	No.	second level indicator	description	indicator classification	indicator type	unit
Strategy and objective	1.	logistics operation system X101	The organization applying with the system should establish an efficient logistics management system, including but not limited to green low-carbon logistics management system, management system for stakeholders, standardized logistics operation process and other	current indicator	qualitative	-
	2.	logistics operation plan X102	The organization applying with the system shall establish an efficient logistics operation plan, including but not limited to the reasonable warehouse layout, optimization of logistics operation route , and the design of multiple transportation modes	current indicator	qualitative	-
	3.	logistics informatization and green information disclosure X103	The organization applying with the system shall establish an information management system, including but not limited to network system, electronic document management, goods tracking, customer inquiry, etc. For details, please refer to GB/T19680 *Classification and evaluation indicator for logistics enterprise*; The organization applying with the system should establish a green information disclosure mechanism and regularly disclose the current indicators of green & low-carbon logistics information	current indicator	qualitative	-
Environmental impact	4.	noise emission value X201	noise emission value = noise emission value / standard limit value of the organization at the logistics node. The standard limit value of noise can refer to the current indicator quantitative% of GB 12348 *Emisson standard for industrial enterprises noise at boundary*	current indicator	quantitative	%
	5.	solid pollutant	solid pollutant production per unit of	current indicator	quantitative	kg/(k

		production per unit of business x202	business = the production of all solid wastes in the logistics activities of the organization (such as waste steel, waste packaging, waste cartons and waste paper, waste tires, etc.) / business			m·t)
	6.	Liquid pollutant emission per unit of business x203	liquid pollutant emission per unit of business = emission of all liquid pollutants (such as waste engine oil, diesel, gasoline, sewage, etc.) in logistics activities of the organization / business volume Sewage discharge shall meet the requirements of relevant national standards on environmental protection	current indicator	quantitative	L/(km·t)
	7.	Compliance treatment rate of solid and liquid pollutants x204	Compliance treatment rate of solid and liquid pollutants = compliance treatment amount of all solid and liquid pollutants in the logistics activities of the organization / total amount of solid and liquid pollutants The sewage discharge should meet the requirements of relevant national standards on environmental protection	current indicator	quantitative	%
Green low-carbon logistics	8.	utilization rate of biodegradable plastic packaging materials X301	Utilization rate of biodegradable plastic packaging materials = usage amount of biodegradable plastic packaging materials (PCs., kg, t) / total usage amount of packaging materials This indicator can measure the use of biodegradable plastic packaging materials in the organization.	developing indicator	quantitative	%
	9.	Utilization rate of reusable packaging materials x302	Utilization rate of reusable packaging materials = the amount of packaging materials used for two or more times (PCs., kg, t) / the total amount of packaging materials used This indicator can measure the use of reusable packaging materials in the organization.	developing indicator	quantitative	%
	10.	Utilization rate of reduced packaging materials x303	Utilization rate of reduced packaging materials = usage amount of reduced packaging materials (PCs., kg, t) / total usage amount of packaging materials	developing indicator	quantitative	%
	11.	Logistics packaging recovery rate x304	Logistics packaging recovery rate = actual amount of logistics packaging materials recovered (PCs., kg, t) / total usage of logistics packaging materials	developing indicator	quantitative	%
	12.	Proportion of new energy vehicles or vehicles meeting the latest national environmental protection	Proportion of new energy vehicles or vehicles meeting the latest national environmental protection requirements = total load capacity of new energy vehicles or vehicles meeting the latest national environmental protection requirements / total load capacity of trucks	developing indicator	quantitative	%

		requirements X305				
	13.	Proportion of unit load transportation x306	Proportion of unit load transportation = logistics volume transported by unit load / total logistics	developing indicator	quantitative	%
	14.	Proportion of joint distribution x307	Proportion of joint distribution = logistics volume of joint distribution used by the organization / total logistics	developing indicator	quantitative	%
	15.	Energy consumption per unit of yards and warehouses x308	Energy consumption per unit of yards and warehouses = total energy consumption / factory and warehouse volume	developing indicator	quantitative	%
	16.	Proportion of electricity using renewable energy x309	Proportion of electricity using renewable energy = electricity using renewable energy (photovoltaic, wind energy, etc.) / total electricity consumption of logistics by the organization	developing indicator	quantitative	%
	17.	Carbon emissions per unit of energy consumption x310	Carbon emissions per unit of energy consumption = total carbon emissions per energy consumption (electricity, water, cooling capacity, steam) / total mass of goods / total transportation distance	developing indicator	quantitative	kgCO_2q/(km·t)
	18.	Carbon emissions per unit of waste disposal x311	Carbon emissions per unit of waste disposal = total carbon emissions per unit of waste disposal / total mass of goods / total transportation distance	developing indicator	quantitative	kgCO_2q/(km·t)
	19.	Carbon emissions per unit of transportation x312	Carbon emissions per unit of transportation = total carbon emissions / total mass of goods / total transport distance	developing indicator	quantitative	kgCO_2q/(km·t)
	20.	Carbon emissions per unit of raw materials x313	Carbon emissions per unit of raw materials = total carbon emissions of raw materials (emission sources except packaging) / total mass of goods / total transportation distance	developing indicator	quantitative	kgCO_2q/(km·t)
	21.	Carbon emissions per unit of packaging x314	Carbon emissions per unit of packaging = total carbon emissions of packaging / total mass of goods / total transportation distance	developing indicator	quantitative	kgCO_2q/(km·t)
Green facilities and equipment	22.	Location of logistics node X401	Logistics node includes logistics park, logistics center, freight yard, warehouse and other logistics facilities. The organization should refer to the fact that the location of the warehouse conforms to the GB/T 50378 *Assessment standard for green building*. The location of the logistics park, logistics center, freight station shall conform to the basic requirements of GB/T21334 *Classification and*	developing indicator	quantitative	-

			planning fundamental requirements of logistics park, GB/T 30334 *Service specifications and evaluation indicators for logistics parks*, and the multi-modal transport function of the transportation connection mode			
	23.	Plot ratio X402	Plot ratio = total above-ground building area / land area. The total above-ground building area is calculated in accordance with GB/T 50353 *Calculation code for construction area of building*	developing indicator	quantitative	%
	24.	Green space rate of warehouse area x403	Green space rate of warehouse area = total green space area of logistics production area / total area of logistics production area. The green space rate of the land scope of logistics production area in the warehouse area should not be higher than 15%. For details, please refer to GB 51157 *Code for design of logistics building*.	developing indicator	quantitative	
	25.	Proportion of high-efficiency lamps in depots X404	Proportion of high-efficiency lamps in depots = number of high-efficiency lamps in depots / total number of lamps used in depots	developing indicator	quantitative	
	26.	Proportion of clean energy handling equipment x405	Proportion of clean energy handling equipment = number of available clean energy handling equipment (forklift, crane, AGV, unmanned vehicle, etc.) / total number of available handling equipment	developing indicator	quantitative	
	27.	Proportion of standardized turnover containers x406	Proportion of standardized turnover containers = number of usable standardized turnover containers (turnover boxes, pallets, cage cars, etc.) / total number of usable turnover containers	developing indicator	quantitative	
	28.	Recycling proportion of turnover container x407	Recycling proportion of turnover container = turnover times of recycled turnover containers (turnover boxes, pallets, cage cars, etc.) / total turnover times of turnover containers on use	developing indicator	quantitative	
	29.	Utilization rate of the carrying capacity (volume) of the means of transport x408	Utilization rate of the carrying capacity (volume) of the means of transport = the freight turnover actually completed / the freight turnover that can be completed by the rated carrying capacity (rated volume). This indicator includes the no-load rate, which is used to measure the utilization rate of the carrying capacity (volume) of the means of transport organized by different modes of transport.	developing indicator	quantitative	
Information management	30.	Smart optimization platform x501	Organization should have auxiliary transportation route planning and qualitative development indicators of priority load pool system	developing indicator	qualitative	

	31.	Logistics status tracking platform X502	Organization should have a logistics status tracking system that can track and notify in real time, automatically provide transportation updates, and share real-time tracking links and estimated time of arrival (ETA) with consumers, so as to improve the stability of development indicators of successful delivery rate.	developing indicator	qualitative	
	32.	Electronic document management platform X503	The organization should have online ordering (including e-commerce), reverse logistics system. The organization should avoid the use of paper documents, labels of goods, etc. Instead, the organization should use reusable labels, electronic signatures and photo certificates, and turn to paperless and contactless delivery.	developing indicator	qualitative	
	33.	Green & low-carbon logistics information disclosure platform X504	The organization should publicly establish an information disclosure platform in relevant channels, and disclose the development indicators of the organization's green & low-carbon logistics related information.	developing indicator	qualitative	

2.1.3 Grading of evaluation indicator of green & low-carbon logistics:

The evaluation of indicators is comprehensively verified according to the organization (or industry) product characteristics, industry requirements, relevant regulations, policies, standards, requirements of stakeholders (such as purchasers) or the organization's green and low-carbon logistics requirements. The indicator weight and score are determined according to the importance of the indicator on the life cycle of product and the impact of logistics system resources, ecological environment and health and safety. If the evaluation indicator needs to be adjusted due to special reasons of the organization or industry, it should be explained in detail and submitted to the standard technical committee. Considering the dynamics of indicators (such as changes in policies, regulations and standards, the time characteristics of indicators, etc.), if it needs to be adjusted in a timely manner, a formal notice will be issued again to update it.

The indicator levels of evaluation indicator system for green & low-carbon logistics management system include a total of 4 levels as level A+, level A, level B and level C. See Table 2 for details.

Table 2 Grade of evaluation indicator of green & low-carbon logistics

Grade	A+	A	B	C
Indicator recognition	Leading role in industry	Advanced in industry	Average in industry	Entry level in industry

2.1.4 Results of green & low carbon logistics certification:

According to the level distribution of the organization's green & low-carbon logistics performance

evaluation indicator table, the organization is certified for green & low-carbon logistics, and the certification results of the organization's green & low-carbon logistics management system are divided into four levels: certified green & low-carbon logistics, silver green & low-carbon logistics, gold green & low-carbon logistics and emerald green & low-carbon logistics. See Table 3 for details.

Table 3 Grade of green low & carbon logistics certification

Level	A+	A+ and A	A+, A and B	All
Certified	>20%	>50%	>90%	=100%
Silver	>50%	>75%	=100%	/
Gold	>75%	=100%	/	/
Emerald	>85%	=100%	/	/

Note: If and only if all the determination conditions of this level are met at the same time, logistics can be rated as the level.

2.2 Management system of zero waste to landfill (Q/SGS-CSTC_ZWL_01)

2.2.1 Scope

The management system of zero waste to landfill is applicable to organizations and activities of any scale and type, and to activities that affect the generation and disposal of waste managed and controlled by the organization. System standards can be used alone, coordinated or integrated with other management systems.

System standards can be used in whole or in part to systematically promote zero landfill of waste. However, only when all the requirements of this standard, including the performance requirements of waste landfill transfer, are included in the organization's management system and all are met, can the organization declare compliance with this standard.

2.2.2 Core of management - PDCA

As an extension and detailed standard of the environmental management system, the *Management system of zero waste to landfill* maintains the core management idea of PDCA of the environmental management system.

PDCA cycle management is a working step of enterprise management. P stands for plan, D for do, C for check, and A for act. PDCA cycle is a program that carries out comprehensive management in a cycle of four stages: planning, doing, checking and acting.

PDCA cycle has four stages and eight steps:

P stage, namely the plan management stage, has four steps: collecting data, finding out problems, finding out the main problems, and formulating plan measures. The plan focuses on the purpose, measures, implementation department, implementation date and completion date;

D stage , the doing stage, has one step, that is, assign tasks as planned and implement them as required;

C stage , the checking stage. In this stage, the executor check the results and find out the lessons of success and failure;

A stage, the acting stage. This stage has two steps, consolidating measures, formulating standards and forming rules and regulations; find out the remaining problems and move to the next cycle.

When the four stages and eight steps of a cycle are completed, a cycle is finished, the management capability is improved, and the remaining problems go to the next cycle. The cycle continues, and management continues to improve.

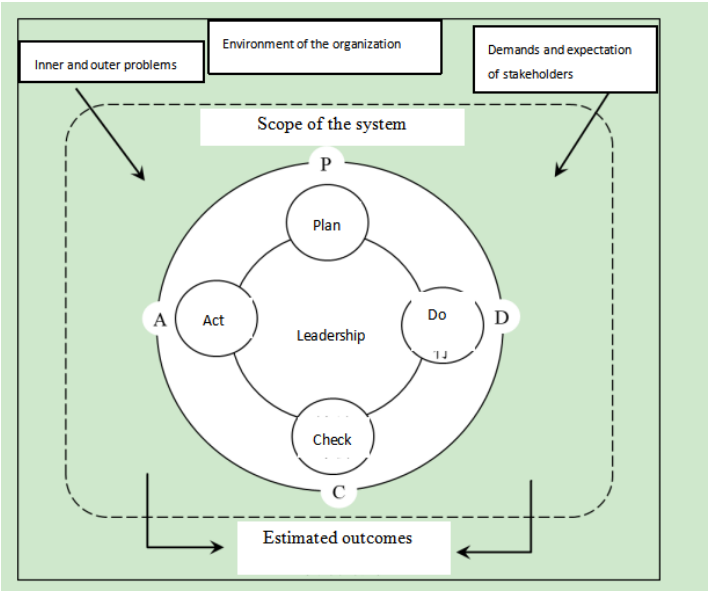

Figure 1: Diagram of PDCA Cycle Management

Note: This figure shows how PDCA cycle management system works in the zero waste to landfill management system.

To establish a zero waste to landfill management system, enterprises need to analyze the internal and external environment and the needs and expectations of relevant parties, combined with the actual

situation of the enterprise, clarify the person in charge and the corresponding management team, and set clear and achievable goals. Based on achieving the goal, start PDCA cycle management and continue to make improvement.

2.2.3 Performance evaluation

In addition to the confirmation of the traditional system certification compliance management, the realization of organizational commitments, the achievement of objectives and indicators, the zero waste to landfill management system has a rigid performance management indicator that is not affected by the organizational objectives and indicators: the landfill diversion rate (LDR)

LDR refers to the percentage of waste transferred from landfill waste through reduction, reuse, recycling, energy recovery, etc. The specific calculation formula and factors involved are as follows:

LDR =（Mreduce + Mreuse + Mrecycle + Menergy）/（Mtotal - Mmandated）

Mtotal = Mreduce + Mreuse + Mrecycle + Menergy + Mlandfill +Mthermal w/o energy + Mmandated

Of which:

Mreduce refers to waste reduction;

Mreuse refers to reuse amount;

Mrecycle refers to mass of recycled waste;

Menergy refers to mass of waste for energy recovery;

Mthermal w/o energy refers to mass of waste of heat treatment without energy recovery;

Mtotal refers to total mass of waste generated before transfer;

Mmandated refers to mass of mandatory waste;

Mlandfill refers to mass of waste sent to landfill.

According to the organization's zero wast to landfill management performance, the zero wast to landfill system is divided into: silver level, gold level and diamond level.

If the LDR is greater than or equal to 90% and meets all the control requirements of this standard, it can be considered as zero waste to landfill. Among them, if the LDR is greater than or equal to 90%

but less than or equal to 94%, it can be considered as reaching the silver level of zero waste to landfill; if LDR is greater than or equal to 95% but less than or equal to 99%, it can be considered as reaching the gold level of zero waste to landfill; if the filling and transfer rate of waste is equal to 100%, it can be considered as reaching the diamond level of zero waste to landfill.

See Table 4 for details.

Table 4 Certification level of zero waste to landfill

Grade	Landfill diversion rate (LDR)
Silver	90% - 94%
Gold	95% - 99%
Diamond	100%

2.2.4 System establishment and certification cycle

The establishment of zero waste to landfill management system usually takes 12 months, including 3 months for the establishment of the system, 6 months for the improvement and adjustment of waste management, and 3 months for normal and stable operation. (it can be adjusted appropriately based on the actual situation, but each process cannot be missing).

Certification audit is usually carried out in two stages: document audit and on-site audit.

(1) Phase I of audit:

a. Master the circumstance of establishment and operation of zero waste to landfill management system;

b. Master the waste management benchmark;

c. Determine the focus of the second stage audit.

(2) Phase II of audit:

The auditors will collect evidence at the site of the organization. This is to evaluate the implementation of the organization's management system, including the compliance with the standards and the effectiveness of the system.

The certification cycle of zero waste to landfill management system is 3 years. After the certification year, it needs to be supervised and audited every year, and the interval between two supervision and

audits should not be greater than 12 months.

III. Effectiveness of the Management System

The establishment of the two management systems can help enterprises effectively manage energy and resources, reduce carbon emissions and achieve the 3060 goal.

3.1 Green & low carbon logistics management system (Q/SGS-CSTC GLCL 01-2022)

3.1.1 Promote concept of green and low-carbon logistics

In this system, the enterprises provide green products, green signs, green marketing and green services, and consumers pursue green consumption, green enjoyment and green security. Among them, the logistics process is a green channel connecting green supply and green demand. We should improve our understanding by establishing standards, and put the awareness of green low-carbon logistics in the primary position of the green revolution.

3.1.2 Development of green and low-carbon logistics standards

Logistics activities involve a lot of relevant industries, government departments and systems. The implementation of green & low-carbon logistics is not only a matter for enterprises, but also requires coordinated regulations and macro-control, strengthening the management of the existing logistics system, building a framework for the establishment and development of green & low-carbon logistics. Development of a integrated certification standard can strengthen the management of the existing logistics system and build a framework for the establishment and development of green & low-carbon logistics.

3.1.3 Consolidate the foundation of green and low-carbon logistics

The key of green & low-carbon logistics not only depends on the establishment of logistics green ideas, the development and compliance of logistics standards, but also depends on the mastery and application of green technology. In terms of green technology, the logistic enterprises should attach importance to mechanization, the use of logistics materials, the automation, informatization and networking of logistics, the necessary public logistics information platform, order management, goods tracking, inventory query and other logistics information service functions. The enterprises should also master and improve the existing logistics infrastructure and its technical equipment, and consolidate the logistics requirements of enterprises.

3.2 Zero waste to landfill management system (Q/SGS-CSTC_ZWL_01)

3.2.1 Inside the organization

Improve system management

Establish a sound waste management system, optimize the management process, and save management costs.

Waste reduction and emission reduction

In the process of enterprise development, we should pay attention to and choose suitable waste reduction measures in real time.

Optimal disposal

In the process of running the management system, the enterprise constantly optimizes the disposal mode of waste and maximizes reuse of resources.

3.2.2 Outside the organization

Improve corporate social image

The zero wast to landfill certification reflects that the enterprise practices the environmental protection concept of green and sustainable development and leads the development of the industry.

Reduce compliance risk

The enterprises pass the zero landfill certification, sort out and improve the compliance management of enterprises, and thus reduce the compliance risk.

IV. Pilot Operation

After the development and establishment of management system standards, SGS China actively promoted them to leading enterprises in relevant industries to pursue the implementation of standards.

4.1 Green & low carbon logistics management system (Q/SGS-CSTC GLCL 01-2022)

After the development and establishment of the Green and low-carbon logistics management system, SGS reached a cooperation agreement with the leading bulk commodity trading service provider and

infrastructure provider Oyeel. The SGS team helped the pilot enterprises in the industrial chain of Oyeel to establish a green and low-carbon logistics management system and strive to achieve the sustainable development of the whole logistics life cycle.

Oyeel is the main force of China Baowu Group's "one core, five elements" strategic smart service industry, and the main builder and operator of smart trading and smart logistics. Based on the smart logistics platform of iron and steel, Oyeel strives to achieve the visibility of carbon emission data in the whole process of logistics supply chain, and builds a green logistics system.

At present, the logistics industry is facing internal pressure from many sources: compliance pressure, low energy efficiency, high operating costs, backward information system, etc. Moreover, due to large industry differences, there is no reference and comparability between industries, the indicator standards are inconsistent, and the gap between logistics enterprises is not obvious. Visualization and unified standards are the first step to be taken. SGS uses digital technology to achieve this goal efficiently. According to the current management mode of bulk logistics, integrated with the actual circumstance of each enterprise, SGS team helps enterprises sort out the management process and compliance requirements of all process of logistics, integrate green and low carbon into the management system, help carbon inventory, and audit the enterprise's green and low carbon logistics indicator system through the online evaluation system to meet the corresponding requirements of enterprise ESG, green procurement and green compliance.

4.2 Zero waste to landfill management system (Q/SGS-CSTC_ZWL_01)

After the development and establishment of the zero waste to landfill management system standards, SGS reached a cooperation agreement with Yuanqisenlin group, and the SGS team helped Yuanqisenlin establish a waste management system in five domestic production plants to achieve zero landfill.

Established in 2016, Yuanqisenlin is an innovative beverage company with independent research and design. In the past few years, it has not only continuously innovated in product upgrading, but also led the development of the industry. Meanwhile, in terms of enterprise management, Yuanqisenlin is also constantly developing a more efficient, environmental friendly and low-carbon sustainable development route.

Integrated with the production practice of Yuanqisenlin's factories, SGS team helps the enterprise sort out the management processes and compliance requirements of all process from waste generation

source to terminal disposal, establish corresponding management systems, and control and reduce waste generation from the source. At the same time, the results of the upstream and downstream conditions of the local solid waste disposal will help enterprises choose the best disposal method to achieve zero waste to landfill.

At present, the project is advancing as planned, and the certification will be implemented after ensuring the stable operation of the management system and upstream & downstream disposal methods. The first factory certification is scheduled to be implemented in August.

V. Future Work Plans

After the development and establishment of green & low-carbon logistics management system and zero waste to landfill management system, SGS will make full use of its own resource advantages, continue to promote certification to enterprises and organizations, and help them improve green & low-carbon logistics management, solid waste management and waste recycling efficiency. Through the implementation of green certification, SGS will promote enterprise to reduce energy consumption and carbon emission, achieve sustainable development throughout the life cycle, and help carbon neutrality.

5.2 Greener Store Certification Framework of Starbucks

I. Background

As the world's leading professional coffee roaster and retailer, since its inception in 1971, Starbucks has been committed to ethical sourcing and repaying more to natural resources than it takes. There has been more than 32,000 Starbucks stores in 82 markets worldwide, including more than 5,000 in China.

In January 2021, Chinese President Xi Jinping replied to Howard Schultz, honorary chairman of the Board of Directors of Starbucks Corporation of the United States, encouraging Starbucks to keep playing an active role in promoting Sino-US economic and trade cooperation and the development of bilateral relations.

In 2020, Chinese President Xi Jinping pledged to the world at the United Nations General Assembly a "carbon deduction goals of 2030 and 2060" for China's CO_2 emissions, making China's contribution to addressing climate change and achieving the goals set by the Paris Agreement. Starbucks responded positively and firmly supported this grand goal, which was in line with the expectations of a green home for mankind. To this end, Starbucks has set its own action plan to implement the carbon emission peak and carbon neutrality goals, reducing carbon emissions, water use, and landfill waste by 50% by 2030, and to achieve the green goal of the whole process of coffee consumption.

To implement the sustainable development goals, Greener Store Certification Framework has been put into operation in Beijing, Shanghai, Suzhou, Shenzhen, Hangzhou, Suzhou and other cities starting from the second half of 2021, which indicates that Starbucks China has already fully launched and practiced Starbucks' cutting-edge environmental protection measures, explored a new green and low-carbon retail model in an all-round way, and encouraged more customers to practice a new green and low-carbon lifestyle together. Meanwhile, it marks the continuous development of Starbucks' "Greening Environment" blueprint, and also represents the beginning of the Greener Store Certification Framework in China.

II. Plans and Ideas

The Greener Store Certification Framework officially launched by Starbucks China is jointly developed by Starbucks and authoritative organizations, covering the whole life cycle of stores. There are as many as 40 indicators, focusing on audit and certification in 8 key areas, including energy conservation, water consumption management and waste disposal.

In the specific implementation process, Starbucks stores must strictly implement 8 standards of Greener Store Certification Framework, including the use of high efficiency and low energy consumption related electrical appliances, the use of 100% mercury-free LED lamps, the use of low-flow faucets, and adhere to garbage classification and other review requirements.

Figure 1 Starbucks Greener Store

The Greener Store Framework not only focuses on traditional store design and construction such as water, electricity and environmental refrigerant, but also focuses on more new perspectives related to store operation and consumption experience such as indoor noise reduction, indoor air quality, convenience of public transportation, reduction of disposable packaging, more healthy and low-carbon plant-based meals, etc., which reflect Starbucks' determination to invite more consumers to experience a sustainable lifestyle.

Meanwhile, Starbucks actively promotes Leadership in Energy and Environmental Design (LEED) Certification for store buildings, so as to fully achieve the green certification standards of Starbucks.

III. Experience and Practice

Starbucks is looking at every step of the journey from a raw bean to a cup of coffee, taking comprehensive measures to reduce its environmental impact. From planting, production, packaging to stores, Starbucks follows the concept of "green" in every step, hoping that each cup of coffee can truly become a better "coffee of tomorrow".

3.1 Greener Store Certification

3.1.1 Energy and water efficiency covers all areas

All Greener Stores are required to adopt comprehensive measures to improve energy and water efficiency. Take lighting as an example, the light in the store is under smart control system without manual intervention. The lighting system is set in daytime, evening and late night modes to effectively reduce power consumption. These measures are estimated to reduce carbon emissions by an additional 15% per year compared with an ordinary store of the same size in 2019. Stores are also expected to reduce water consumption by an average of 15% to 20% through water management measures such as low-flow faucets.

3.1.2 Fully implement renewable energy

The use of renewable energy is an important part of the consumer sector's commitment to "carbon 3060 goals". Starbucks Greener Stores are required to purchase green electricity through the National Green Card Subscription platform and use 100% renewable energy, which Starbucks hopes will set a benchmark for sustainable transformation in the consumer sector through all certified Greener Stores.

3.1.3 Actively promote recyclable assembly design

About 50% of the building materials in the store can be recycled, upgraded or degraded in the future. The bar and back area of the whole store adopts a new modular design. The whole bar is composed of modules with different functions, which can be dismantled and assembled according to demand. If the store is revamped in the future, the old modules can be "reinstalled" in other stores.

3.1.4 Explore low-carbon and environment-friendly food ingredients

Starbucks is committed to providing consumers with a richer taste and sustainable consumption experience. More than 50% of the food and dairy drinks in the store are plant-based. Dairy drinks will

also use oat milk by default, and 15 new plant-based meals will be introduced, covering a range of bakery products, sandwiches and cakes. It has been calculated that, compared with regular muffin containing animal fats, each chocolate muffin with oat milk reduces greenhouse gas emissions by 60g, equivalent to about 0.1 KWH of electricity.

Figure 2 Inside the Starbucks Greener Store

3.1.5 Support renewable products

Raising the awareness of sustainable development among employees is the core of green operation. The green apron worn by the baristas in the store is made of recycled PET beverage bottles after cleaning, processing and recycling into polyester chips, yarns, and fabrics, and finally processed into a unique green apron. It not only reduces the waste of PET beverage bottles, compared with traditional textile technology, it can also reduce energy and resource consumption and reduce carbon emissions of products. According to estimates by professional organizations, such a green apron can reduce greenhouse gas emissions by about 1kg in its life cycle.

3.1.6. Explore waste recycling

Starbucks hopes to invite more consumers to experience a sustainable lifestyle. Coffee grounds, one of the main wastes in the store, are efficiently recycled. Part of the coffee grounds will be shared with consumers free of charge for dehumidification and deodorization, and the other part will be used as organic fertilizer for crops and gardens after composting, thus reducing the use of chemical fertilizers with high carbon emissions and high pollution. Meanwhile, besides completely stopping the use of plastic straws and promoting biodegradable coffee grounds straws, guided by a sustainable lifestyle, the stores also launch reusable accompanying cups, and encourage dine-in customers to use store-owned cups or bring their own cups with discounts, reducing waste generated by disposable tableware.

In fact, the "green" pursued by Starbucks' Green Certification Framework is not only integrated into every straw, every accompanying cup, and every coffee grounds received, but also gradually extends to the "third space" around consumers. Leadership in Energy and Environmental Design (LEED) Certification is one of them. In response to global climate change, Starbucks realizes that buildings will have a significant impact on the consumption of energy and resources. Making buildings greener has become the pursuit of more and more enterprises with social responsibility. LEED Certification System is the most perfect and influential evaluation standard in all kinds of building environmental protection, green building and building sustainability evaluation systems in the world.

In 2019, Starbucks' Shanghai Roastery was certified as a LEED Platinum store, the highest level of LEED Certification. So far, only 10% of the official LEED projects in the world have been certified as a Platinum store, and only 1% of the retail stores have achieved this title. The Shanghai Roastery is the first store in the Chinese catering industry to get this certification. Differs from that of ordinary office building, Shanghai Roastery is a retail business mode that caters countless customers every day. When evaluating it, the LEED Certification system not only examines the energy saving and emission reduction of it as a "building", but also pays to whether the experiences of employees and customers meet the requirements of sustainable development.

3.2 Promotion of green planting

For more than 20 years, Starbucks has worked with Conservation International on the certification of the Coffee and Grower Fair Practice (C.A.F.E.Practice) to advance the quality, economic responsibility, social responsibility and environmental requirements of coffee products at their source. Currently, nearly 99% of Starbucks' global coffee is purchased under this code, and the last 1% is to support and promote the practice of sustainable cultivation by new coffee farmers[28].

3.3 Advocating green production

Traditional coffee roasting also generates carbon emissions. To achieve the goal of "coffee of tomorrow", which is as low energy consumption and carbon neutrality as possible in its roasting process, Starbucks has invested 1.1 billion yuan ($156 million) to build the Starbucks China Coffee Innovation Industrial Park in Kunshan, which is expected to be completed and put into operation in 2023. The park will introduce state-of-the-art roasters and is expected to reshape future sustainable coffee production.

[28] Data from Starbucks 2020 Global Environmental & Social Impact Report

At the same time, in terms of design, the industrial park is in accordance with the international LEED Certification standard and China Green Building Three-star Certification standard, and applies the concept of sustainable development to emission reduction, energy saving and waste treatment. The high efficiency and energy saving baking technology can reduce carbon emissions by more than 30% compared to the traditional way, and renewable energy use will be up to 30%.

3.4 Practice of green life

In 2020, Starbucks launched the GOODGOOD Star FoodismTM program, actively advocating consumers to explore the environmentally friendly lifestyle of “being good to myself, the earth, and making the good better”. The program started from every cup of “coffee of tomorrow”, and worked with customers to make the world a little better.

In addition, through innovative sustainable packaging, Starbucks encourages consumers to start from the little things in their daily lives, strive to reduce waste and promote recycling. It is expected that by the end of 2022, all Starbucks hot drink cup lids in mainland China will be fully upgraded to easy-to-recycle polypropylene materials. The overall use of materials can be reduced by 12%, and it is expected to reduce the use of 100 tons of materials a year; at the same time, Starbucks China has fully activated biodegradable straw containing extracted coffee powder, which is expected to reduce about 350 tons of waste a year.

3.5 Promote LEED building certification for stores

In fact, the "green" pursued by Starbucks greener certification system has gradually extended to the "third space" around consumers. The requirement that the building of the stores must pass LEED (Leadership in Energy and Environmental Design) certification is an important part of it. In response to global climate change, Starbucks is as aware as anyone that the use of buildings will have a significant impact on energy and resource consumption. Making buildings greener has become the pursuit of more and more socially responsible companies. The LEED certification system is the most complete and influential evaluation standard in various building environmental protection, green building and building sustainability evaluation systems in the world.

In 2019, the Shanghai Roastery of Starbucks obtained the LEED Platinum level, which is the highest level of LEED certification. So far, only 10% of LEED projects in the world have been awarded the platinum level, and only 1% of these retail stores can achieve this title. Shanghai Roastery is the first restaurant in China to receive this certification. Differs from that of ordinary office building, Shanghai

baking workshop is a retail store providing service to customers everyday. LEED certification system not only examine the project for assessment as "buildings" energy conservation and emission reduction, but also pay attention to it's business condition, staff and customers experience is also in line with the requirements of sustainable development.

IV. Expected Effectiveness

Offline stores in the chain catering industry are the top priority for the sustainable transformation of the consumer sector. Starbucks' Greener Store Framework is an experiment for exploring green retail in an all-round way and creating low-carbon consumption scenarios. Each Greener Store is expected to reduce carbon emissions by 10.57 tons and water consumption by 301.7 tons per year compared to an ordinary Starbucks store of the same size in 2019. These benefits do not take into account the reduction benefits of 100% use of renewable energy (green certificate).

Starbucks currently has more than 5,000 stores across China. It can be expected that the carbon emission reduction benefits generated by the implementation of Green Certification in more and more Starbucks stores will surely become a more significant contribution of Starbucks to global sustainable development.

V. Problems and Suggestions

Sustainable development is not only the future of the industry, but also the present of the industry. It is a trend that has happened around everyone. The operation process of the new framework is bound to have various conflicts with the existing habitual thinking, including material form and ideology. Starbucks will dynamically adjust with the development of technology and social needs, adhere to the overall goal of "carbon emission peak and carbon neutrality", and continuously advocate, explore and pursue systematic green consumption solutions that can give consideration to good consumption experience and "carbon 3060 goals".

VI. Future Work Plans

With the opening of a store in Hangzhou Canal Asian Games Park in 2022, Starbucks has rolled out its plan to achieve "3060 carbon goals" in China. In the future, Starbucks will continue to open Green Certified Store in China, empower partners and connect more consumers. Starbucks will add new environmental significance to each cup of coffee, unswervingly adhere to the mission of "Greening

Environment", and lead more catering enterprises to join the "carbon 3060 goals".

What Starbucks is after is that innovation must be sustainable, reproduceable, and transferable. Only then is a truly organic and recycling idea. And Starbucks' core concept of "Greening Environment" is the everlasting circle of life.

Starbucks hopes to open 6,000 stores in the Chinese market by 2022. However, what Starbucks is committed to pursuing is not just the speed, but also the unique experience that each store can provide customers, and how to better assume its responsibilities to society and the future. In the future, Starbucks will continue to increase investment in the Chinese market, enhance green vitality in store design, logistics, operations and other fields, create more Greener Stores and sustainable "Greener Third Space" experiences for Chinese consumers.

On the occasion of Starbucks' 50th anniversary, Starbucks promises that by 2030, in the process of global coffee production, processing and operation, compared with the data of 2019, it will achieve the goals of halving carbon emissions, water use and waste. The Greener Store Framework is an important step towards this sustainable vision. Starbucks plans to open 60 certified Greener Stores in mainland China one after another in the next year, and gradually expand to all newly opened and renovated stores in mainland China, so as to make continuous contributions to the low-carbon development of the retail industry in China and around the world.

5.3 Green Travel with Pollution Deduction and Carbon Emission Reduction by Meituan

I. Meituan Plan for Green and Low Carbon

1.1 Background

Transportation industry is one of the most important industries of China's national economy. With the development of social economy and the acceleration of urbanization, urban trip plays an increasingly important role in people's livelihood. The rapid development of urban transportation, on the one hand, provides convenient, efficient and comfortable trips, but also leads to the rapid increase in the number of motor bicycles in the city, causing a series of energy and environmental problems.

In urban transportation, the carbon dioxide emissions caused by motor bicycles are the main greenhouse gas emissions, and the exhaust emissions of motor bicycles are an important source of air pollution. The main pollutants emitted by motor bicycles include carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and particulate matter (PM). In addition to the environmental air pollution caused by exhaust emissions, the emissions of carbon dioxide (CO_2), sulfur compounds (SOx), nitrogen oxides (NOx), chlorofluorocarbons and other emissions generated during the use of motor bicycles can also cause climate and environmental problems such as greenhouse effect, ozone layer destruction and acid rain. Carbon monoxide (CO), nitrogen oxides (NOx), sulfides (SOx), unburned hydrocarbons (HC), particulate matter (PM) and odor gases emitted by motor bicycles cause serious air contamination.

At present, China has become one of the world's largest carbon dioxide emitter, of which the carbon emission in the transportation sector accounts for 10% of the national carbon emission, while the carbon emission in urban transportation accounts for 80% of the transportation sector. The carbon emission reduction of urban transportation should become an important driving force for China's carbon emission peak and carbon neutrality strategy.

1.2 Outline of the case

As one of the China's leading e-commerce platform for daily life services, Meituan has always focused on the "retail + technology" strategy. Popular apps such as Meituan, Dazhongdianping, Meituan takeout are all under Meituan company, with services cover more than 200 categories, including catering, takeout, shared taxi, shard bike, shared electric bike, hotel, tourism, film, leisure and entertainment.

The business of Meituan covers more than 2,800 counties and cities across China. Meituan's performance report for the first quarter of 2022 shows that the number of its users has reached 690million, with an average of 37.2 transactions per trading user, and the number of active businesses has reached 9 million.

Meituan not only continues to invest in the new infrastructure of life service industry to provide better services for users, but also actively practices low-carbon measures. In the field of trip, as the initiator and leader of the global smart shared bike, Meituan bike (formerly "mobike") advocates the concept of low-carbon trip, and explores the circular economy through innovative models. The green, convenient, environmentally friendly and healthy shared bike effectively solves the problem of "the last mile" of urban trip, reflecting the improvement of urban traffic through technological innovation and model transformation. It provides a smart solution for sustainable development of green urban trip.

At present, Meituan operates millions of shared bicycles and shared electric bikes in more than 300 cities across China, generating more than 20TB of big data on trip every day, forming one of the world's largest mobile Internet of Things.

1.3 Innovative ideas

1.3.1 Integration of traditional trip mode and modern technology

As a key component of shared transportation facilities, shared bikes has been greatly welcomed by users as soon as it is launched. Meituan shared bikes and shared electric bikes are new comprehensive applications integrated with the digitalization, networking and smartness. It not only applies the internet of things, big data and cloud platform technology to reflect technological innovation, but also applies smart operation management based on the whole life cycle to deliver the mode innovation.

1.3.2 Whole life cycle actions for pollution reduction and carbon reduction

Meituan is committed to promoting and practicing the whole life cycle environmental protection actions of its Meituan bicycles and electric bicycles. It implements the 3R principle (reduce, reuse, recycle) in the whole process of design, procurement, production, launching, operation, scrapping and so on. The waste bicycles are 100% recycled, leading the industry's whole life cycle management, energy conservation and environmental protection.

1.3.3 Optimizing the trip mode structure with carbon emission reduction

Through efficient connection with the public transport system, Meituan shared bike and shared e-bike is conducive to optimizing the trip structure, increasing the proportion of green trip, achieving emission reduction in the whole trip chain, accelerating the development of a green lifestyle, and achieving carbon emission reduction in transportation of China.

1.4 Implementation objectives

It is expected that by 2023, Meituan will help cities to initially develop an eco-friendly, clean and low-carbon green trip service system, and the urban environment will be significantly improved. The proportion of green trip in cities where the project is implemented will exceed 70%.

II. Solution for Green Travel

2.1 Main contents

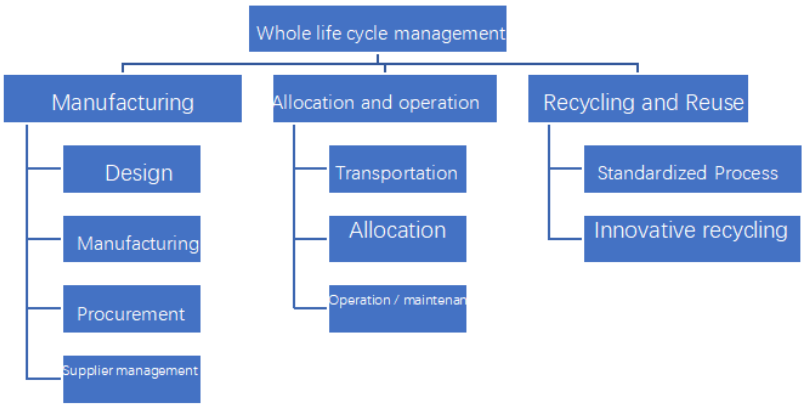

Figure 1 Technical roadmap of Meituan life cycling bike management plan

2.1.1 Manufacturing

Meituan implements the general plan for spare parts, at the initial stage of research and development, the designers consider the universality of product parts, so that spare parts can be compatible with more types of bicycles. This will include:

(1)100% of the same specification. All bicycle suppliers use unified technical standards to ensure that the bicycles are of the same specification;

(2)Versatility over 90%, that is, all generations of bicycles use parts of the same specification as much as possible to ensure the maximum interchangeability and versatility of parts;

(3)Reduce 30% of the material numbers, which means to increase number of interchangeable part item, and reduce labor and material consumption.

Design for Easy maintenance: at the initial stage of design, the convenience of product parts installation and disassembly is well considered to reduce the proportion of disassembly requiring two tools at the same time.

The durability of products is considered at the early stage of research and development to ensure that they are more durable than similar products. This includes:

(1) All spare parts shall meet 1.1 times the fatigue test times required by ISO4210;
(2) All plastic parts are required to meet the xenon lamp aging testing for more than 200 hours;
(3) The front basket on the bike marked with 5kg maximum load is able to pass the fatigue test according to 10kg load, some types of baskets are tested under static load of 80kg.

Meituan cooperate with enterprises on supply chain to improve the efficiency of energy production, recycling and sharing. In addition, in the selection of suppliers for bicycle manufacturing, Meituan electric bicycle also takes green environmental protection as an important indicator and requires suppliers to provide relevant systems and scientific research documents. Meanwhile, referring to the Chinese national requirements on management of green supply chain, Meituan also requires and restricts suppliers to take measures to improve the capacity of green production.

2.1.2 Allocation and operation

2.1.2.1 Transportation

In order to reduce the pollution and emissions in the production and transportation of electric bikes, Meituan requires all manufacturers to change the traditional carton packaging to full assembly net packaging. Meanwhile, Meituan will coordinate the manufacturing and transportation arrangements of electric bicycles in accordance with the allocation plan of vehicles throughout the country to minimize the impact on the environment.

2.1.2.2 Reasonable and standardized allocation

For reasonable allocation of bikes in the city, Meituan has developed calculation model for total amount of bicycles, big data supervision platform, electronic license plate and other technologies, and has cooperated with third-party scientific research institutions such as school of transportation of Southeast University, Guangzhou Institute of Urban Planning and Survey, and Urban Smart Trip Information Technology Research Institute on the development of reasonable allocation scale calculation model of shared electric bicycle in cities, help government regulatory agencies to determine the scale of operations in the city.

2.1.2.3 Refined operation and maintenance

Meituan has independently built a whole life cycle intelligent management platform for electric bicycles. The platform records the maintenance records of each part of the bike, which can clearly trace the service life of all parts, and optimize the design and production of bicycles according to the maintenance records, so as to improve the service life of bicycles and reduce resource consumption and carbon emissions caused by maintenance. Each Meituan electric bicycle is equipped with "Beidou+GPS+ GLONASS" triple satellite positioning chip and Internet of things communication chip. With the help of Internet of things, Meituan is able to realize 100% recycling and maintenance of waste bicycles. On the waste smart locks, spare parts such as baskets, frames, wheel will be recycled and reused after

passing the test.

In the maintenance of the old bicycles, Meituan replaces the damaged fender with mud plate made of recycled materials from takeaway lunch boxes. This is a plan to develop the circular economy of takeaway lunch boxes with Meituan Takeaway's "Qingshan Action". A set of Meituan bicycle fenders requires about 70g takeout lunch box recycling. After recycling, cleaning, melting granulation, modified granulation, melting and injection molding, performance testing and other process, the takeaway lunch box can be made into a bicycle fender. The company is planning to apply lunch box recycling products to more Meituan bicycles and Meituan electric bicycles.

2.1.3 Recycling and harmless treatment

Meituan can collect and judge the status of each electric bicycle in time by big data management platform, users' breakdown reporting and other methods. Meanwhile, Meituan has established a well operated management process and scrapping standards for all series of vhicles, and the operation and maintenance personnel in cities can identify and classify the status of bikes according to the standards.

In terms of the scrapping and recycling of bikes, Meituan bicycles has joined hands with the recycling enterprises including China Renewable Resources Development Company and Tianjin Xinneng Renewable Resources Company to provide Meituan bicycles with professional services such as batch recycling, disassembly and harmless treatment after the end of the life cycle of Meituan bikes and electric bikes.

2.2 Significance of the case

2.2.1 Reduce carbon emissions by substituting high carbon trip modes with shared bicycle

According to the *Report on pollution reduction and carbon reduction of shared cycling*, the emergence of shared cycling has partly replaced high-carbon trip modes such as private cars, and this substitution has produced environmental emission reduction benefits. The study found that the combination of shared bicycles or electric bicycles + subway or bus has a strong substitution effect for high-carbon trip.

In the cities with subway, the carbon emission reduction factor for people using shared bicycles per kilometer is 48.65g/pkm. The emission reduction factors of CO, HC, NOx and PM are 0.256g/pkm, 0.022 g/pkm, 0.019g/pkm and 0.007g/pkm respectively. The carbon emission factor of all transportation modes of shared electric bicycles under the baseline scene of cities with subways is 61.03g/pkm. After deducting the carbon emission factor of 7.02g/pkm for one kilometer of people using shared electric bicycles, the carbon emission reduction factor of 54.01g/pkm for one kilometer of people using shared electric bicycles in cities with subways; The emission reduction factors of CO, HC, NOx and PM are

0.336g/pkm, 0.029g/pkm, 0.024 g/pkm and 0.009g/pkm respectively.

In cities without subways, the emission reduction factor for people using shared bicycles per kilometer is 53.94g/pkm. The emission reduction factors of CO, HC, NOx and PM are 0.292g/pkm, 0.025g/pkm, 0.021g/pkm and 0.008g/pkm respectively. The carbon emission factor of all transportation modes under the baseline scene of shared electric bicycles is 66.32g/pkm, excluding the carbon emission factor of 7.02g/pkm for one kilometer per person during the use of shared electric bicycles, and the carbon emission reduction factor of 59.30g/pkm for one kilometer per person for shared electric bicycles in cities without subways; The emission reduction factors of CO, HC, NOx and PM are 0.373 g/pkm, 0.032g/pkm, 0.027g/pkm and 0.010g/pkm respectively.

Based on the above carbon deduction factors, the users of Meituan bikes and electric bikes achieved carbon deduction of 437,000 tons.

2.2.2 Promote the elimination of private over-standard electric bicycles through green products

On April 15 2019, the mandatory national standard GB17761-2018 *Safety technical specification for electric bicycle* was officially implemented. It is clearly pointed out that electric bicycles under the the old national standard will not be allowed to use by December 31, 2021. According to statistics, at present, 90% of electric bicycles on the market belong to bicycles that exceed the stipulation of new standard. The emergence of shared electric bicycles can accelerate the increase in the number of compliant bicycles that meet the GB17761-2018, and significantly improve the overall level of safety of electric bicycles in China. Meituan electric bicycle attaches great importance to the implementation of GB17761-2018, actively invests in scientific research and technology development, and takes the safety performance, smartness and environmental protection level of the bicycle as the core indicators. Meituan has launched a brand new model of electric bicycle, using safe, environmental friendly, durable and recyclable materials, reducing the use of lead-acid batteries, and promoting the compliance, safety, green and sustainable development of the industry.

2.2.3 Promote energy conservation and emission reduction through green technologies such as electronic fence

With the help of Beidou navigation technology and Internet of things communication chip, Meituan electric bicycle has improved the positioning accuracy of vehicle. Supported by the big data, Meituan has developed green technologies such as electronic fence and smart scheduling, which can further help save energy and reduce emissions by guiding users to park in reasonable area, reducing transportation

costs and energy consumption of manual operations, and thus improve the management accuracy and operation efficiency. The specific aspects lies as follow:

(1)Meituan pursues the large-scale and auto management of vehicles through electronic fence technology. For example, the patented technology *Method of determining whether objects are in the target area, parking management equipment and system* (Patent No.: ZL201710296303.6), which won the 21st China Patent Award, is based on Bluetooth communication technology or GPS precise positioning technology to identify whether shared electric bicycles are parked in the designated area. The system allows users to park normally in the parking area, and remind and punish users parked out of the parking area;

(2)In terms of refined operation and maintenance, Meituan realizes the smart scheduling of electric bicycles based on accurate positioning, big data analysis, cloud computing and other technologies. For instance, in the patented technology *Bicycle scheduling method, server, client and system* (Patent No. ZL201711268688.1), the scheduling area is divided into multiple parking scheduling units, and the bicycle demand of the scheduling unit and the average bicycle turnover rate, thus to conduct real-time analysis of the transfer in status, determine the supply and demand relationship of bicycles in the scheduling unit, and intelligently guide the transfer of bicycles from the oversupply scheduling unit to the oversupply scheduling unit, so as to improve the operation and maintenance efficiency of bicycles. Meituan bicycle and electric bike has 47 patents on the above two technologies to provide smart guidance for bicycle delivery, scheduling and maintenance, improve refined operation efficiency, effectively reduce energy consumption in operation and maintenance, pursue win-win and sustainable development between enterprises and cities, and help develop a green city.

At present, Meituan bicycle and electric bike has submitted 585 patent applications at home and abroad, including more than 230 invention patent applications and more than 360 patent authorizations, making it the enterprise with the most core intellectual property rights in the shared bicycle industry of China. Meituan bicycle and electric bike has won the China Patent Award issued by the State Intellectual Property Office for two consecutive years, and also won the honorary titles of "National Intellectual Property Demonstration Enterprise" and "Beijing Intellectual Property Demonstration Organization".

III. Recycling for Whole Life Cycle

Meituan bicycle and electric bike is committed to sustainable development and the concept of "full life cycle management" guided by green, low-carbon and circular economy. It gives full play to its corporate social responsibility and actively participates in and leads the green and low-carbon development of the industry in terms of development concept, development model and practical actions.

Since the launch of the "whole life cycle" action of Meituan bicycle, 1.48 million tires and 1.26 million smart locks have been refurbished and reused. Plastic parts of Meituan bikes such as mudguards and baskets, Meituan e-bike seat barrels have been recycled, with a recycling rate of 70%. Through cooperation with the renewable industry, especially with China Renewable Resources Development Company, Tianjin Xinneng Renewable Resources Company and other professional enterprises, all Meituan bicycles and e-bikes have achieved batch recycling, disassembly and harmless treatment after the end of their life cycle. The above measures reduced Meituan bicycle's carbon footprint in the whole life cycle by 74.3% (84 kg) and Meituan electric bicycle by 24.2% (114.4 kg).

On this basis, Meituan Bicycle innovatively recycles the tires of waste vehicles for the laying of the sports fields and donates them to children in rural areas. Part of the plastic particles for the sports fields are from the recycled polyurethane tire materials of Meituan bicycle. The material has been strictly tested and all indicators meet the standard of GB 36246-2018 *Sports areas with synthetic surfaces for primary and middle schools*. The project provides a safe and comfortable standard basketball court for rural children, and realizes sustainability by encouraging public participation.

By August 2022, the project has built 24 basketball courts in Tibet, Qinghai, Sichuan and Guizhou, covering rural schools in 23 counties in 11 provinces, and recycled more than 50000 Meituan bicycle tires. Meanwhile, by giving full play to the advantages of internet platform enterprises, the project introduced the "carbon reduction" of cycling in Meituan app, guided users to accumulate carbon reduction through green cycling, encouraged users who reached the carbon reduction standard to participate in the co-construction of the sports ground, and motivated the participation of millions of users.

Figure 2 Some of the sports fields constructed by recycle material of Meituan bicycle tires

IV. Implementation and Effectiveness

Meituan's shared bicycles system in whole life cycle for pollution and carbon emission reduction has obvious green economic benefits, environmental benefits and sustainable development benefits of the whole society.

4.1 Green economic benefits

4.1.1 Promote consumption transformation and upgrading

On the premise of meeting the trip needs, private electric bicycles can be replaced by shared ones. Accounting as 60 million bicycles in total be put into use, and the cost per bicycle as 3,000 yuan, in an ideal state, enterprises will consume all the output of electric bicycles in the next two years, and users can save 180 billion yuan in car purchase costs for other consumption.

4.1.2 Push on industrial transformation and development

The expected order volume of shared electric bicycles will exceed 25 billion yuan, and its development will greatly promote the expansion and transformation of the scale of industrial chains, optimize targeted products for standard and smart development.

The industrial chains involved in electric bicycles include: bicycle manufacturers, suppliers of various parts (more than 20 categories such as frame, handlebar, lamp, battery, master control, tire, wheel hub), raw material suppliers (iron pipes, plastic particles) and some terminal operators. From the perspective of market evaluation, it is expected that the total annual output value of shared electric bicycle orders will exceed 25 billion yuan, which will greatly promote the entire electric bicycle industry. Bicycle manufacturers and upstream industrial chain enterprises began to make large-scale investments in personnel recruitment, equipment purchase, capacity expansion, mold investment, new product research and development, and stimulated the investment of enterprises ranging from millions to billions of yuan. With the development of the industry, manufacturing takes the leading transformation from business-to-customer to business-to-business, together with upgrading of automation, smartness and digital production. More high-tech elements are integrated into the body, lock and battery design of shared electric bicycles, and the standards in terms of durability and safety are also higher than before. Higher requirements are put forward for the technology, process, process, management and other process of electric bicycle manufacturing. More smart technologies and means are introduced into the production system and supply chain management system of the whole bicycle manufacturing industry.

In the meantime, with the help of the network operation platform, the shared electric bicycle enterprises can effectively feed back the online operation data, user feedback data and other consumer data to the production end, so as to form a customer-to-business based user data-oriented production mode. Under this mode, the manufacturing enterprises can optimize the product design, improve the process flow, and comprehensively help the standardization and smartness of the industry.

4.1.3 Implement the planning and construction of urban transportation supporting infrastructure

Shared electric bike is an important supplement to green urban trip and helps to build a multi-level and diversified urban trip service system. In the road system, the city management should focus on the allocation of right of way. In public areas, rail stations, and areas around bus stops, full consideration should be given to the planning of non motor bicycle parking areas, and shared bicycle parking facilities should be incorporated into the designing of rail and bus stops.

4.2 Environmental benefits

The use efficiency of shared electric bicycles is 3-4 times that of private electric bicycles, which means that one shared electric bicycle can replace 3-4 private electric bicycles. By means of sharing, on the premise of meeting the same trip needs, 60 million shared bicycles can replace 180-240 million private electric bicycles with low-frequency use, so as to improve the efficiency of bicycle use, reduce the number of electric bicycles, and minimize the risk of long-term parking of electric bicycles. Meanwhile, the city management should encourage the public to give priority to shared bike, electric bicycles and other green trip modes, reduce the total traffic volume of cars, and improve the green trip level of cities.

Meituan electric bicycle has constantly launched new products, services and operation modes, committed to achieving longer distance substitution and the transformation from low carbon to net zero, and guiding people to use Meituan electric bicycle for 3-10 km trips. Meituan electric bicycle will continue to contribute to reducing carbon emissions. Statistics show that it only costs 0.5 kwh of electricity to ride 100 kilometers with Meituan electric bicycle, which costs less than 1 yuan, while ordinary cars cost 60 yuan of gasoline. In terms of carbon emission, Meituan electric bicycle's carbon emission is 1/40 of that of ordinary cars, and its energy consumption is 1/50 of that of cars.

The service methods of Meituan bicycle and Meituan electric bicycle constantly guide people to enhance their awareness of low-carbon life and form the habit of low-carbon trip. The extensive mass base has significantly enhanced the effect of carbon reduction. During the pandemic, the proportion of using shared bicycles and electric bicycles in individual cities accounted for more than 50% of the

overall proportion, which played an important social role. On this basis, people gradually formed the habit of green and low-carbon trip.

4.3 Benefits of social sustainable development

The new business mode of shared bikes can provide lot of job opportunities such as platform operation, program service, scheduling, maintenance and charging personnel, and provide support for the employment rate during the pandemic. Based on the calculation that one operation and maintenance personnel is required for every 100 shared electric bicycles, 60 million shared electric bicycles will need at least 600,000 employees.

In the face of many adverse factors brought about by the COVID-19, stabilizing and promoting employment is still the key work for the government. The shared electric bicycle platform actively plays the role of digital economy and platform economy in absorbing employment, increases employment flexibility, plays the role of "reservoir" of flexible employment, and provides a new way to stabilize employment with high wages. Take Tai'an, Shandong as an example. Last year, Tai'an issued the announcement of the proposed access of shared mopeds in Tai'an urban area. The announcement showed that in order to promote low-carbon environmental protection, energy conservation and emission reduction in the field of urban public transport, and improve the modern urban public transport system, it is planned to regulate and promote urban shared electric bicycles in Tai'an. Faced with the situation that the construction site could not operate as scheduled and workers would soon in financial difficulties due to the epidemic, Tai'an municipal introduce these workers to join the shared electric bicycle operation service team, which solved the urgent need for families without income for the time being. And the wages of operation and maintenance personnel in the shared electric bicycle industry are generally higher than the local average.

City	Average monthly income of Meituan group (Yuan)	Average monthly salary of the city (Yuan)	Rate
Quanzhou	8337	3311	2.5
Foshan	7514	4180	1.8
Changsha	7176	4753	1.5
Chongqing	6381	5316	1.2
Proportion of rural migrant workers in Meituan group			
Quanzhou		58%	
Foshan		33%	
Changsha		59%	
Chongqing		53%	

Figure 4 Salary of Meituan electric bicycle operation and maintenance personnel

Based on Meituan's contribution to green cities, Meituan bike (formerly Mobike) was awarded the title of the new "climate maker" by the World Wide Fund for Nature in June 2017, and won the "Special award for sustainable urban transportation". In December 2017, the United Nations Environment Program awarded the 2017 "Guardian of the Earth" title to Meituan bicycle, in recognition of its great contribution to promoting green trip, mitigating air pollution and climate change. This is the first time that a Chinese enterprise has won this honor since the award was established 13 years ago.

V. Problems and Suggestions

5.1 Necessary policies

With the development of technology and the increasing demand for decarbonization in the transportation sector, supporting policies, regulations and standards should be issued in time to form a policy guidance that encourages urban transportation to develop in the direction of electrification, sharing, diversification and smartness.

5.1.1 Support the development of an integrated trip system of "bus priority + shared bicycle".

By shared bicycles and e-bikes, it is possible meet the needs of short-distance trip, and effectively integrate and seamlessly connect with public transport stations such as bus and subway, so as to drive the increase of the proportion of public transport. With the support of policies and regulations, it is necessary to combine the supporting construction of road facilities that follow the guidance of laws and regulations to form a perfect comprehensive trip system.

5.1.2 Form a total amount control guidance suitable for trip and facilities

The city management should issue standards and regulations for the total amount control allocation layout suitable for urban trip needs and parking space capacity restrictions, guide the reasonable formulation of the allocation layout and development plan of shared bicycles and electric bikes, and focus on the reasonable allocation in local densely populated areas such as residential areas, industrial parks and business districts.

5.1.3 Strengthen supervision and establish a fair competition mechanism

The city management should actively encourage and further regulate enterprises to carry out innovative riding services, optimize the allocation of government resources, implement a resource allocation mode guided by the results of service quality assessment. The enterprises should create a survival mechanism,

improve service quality. The administration departments should strengthen regulatory means and technology, and strictly prevent enterprises from investing in bicycles in violation of regulations, resulting in vicious competition in the industry.

5.2 Improve urban cycling infrastructure

The urban transportation infrastructure should be laid out in a low-carbon direction to build a safe, continuous and comfortable urban riding system.

5.2.1 Improve the cycling facilities network.

The city management should actively strengthen the planning and construction of bicycle lanes, convenient crossing facilities and bicycle parking areas, improve the connection capacity between shared bicycles and bus stops, rail stations and core areas, coordinate and synchronously develop shared (electric) bicycle in the process of developing public transport, form organic supporting facilities, establish and improve a multi-level and diversified urban trip service system.

5.2.2 Encourage government-enterprise cooperation to achieve digital governance of slow travel system

The city management is advice to constantly improve the parking space for cycling bicycles, encourage government and enterprises to share (electric) bicycle enterprises to share big data, participate in the development of slow-moving systems and the management of cycling environment, and carry out the construction of bicycle lanes, smart car bars, mechanical bike parking system and other facilities.

5.3 Promote green riding innovation pilot projects and develop smart low-carbon cities

Under the action plan for green trip, the city management should promote the development of low-carbon smart cities in combination with new modes and technologies of shared trip.

5.3.1 Carry out pilot demonstration of urban cycling carbon reduction.

It will be necessary to explore the development of an integrated green trip demonstration park from circular production to circular consumption, promote the development of carbon emission trading market system, and implement the carbon credits trading pilot projects.

5.3.2 Encourage government-enterprise cooperation to promote innovative cycling services.

For cities where the operation of traditional public bicycles is difficult to sustain, it is possible to implement the development of shared bicycles through government purchase services, franchising, joint ventures with local public transport enterprises and other ways to achieve a win-win situation for the public, the government and enterprises.

5.3.3 Establish a transportation carbon integration platform

The carbon reduction of cycling will be included in the carbon neutrality pilot. The voluntary emission reduction behaviors of individuals or enterprises will be detected, measured and managed, and carbon reduction points rewards will be issued to enhance the sense of participation and acquisition of green trip of residents and enterprises.

VI. Continue to Promote Green Travel

With the continuous promotion of urbanization in China, the density of functional points (catering, leisure and entertainment, office, housing, etc.) in the core areas of each line of cities continues to increase, the distance is significantly shortened, and the proportion of medium and short distance trip demand increases. Meanwhile, in terms of urban traffic congestion and the shortage of parking spaces, the convenience of travelling by bike has been significantly improved, and the shared (electric) bicycle market has great prospects.

6.1 Development of shared electric bicycle platform with integrated services

China's daily demand for trips by electric bicycle is one billion times, and it needs to complete nearly 100 million times of charging process every day. Among them, about 300 million trips per day can be converted into shared electric bicycle trips. Calculated by 2 yuan per trip, the annual market scale will exceed 200billion yuan, which does not include the power exchange market. In addition, the sharing platform based on bicycles can integrate more services in the future, such as power exchange, battery sales, bicycle maintenance, bicycle insurance, life services, financial services, data sharing and advertising. The integrated service content of the shared electric bicycle platform has great potential.

6.2 Pay attention to the allocation scale of shared bicycles

According to the data of 2020 special research report on the safety management of shared electric bicycles in China of AI Media Consulting, it is expected that more than 8 million shared electric

bicycles will be launched in 2025, and the number of shared electric bicycles in China has exceeded 1 million in 2019. In the next five years, as major enterprises gradually promote the distribution of shared electric bicycles, users' demand for shared electric bicycles has been further stimulated, especially in the third and fourth tier cities in China, the covering rate will maintain a sustained and rapid growth trend. It is expected that the number of shared electric bicycles will exceed 8 million in 2025, and the compound growth rate from 2019 to 2025 will reach 41.4%. Meituan will balance the supporting capacity of the whole life cycle and continue to develop the allocation scale based on accurate calculation.

6.3 Develop the revenue market of shared trams

At present, people have shifted from tool selection to the pursuit of trip experience. Users will use shared electric bicycles in the case of road/personnel congestion, fatigue, and time rush. Facing the trip distance within 5 kilometers, people tend to choose shared electric bicycles.

According to the survey data of AI Media Consulting, about 30% of the respondents use shared electric bicycles 1-2 times or more than 3 times a week. In 2019, the revenue scale of China's shared electric bicycles reached 3 billion yuan. With the continuous expansion of the launch scale of shared electric bicycles and the improvement of the public's awareness of shared trip, the daily utilization rate of shared electric bicycles is further promoted. It is estimated that the revenue scale of shared electric bicycles will exceed 20 billion yuan in 2025.

6.4 Continuously improve the management level and operation efficiency of urban smart transportation

With the implementation of the GB 36246-2018, shared bicycles have developed rapidly with the new Chinese national standard as an important reference. In addition, 5G, AI and other new infrastructure will accelerate data sharing and smart city development. First, data resource sharing improves the level of smart traffic management. The platform will share the collected basic data and information of road traffic with the traffic management department in real time, and support the harmonious trip of people, bicycles and roads, which not only provides support for traffic management and decision-making, but also provides real-time traffic information for residents, ensure traffic safety, improve traffic environment and improve energy efficiency. Second, the city management should think of reducing the laying of public transport lines in remote areas and improve the efficiency of the use of public transport resources. By optimizing the construction density of existing bus stops, supplementing the demand for bus lines of remote routes, it is feasible to reduce the cost and improve the efficiency of the use of limited public transport resources.

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