BRI International Green Development Coalition
2021 Policy Study Series

BRI Case Study Report on Green Development of Cities

In April 2019, Chinese and international partners officially launched the BRI International Green Development Coalition (BRIGC) at the Second Belt and Road Forums for International Cooperation. BRIGC aims to establish a policy dialogue and communication platform, an environmental knowledge and information platform, and a green technology exchange and transfer platform, so as to advance global consensus, understanding, cooperation, and action of a green Belt and Road Initiative (BRI).

China and many BRI participating countries are facing a series of environmental challenges caused by rapid urbanization. Green and sustainable development is our common need and future direction. Promoting green city construction is an inevitable trend of urban development in all countries around the world and it is also a necessary way to protect urban ecological environment and to cope with climate change. Taking into consideration the United National 2030 Sustainable Development Goals (SDGs), the current Report demonstrates 21 green city development cases from over 10 countries and focuses on eight key aspects of the green urban development, including green and low-carbon urban planning, zero-waste cities, pollution control and environmental improvement, green energy, biodiversity and nature-based solutions, sustainable transportation, green buildings, and international cooperation on the development of green cities. By sorting out and summarizing the common experience of urban green development in different countries and different fields, this··report can provide insights to solving complicated and cross-sectoral problems in urban management and help more cities to transform green development concepts into green practice and create incentives for sustainable development.

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Executive Summary

With countries around the world putting “carbon neutrality” on the agenda, the low-carbon development of urban infrastructure, transportation and energy is becoming increasingly important. Promoting the green transition of cities is of great significance to developing a green and low-carbon circular economy in an all-round way. currently, many cities have proposed and implemented plans to promote renewable energy, carbon neutrality and climate resilience, providing experience and good practices for other cities to pursue green development.

With rapid economic growth and urbanization, BRI participating countries are faced with the challenges of overconsumption of resources, environmental pollution and biodiversity loss. In the future, the strain between economic development and fragile eco-environment will become even more prominent, making it urgent for BRI participating countries to pursue green and sustainable development. BRI participating countries, mostly developing countries, are in similar stages of development with similar ecological and environmental challenges. They have accumulated much experience and best practices that need to be shared.

BRI International Green Development Coalition (BRIGC) established the Thematic Partnership (TP) on Improvement of Environmental Quality and Green Cities with Chinese Academy of Environmental Planning of MEE, Belt and Road Environmental Technology Exchange and Transfer Center (Shenzhen), and World Resources Institute as the lead partners. The TP aims to provide support and services to green urban development in BRI participating countries with energy and resource conservation, living environment improvement, green transportation system and green and smart cities as the priority areas.

BRI Green City Development Case Study Report is organized by the BRIGC Secretariat and jointly prepared by the TP on Improvement of Environmental Quality and Green Cities and C40 Cities Climate Leadership Group. The Report showcases the valuable experience of BRI participating countries in promoting the green development of cities, through scientific research and data analysis in consideration of the United National 2030 SDGs. The Report focuses on eight priority areas of relevance to the development of green cities, including green and low-carbon urban planning, zero-waste cities, pollution control and environmental improvement, green energy, biodiversity and nature-based solutions, sustainable transportation, green buildings, and international cooperation on the development of green cities. The cases are selected from BRI participating countries or key cities on the Silk Road Economic Belt and 21st Century Maritime Silk Road, with priority to projects invested and built by Chinese enterprises, initiated by host countries and constructed by Chinese enterprises, or inspiring to the development of green cities.

The Report showcases 21 green city development cases from over 10 countries, including: Shenzhen International Low-Carbon City, Sustainable Development in Guangzhou, China-Belarus Great Stone Industrial Park, Capannori Zero-Waste City in Italy, Zero-Waste City of Singapore, Zero-Waste City of Shenzhen, Comprehensive Air Pollution Control in Beijing, Sewage Treatment and Utilization in Israel, Black and Odorous Waters Treatment of Nakao River in Nanning, King Salman Energy Park (SPARK) in Saudi Arabia, the Development of 100% Renewable Energy City in Dunhuang, Urban Agriculture in Rosario of Argentina,

Kunming's Toolkit for Biodiversity Conservation, Green Corridor in Lisbon, Forged by Floods: Wuhan Yangtze Riverfront Park, the Introduction of Clean Electric Buses in Chili, Diesel Multiple Unit (DMU) Trains in Malaysia, Promotion of Bike Sharing in Hangzhou, South Africa's Green Building Rating Tool, Vertical Greening in Singapore, Model City of the Application of Renewable Energy in Buildings in Fuzhou, and China-ASEAN Partnership for the Development of Eco-friendly Cities.

Selected from different countries in different areas, these cases provide similar experience. First, governments need to provide policy guidance and organize overall planning and design. The government plays the guiding role in supporting the development of green cities through setting up strategic goals for development, identifying development pathways and developing regulations and standards for project implementation in an integrated and scientific manner. Second, practices need to be carried out according to local circumstances. Cities should make and implement urban development plans according to local circumstances and identify the optimal development pathways for themselves. It is important to take the comprehensive development of the city into consideration and start from pilot programs in priority areas. Third, we need to make full use of science and technology to promote innovative development. In the process of urban construction, it is important to introduce in advanced and mature science and technology and encourage the R&D and application of new technologies. Fourth, we need to establish communication and cooperation mechanisms among cities. Such mechanisms allow cities to share experience and technologies, seek for external support, take joint actions to promote regional green development and replicate and promote best practices. Fifth, we need to make engagement mechanisms more inclusive to enhance social participation. It is important to motivate the engagement of the public through education and publication to promote energy-saving and environmental-friendly production models and lifestyles. Sixth, we need to encourage investment in green development projects. It is important to expand the channels of financing with government investment as the pillar and the active engagement of NGOs, businesses and social capital to more effectively promote the green development of cities.

Case study and experience sharing will provide insights to addressing complicated and cross-sectoral bottlenecks in urban management, boost the confidence of BRI participating countries in promoting the green city development, help more cities to transform green development concepts into practice, and create momentum for sustainable development.

Chapter 1. The Background of Green City Development

The rapid growth of global economy is often accompanied by energy consumption and environmental pollution, and urbanization becomes the main factor causing these problems. A study showed that the urban area only accounts for 1% of the world's total land area, but it has more than 54% of the population, consumes more than 70% of the world's energy, and emits more than 70% of the world's greenhouse gases[2]. With the rapid development of global urbanization, the world's urban population will further increase, and is expected to reach 5 billion in 2030[3]. In the past 70 years, most countries in the world have risen peacefully. The global urbanization rate has rapidly increased from 29.4% in 1950 to 56.2% in 2020[4], especially in developing countries in Southeast, South Asia, and Africa, where countries along the “Belt and Road” have made huge contributions and still have much potential to increase in the future. However, rapid urbanization in developing countries has also brought about a series of ecological and environmental problems such as greenhouse effect, atmospheric ozone depletion, soil erosion, deforestation, land desertification and water pollution [5]. Therefore, improving the quality of urbanization and seeking a "green" urban development path has become the consensus of international community.

Green city is a reflection and rethinking of the traditional industrialization-driven urban development model. It essentially reduces the high dependence on natural resources, emphasizes the harmonious coexistence of man and nature, pursues the development goal of the organic integration of society, economy and ecology, and adapts to the city’s development goals and the inherent requirements of sustainable development [7]. Among them, the connotation of "green" is inseparable from "sustainable" and "sustainable development" [8]. In 1991, the United Nations Human Settlements Program (UN-Habitat) and the United Nations Environment Program (UNEP) proposed and implemented the Sustainable Cities Programme (Sustainable Cities Programme, SCP), promoted the global green development. Green cities are open and all-encompassing. The urban development concepts of ecology, livability, low-carbon, forest, sponge, and wisdom are all interpretations of people-oriented and sustainable development ideas, and present different aspects of green cities. Different cities interpret the connotation of “green” according to local conditions, which can be manifested in the greening of energy use, the protection of ecosystems, the construction of sustainable transportation, the improvement of environmental quality, the creation of waste-free cities, and the planning of low-carbon cities.

From a national perspective, the United Kingdom is one of the first countries to advocate green development, taking the construction of green cities as the carrier of its green development model. Germany has made breakthroughs in the exploration of the development of green environmental technology industry. Japan formulated the “Green Development Strategy” master plan in 2012, and carried out a green revolution at the economic and social levels accordingly. In 2012, China proposed to put the construction of ecological civilization in a prominent position, aligned the ecological civilization in an equal position with political civilization, economic, social and cultural development, and promoted it to the height of "five in one"; and it was made clear at the end of 2013 that “The concept and principles of ecological civilization should be fully integrated into the whole process of urbanization, and take a new road of intensive, smart, green, and low-carbon urbanization.” The focus of green city construction in the fields of green energy, green buildings, green transportation, circular transformation of industrial parks,

comprehensive improvement of the urban environment, and green new life actions has pointed out the direction for the development of Chinese cities. In order to promote the development of green city, Mongolia issued the "Ulaanbaatar Green Development Strategic Action Plan 2020" in 2015, striving to improve the ecological environment of Ulaanbaatar and create a low-carbon urban development model.

Since the French architect Le Corbusier first proposed the "green city" the concept and connotation of the green city have been dynamically updated. By the end of the last century, the academic and theoretical circles have gradually formed some basic standards for measuring green cities: 1. Green cities have full viability in nature; 2. Green cities are the harmonious relationship and organically connected ecosystem of biological resources, cultural resources, economic resources, and ecological environmental resources; 3. Green city has a vast natural environment space and rich ecological environment types, so as to maximize the protection and maintenance of biodiversity that coexists with human beings; 4. The most important function of green city is to maintain human health and encourage humans to live, study and work in the natural environment; 5. Green cities protect natural resources and recycle all kinds of waste that are inevitable; 6. Green cities promote the comprehensive development of culture and are the place of joy and upward progress; 7. The various components of the green city are planned and laid out according to the aesthetic relationship, so as to provide humans with beautiful and rhythmic settlements; 8. The green city scientifically plans the spatial pattern of the city and human social activities, thereby provides mankind with a living place and new space facing the future with continuous progress [15].

In the 21st century, with the development of new technologies and technological progress, the green process of city development has undergone new changes; on the basis of maintaining the harmonious coexistence of man and nature, green cities have ushered in new opportunities.

The first is the modernization of urban infrastructure. The trend of urban development is to vigorously develop modern, digital infrastructure, and provide a more convenient and efficient urban life network. At the same time, it is necessary to build a green city, an ecological city, and form a new situation of a civilized city that combines technology and green with both efficiency and ecology. Urban development will inevitably require the construction and renovation of infrastructure. For example, communication network infrastructure represented by 5G, Internet of Things, and Industrial Internet; deep application of Internet, big data, artificial intelligence and other technologies to support the transformation and upgrading of traditional infrastructure, and then the formation of integrated infrastructure such as intelligent transportation infrastructure and intelligent energy infrastructure Facilities; and infrastructure with public welfare attributes such as major scientific and technological infrastructure, scientific and educational infrastructure, industrial technological innovation, etc. Integrating these new infrastructure constructions into the green development of the city is the correct way for the development of a modern city. Emerging technologies also provide more opportunities for the green development of the city. For example, in terms of raw materials, the birth of more environmentally friendly and reusable materials has greatly reduced the resource consumption and ecological pollution of infrastructure construction. 5G technology, artificial intelligence, and the Internet of Things provide a more intelligent and sensitive platform for monitoring and investigating environmental pollution, so as to find and track pollution sources faster and more accurately, and carry out certain measures to eliminate hazards [16].

The second is the global carbon emission reduction and carbon neutral commitment. Climate change and

extreme weather are increasingly affecting city life. In order to mitigate and adapt to climate change, urban development is gradually transforming to green and low-carbon, while vigorously improving the climate resilience of cities. Countries have made carbon emission reduction and carbon neutral commitments. Up to now, 127 countries have made carbon neutral commitments. The total greenhouse gas emissions of these countries account for 50% of global emissions, and the total economic volume ratio exceeds 40% of the world. The European Union, Germany, France and other developed countries have successively issued Green New Deals and carbon neutral strategies, and countries such as the United Kingdom and Sweden have also incorporated carbon neutrality into their laws. China has also proposed a dual carbon goals of carbon peak in 2030 and carbon neutrality in 2060. Under the constraints of controlling carbon emissions, countries have developed green low-carbon technologies, developed new energy technologies, launched low-carbon buildings, and built sustainable transportation systems, which have introduced new directions for the development of green cities.

The covid 19 pandemic has allowed us to re-examine the relationship between human and nature, to pay attention to the integrated protection and systematic management of mountains, waters, forests, farmlands, lakes, grasslands, desert and glacier and finally to think deeply about how to establish a management system for the coordinated development between human and nature in the context of ecological civilization construction. Cities need to search for opportunities and motivation in this green development area. All environmental, social and economic challenges are interrelated, and mankind must take urgent action to jointly tackle global environmental problems. Through international commitments and low-carbon actions, we will follow the path of urban green development, preserve a healthy home on the earth, and realize the sustainable development of mankind.

With the transformation of the concept of urban development and the popularization of green and sustainable development, the construction of future cities will inevitably move towards low-carbon and green aspects. Cities are the main body of economic and trade activities along the Belt and Road and an important carrier for the construction of the "Green Silk Road." The construction of green cities can not only meet the economic and social development needs of the countries along the “Belt and Road”, but also help the countries realize the sustainable development of the harmonious coexistence of man and nature. Green city development experience will help Belt and Road cities jointly find a path of sustainable urban development and contribute to the green and low-carbon transformation of the region.

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Chapter 2. Green and Low-Carbon City Planning

1 Great Stone Industrial Park

Great Stone Industrial Park is located close to Belarus' capital, Minsk and directly on the Northern Corridor of the New Silk Road trade route, forming a key part of the Belt and Road Initiative. Positioning itself as an energy-saving, environmental-friendly project, the park integrates eco-environmental protection into its general plan to ensure the implementation of green development concepts and the highly efficient utilization of resources throughout the process of construction and operation.**Background**

Belarus is a country in central Eurasia that is a key transfer station on the Silk Road Economic. It serves as a communication link between Europe, CIS and Russia, providing excellent links into Europe and Russia and the Baltic and Black Seas. 90% of the China-Europe freight trains transfer rails at Brest on the border of Belarus and Poland. As a logistics hub in Eurasia, Belarus has well-developed transport links and ready-to-use utilities infrastructure, providing easy access to the EAEU market within close proximity of the European Union.

1.2 Project overview

Development of the park dates back to 2015, when leaders of China and Belarus inspected the area. China National Machinery Industry Corporation Ltd. (Sinomach) and China Merchants Group (CMG) took a lead in its construction. The park, covering an area of about 112 km^2 with a planned territory of 91.5 km^2, is currently the largest and highest-level overseas economic and trade cooperation zone invested and developed by China.

In October, 2010, during Belarusian president Lukashenko's visit in China, the Ministry of Economy of Belarus signed *Agreement on the Establishment of China-Belarus Industrial Park in the Republic of Belarus* with China CAMC Engineering Co., Ltd. In September, 2011, the two governments signed *Agreement between The People's Republic of China and the Republic of Belarus on China-Belarus Industrial Park*, officially kicking off the construction of Great Stone Industrial Park. In July, 2013, Chinese president Xi Jinping and Belarusian president Lukashenko jointly announced the establishment of comprehensive strategic partnership between the two countries with expanding mutual investment, fostering joint ventures and constructing the second stage of the Great Stone Industrial Park as the priority. In May, 2015, president Xi Jinping identified Great Stone Industrial Park as a key project for China-Belarus cooperation and proposed to make full use of intergovernmental coordination mechanisms to facilitate the future development of the park and build it into a pearl on the Silk Road Economic Belt and a model for mutually-beneficial, win-win cooperation between the two countries.

The park, located in Smolevichi district of the State of Minsk, is only 25 km, or 30 mins drive, from the capital city. The international airport is less than 5 min drive and the Moscow-Berlin international highway (M1/E30 and M2) passes by the park's entrance. The park's priorities are the development of high-tech, innovative, science-intensive, export and environmental-friendly production, with mechanical engineering, fine chemistry, electronics and telecommunications, biotechnology, pharmaceuticals, new materials and logistics

as priority directions. The planned territory includes industrial and transport facilities, residential areas and social facilities, offices, shopping and entertainment complexes, financial and research centers.

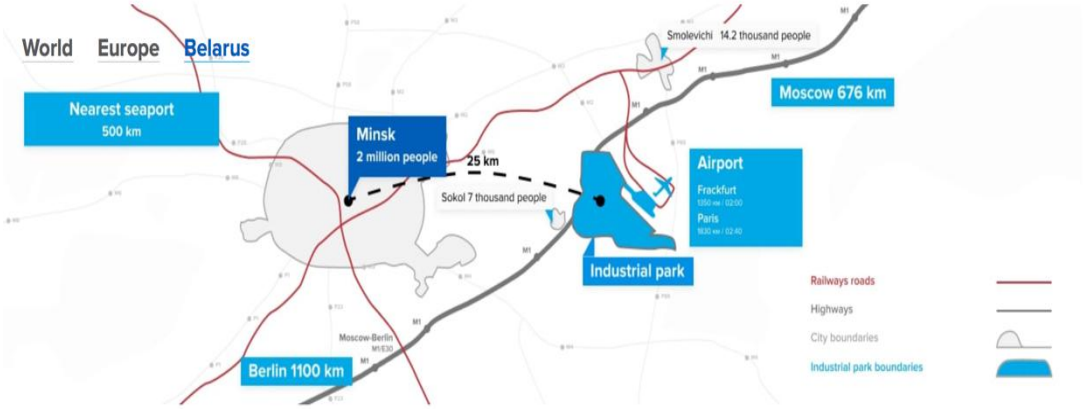

Figure 2-1: Geographical location of Great Stone Industrial Park

By the end of June, 2021, the park has 71 residents with a contracted investment of over USD 1.2 billion. The construction of the park is being carried out in five stages. The first stage is a territory of 850 hectares, where all communications infrastructure has been completed, including a 32 km road and power supply system, and electricity, water, gas, sewage treatment, and communication networks. Now, 515 hectares of land are ready for lease with 85,000 m2 of standard factory buildings being built. The office building project won “Excellent Project Award of Belarus” and “Luban Award for Overseas Projects”; the infrastructure construction project won “Free Zones of the Year”.

1.3 Green Development experience

1.3.1 Integrating green development concepts into the general plan

China International Engineering Consulting Corporation (CIECC) is entrusted with the development of the general plan from the very start of site selection and business negotiation. A thorough analysis of the economic feasibility of the park was also conducted. The general plan analyzed the political, economic and social environment of the local area, the favorable conditions and existing infrastructure of the park, the positioning of the project and the development goals of the parks. In particular, the general plan identified the park’s priorities as the development of high-tech, innovative, science-intensive, export-oriented and environmentally-friendly production with ecological-friendly, energy-saving, green and sustainable development as one of the major tasks for construction. Besides, the general plan also includes a special chapter on environmental protection with detailed explanation of the hydrogeological condition and eco-environmental friendly facilities needed, providing scientific guidance on the sustainable development of the park in the future.

Meanwhile, Great Stone Industrial Park established a multi-level management structure with the Industrial Park Development Company at the center, leading local universities and research institutions to jointly promote the development of the general plan. An intergovernmental coordination council composed of the Ministry of Commerce of China, the State-owned Assets Supervision and Administration Commission of the State Council and the Ministry of Economy of Belarus held a series of meetings to facilitate communication.

1.3.2 Introducing in professional environmental agencies

The Industrial Park Development Company invited EMAS (Eco-management and audit scheme) certified professional agencies to conduct environmental assessment for the park. In 2018, Great Stone became the first organization in Belarus to be granted with the EMAS certificate, which is considered to be the world's most advanced sustainable development management scheme. This fully shows that Great Stone Industrial Park is qualified as an ecological garden city and a model project in sustainable development and ecological and environmental protection.

Figure 2-2: EMAS Certificate for Great Stone Industrial Park

1.3.3 Improving the land resource utilization rate

Optimizing the layout of the park helps with the efficient use of land resources. Dividing the park into four functional zones, the general plan proposed a layout featuring "one belt, two axis, three cores" to realize the scientific and efficient use of land. "One belt" refers to the ecological landscape belt composed of the green belt along M1 highway and the waterfront landscape belt. "Two axis" refers to the east-west tourism and recreation axis and the north-south industrial development axis. "Three cores" refers to the exhibition and trade area in the north, the commercial and business facilities in the central area and the recreational facilities in the west. In terms of functional zones, the park has production zones, high-tech zones, R&D zones, residential areas, recreational areas and areas reserved for future development. Besides, the park attaches great importance to ecological and environmental protection and keeps the natural reserves, water bodies, 15 villages and 13 plant areas in the planned territory of the park intact in its general plan.

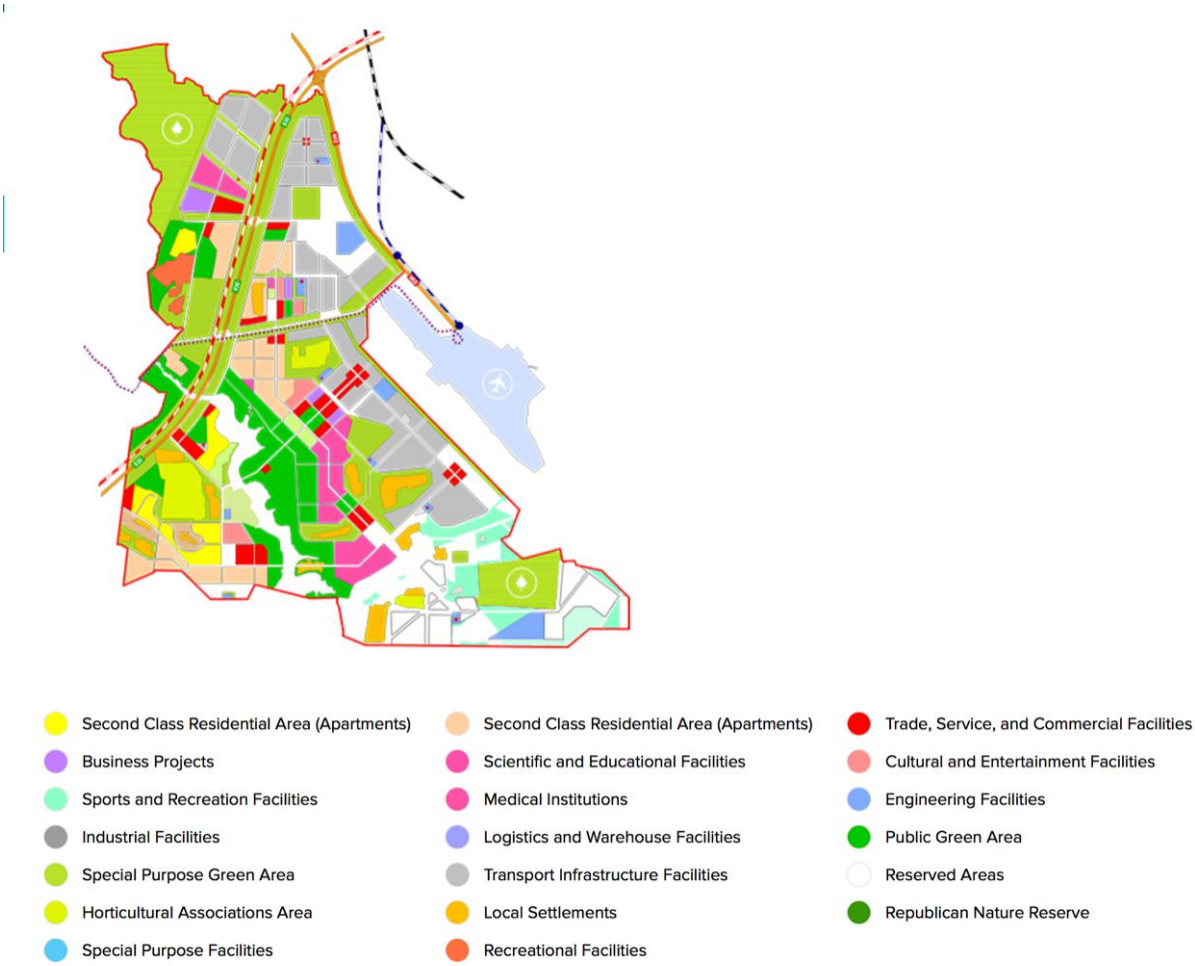

Figure 2-3: General Plan of Great Stone Industrial Park

1.3.4 Improvement of ecological environment

The coverage of green space is an important indicator for ecological and environmental improvement in the park. Attaching great importance to the protection of ecosystems, the park adopts an integrated approach towards spatial planning, emphasizing the bond between functional zones and green space, which will effectively promote the development of ecological shields. Back in the early stage of project planning, Great Stone Industrial Park has set the requirements for ecological and environmental protection to protect, effectively utilize and restore existing natural resources as much as possible, so as to realize sustainable development. With an overall green space coverage of nearly 50%, the park keeps all villages and plant areas in its territory intact, implements systems and regulations for the protection of the environment and green space, and requires the observance of the above regulations by residents and developers in the construction of infrastructure facilities and buildings. Moreover, the park has been constantly expanding the area of green space to create landscapes.

(a) China-Belarus Commerce and Trade Logistics Park

(b) No.4 Avenue of the Park

(c) Sewage treatment plant

(d) Rainwater treatment plant

Figure 2-4: Comparison of green space in Great Stone Industrial Park in 2014 and 2019

1.4 Case Summary

Great Stone Industrial Park is the largest project in Belarus under the Belt and Road Initiative, and it is also one of the projects with the most development potential in Belarus. The park establishes a scientific overall

planning and also a special green development planning in order to ensure that the concept of green development is integrated into each space unit， to incorporate resource conservation, environmental friendliness, and ecological protection as core content into the park construction and development. The park also advocates resource conservation and effective energy usage and actively improves the quality of the ecological environment around the park. That is why that the Great Stone Industrial Park is a vivid example of jointly building a green “Belt and Road”.

2 Longgang International Low Carbon City

2.1 Background

Longgang International Low Carbon City is located in Longgang District in the northeast of Shenzhen. It covers an area of 388.21 square kilometers and has a permanent population of about 3.98 million. It is the district with the fastest population growth in Shenzhen. Longgang District in the past was still deserted, but since the official launch of the international low-carbon city at the end of 2012, after more than 8 years of exploration of urban green development, the area where the international low-carbon city is located has achieved a "glorious turn" with industrial transformation and upgrading, and economic growth. In 2020, the regional GDP within the scope of the international low-carbon city will reach 16.302 billion yuan, which is three times that of 2012; the added value of industrial enterprises above designated size will reach 9.296 billion yuan, more than twice the 2.978 billion yuan in 2012. Ten technological systems including green buildings, clean transportation, sewage recycling, waste recycling, energy and low carbon have been applied in the area, 97 advanced technologies, and the construction concept of Sponge City runs through the entire area, which has become a veritable demonstration area of green and low carbon technologies.

Longgang District is represented by an international low-carbon city, practicing the concept that green water and green mountains are golden mountains and silver mountains, taking the construction of ecological civilization as a major strategy to enhance Longgang's core competitiveness, implementing the most stringent ecological environmental protection system, and successively being rated as "National Level Ecological Demonstration Zone", "The Second Batch of National Water and Soil Conservation Supervision and Management Capacity Building Zones", "The First Batch of National Low-Carbon City (Town) Pilots", "The First Batch of Industry-City Integration Demonstration Zones in China", "National Town with Cultural Tourism Features", "National Forest Village", "National Ecological Civilization Construction Demonstration Zone", etc., which gather a number of national "golden signboards". Today, Longgang has become an important support point for Shenzhen to drive Guangdong, Hong Kong and Macao to participate in the construction of the "Belt and Road".

2.2 Project overview

Shenzhen Longgang International Low Carbon City is located in Pingdi Street, Longgang District. It used to be the most backward and carbon-richest area in Shenzhen. The GDP per unit area is only 1/5 of the city's average, but the energy consumption and carbon emission intensity are about 2 times of the city's average. In 2008, Shenzhen began planning to establish an international low-carbon city. In June 2010, Shenzhen and the relevant departments of the Netherlands conducted many exchanges on the cooperation in the construction of a China-Dutch (Europe) low-carbon city project, and clarified the intention of China and the Netherlands to build a China-Dutch low-carbon city. In December 2011, with the support of the National Development and Reform Commission, the Shenzhen Municipal Government and relevant Dutch authorities held the "China-Netherlands (Europe) Low-Carbon City Expert Seminar" to discuss the planning and vision of low-carbon cities. In the following year, Shenzhen and the Netherlands proposed to cooperate in the planning and construction of Shenzhen International Low-Carbon City. Based on Pingdi's location at the intersection of Shenzhen, Dongguan and Huizhou, with low development and construction intensity, good

ecological protection, and superior conditions for low-carbon construction, the local government decided to plan and build an international low-carbon city in Pingdi to create a flagship project of Sino-European sustainable urbanization cooperation.

On the morning of August 21, 2012, the launch ceremony of the Shenzhen International Low-Carbon City Launch Zone Project was held in Gaoqiao Industrial Park, Pingdi Street, Longgang District, marking the official start of development and construction of Shenzhen International Low-Carbon City as the flagship project of Sino-European sustainable urbanization cooperation. The total planned area of the park is 53.14 square kilometers. The Gaoqiao Park and its surrounding areas are 5 square kilometers as the expansion area, and the core area is about 1 square kilometers as the start-up area. At present, it is under rolling development and construction in accordance with the three circles of "core area-expansion area-global scope", with a construction area of about 1.8 million square meters and a construction period of 7 years. The park is located in the hinterland of the junction of the three cities of Shenzhen, Dongguan and Huizhou, close to the central city of Longgang. There are Huiyan Expressway, Outer Ring Expressway, Longgang Avenue, Huiyan Expressway, the east extension of Metro Line 3, and the Shenzhen-Huizhou Intercity Line (Pingdi has a station), making the transportation convenient and extending in all directions.

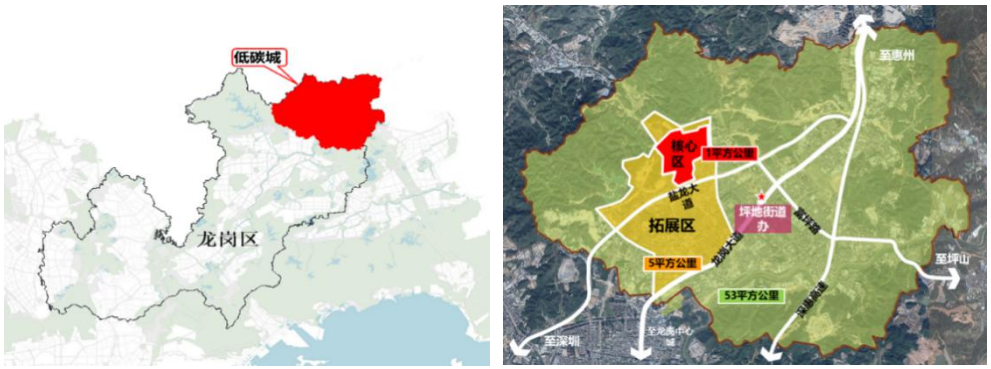

Figure 2-5. Location of Longgang International Low Carbon City

The superior geographical location and convenient transportation have created significant development opportunities for the international low-carbon city. Since 2016, the region has concentrated on signing contracts for 30 flagship projects in 17 sectors, such as China-Europe Future City, German Town, Overseas Chinese Town International Low-Carbon Demonstration City, etc., with an investment of over 75 billion within a year; A large number of domestic and foreign companies such as Royole Technology, Jieke Electronics, and Space Technology South Research Institute have also been introduced, and the proportion of high-tech companies has increased significantly. Compared with 2012, the number of enterprises above designated size increased from 94 to 282 in 2019, the number of national high-tech enterprises increased from 9 to 246, and the number of enterprises with 100 million yuan increased from 13 to 76. An industrial layout integrating high-tech, biotechnology, aerospace technology, environmental protection industry and large-scale service industry has been initially formed.

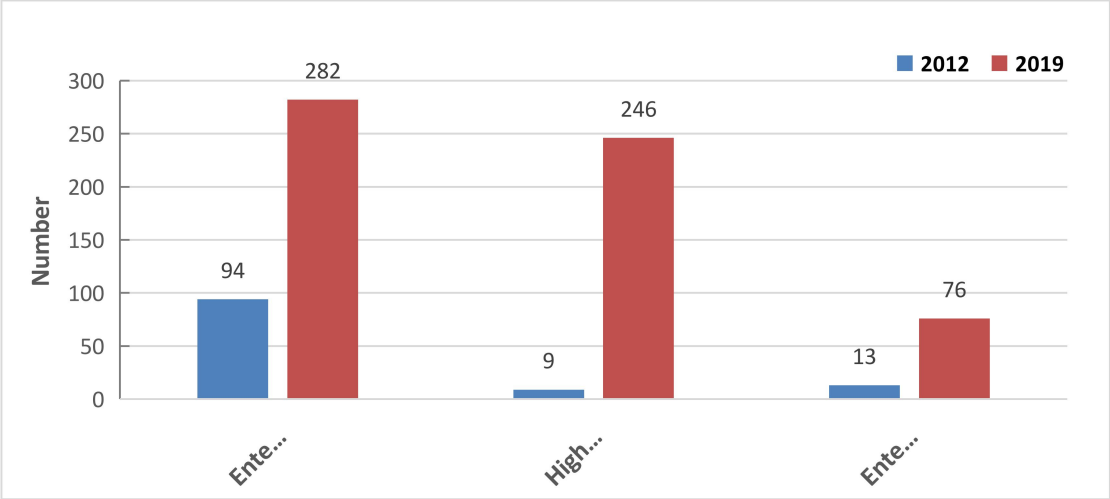

Figure 2-6. Number of Enterprises in International Low Carbon City

As of 2019, the regional GDP reached 15.133 billion yuan, nearly twice that of 5.407 billion yuan in 2012, with an average annual growth rate of 13.7%. The added value of industrial enterprises above designated size reached 8.224 billion yuan in 2019, ranking third in the region in total, which increased by 176.2% compared with 2.978 billion yuan In 2012, with an average annual growth rate of 13.4%. The total fixed asset investment was 12.104 billion yuan, increased by 383.9% over 2012's 2.501 billion yuan, with an average annual increase of 21.8%. The street total amount ranked from 8 in 2012 jumped to the third place among the 11 streets in 2019, which showed a strong economic growth.

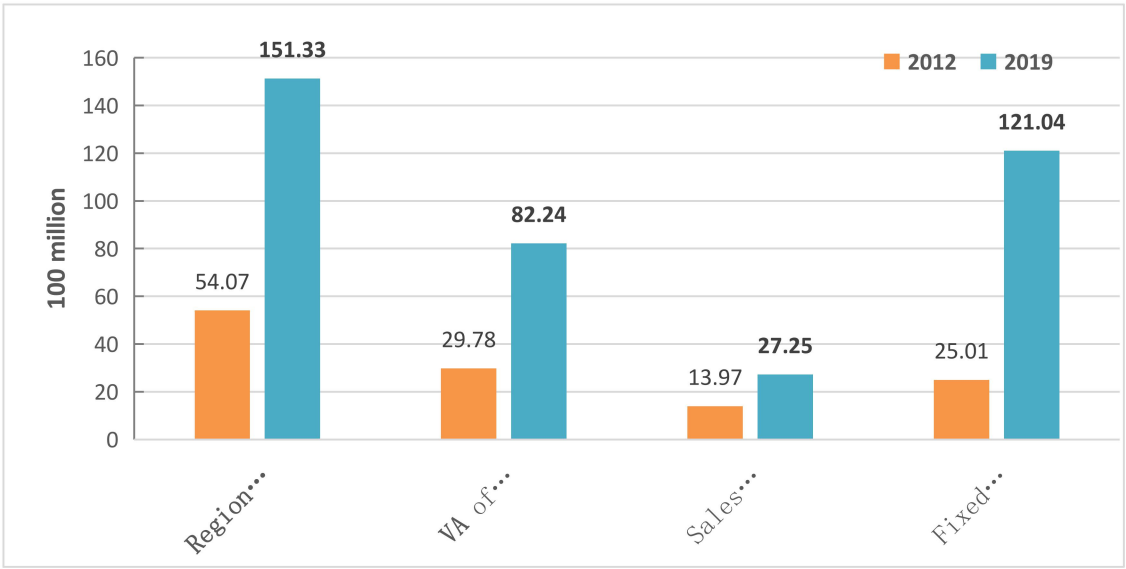

Figure 2-7. Economic Indicators of International Low Carbon City

Not only that, since 2013, Shenzhen International Low-Carbon City has successively hosted the Shenzhen International Low-Carbon City Forum for 5 times, bringing many useful attempts and experience explorations to the country, provinces and cities in the field of green, low-carbon and sustainable development. Among the 18 key development areas of Shenzhen, it is the only carrier and demonstration

window featuring green and low-carbon development. Moreover, the international low-carbon city has won many domestic and foreign honors: in 2012, it was listed as the flagship project of China-EU sustainable urbanization cooperation by the National Development and Reform Commission; in 2014, it was selected as one of the top ten new urbanization examples in the country by the National School of Administration and People's Daily Online, and it was listed as the Asia-Pacific Economic Cooperation Organization low-carbon town demonstration projects and won the Paulson Foundation "Sustainable Development Planning Project Award"; in 2015, it was selected as the first batch of national low-carbon city (town) pilots by the National Development and Reform Commission, and won the first "China-Europe Green and Smart City Award" pioneering award ; In 2016, he was awarded the title of "China-Europe Urbanization Partnership Demonstration Zone" by the National Development and Reform Commission and the European Commission; In 2016, he was awarded the China-Europe Urbanization Partnership Demonstration Zone and the first prize of National Urban and Rural Planning and Design; in 2017, he was awarded by the U.S. Green Building Association with the Low Carbon Research Institute Platinum Certification (LEED-CI). In 2018, he was honored with the Excellent Urban and Rural Planning and Design Award for the Detailed Planning of Low-Carbon City Sponge City; In 2020, the Lecheng project of low-carbon city won the world-leading design award, France NDA (Novum Design Award) 2020 Gold Award.

2.3 Green Development experience

2.3.1 Strictly Observe the Red Line of Ecological Protection and Implement the Green and Low-carbon Plan

The total planned area of Shenzhen Longgang International Low Carbon City is 53.14 square kilometers, which is equivalent to twice the sum of Qianhai Free Trade Zone and Nanshan Science and Technology Park. However, the scale of construction land is only 19 square kilometers with 63% of the basic ecological line control area, and the green coverage rate Up to 52%. There are five major ecological systems in the park: Honghualing, Songzikeng Mountain, Huangzhukeng, Changkeng Reservoir, and Longjin Mountain, with abundant resources and superior environment. There are also four rivers in the area: Dingshan River, Huangsha River, Longgang River, and Chunzi River, with well-developed water systems and crossing rivers. From the perspective of planning and design, the concept of green and low-carbon is everywhere. The street lights on both sides of the road use wind-solar complementary lights to reduce energy consumption; supporting charging facilities are installed on the street to ensure the charging needs of electric vehicles; the steel structure which is abandoned has made various sculptures in squares and gardens; unfinished buildings have been transformed into low-carbon Lecheng Hotel; Xinqiao Shiju Hakka Enclosed House has been transformed into an international low-carbon experience center. In addition, there are also landmark buildings such as a low-carbon convention and exhibition center, an experience center, and a cultural conference center in the park, which can not only provide public services, but also become a highlight with low-carbon connotations.

2.3.2 Build A Demonstration Platform for the Application of Green and Low-carbon Technologies

At the end of 2012, the first batch of international low-carbon city projects started, and they were put into use half a year later. It is the start of the 1.5-level development model with low investment and quick results in China. This model has been widely promoted and used in the construction of new areas such as Qianhai and has achieved good results; Existing buildings in the area and the surrounding environment are all

renovated by the three-star standard of green building, applying ten technological systems such as green building, clean transportation, sewage recycling, waste recycling, energy and low carbon, and 97 advanced technologies. The Future Building in the area is the first full-DC building that has stepped out of laboratory scale applications. It passed the acceptance of the Ministry of Housing and Urban-Rural Development of the Comprehensive Demonstration Project for Net Zero Energy at the end of 2019, and was selected as the 40 scientific and technological cooperation achievements for the 40th anniversary of the establishment of diplomatic relations between the United States and China, and also the United Nations Development Program (UNDP) China Building Energy Efficiency Improvement Demonstration Project; There is a 2.08 km integrated pipe gallery in the area, which is the first systematic regional integrated pipe gallery system in Shenzhen. The concept of Sponge City runs through the entire process of urban planning, construction and operation , which has built a self-organized, self-circulating habitat network organization system, rainwater storage and water purification systems, and has become a demonstration area of green and low-carbon technology.

2.3.3 Create A New Trend of Green and Low-carbon Life

Shenzhen Longgang International Low-Carbon City vigorously promotes the concept of simple and moderate, green, low-carbon, civilized and healthy life through the eight creation actions of green institutions, green families, green schools, green communities, green businesses, green travel, green buildings, and green environment. It actively create a new fashion of green and low-carbon life. For example, it was proposed in the “green agency” action to implement energy consumption measurement by buildings and offices, establish energy consumption statistics accounts, and implement energy consumption publicity. In the “green home” action, it was proposed to sign the "Green Family Life Behavior Convention", establish and improve the "carbon account", use the inclusive mechanism, and carry out the "green family" list and commendation activities. In the “green community” action, it is proposed to create a "near-zero emission" demonstration community, promote the balance of work and housing, and guide Pingdi merchants formulate energy-saving emission reduction and recycling management systems, and carry out the activities of creating units to sign green and low-carbon commitments; in the “green merchant” action, it is proposed to establish a green management system, improve the green supply chain system, and strictly implement the requirements of the "Enterprise Green Procurement Guidelines". It also vigorously promotes simplification of commodity packaging, and prohibit the use of non-degradable plastic products in accordance with laws and regulations. In the “green travel” action, it is proposed to build a safe, accessible and green ecological corridor that benefits the people, and improve the cycling and walking slow-travel network. In the “green building” action, it is proposed that all new buildings within the construction land shall be planned, designed, constructed, and operated in accordance with the green building standards, and special funds shall be arranged to promote energy-saving renovation of existing public buildings. In the “green environment” action, various parks shall be vigorously promoted to plan and construct, promote ecological space protection and restoration, and construct water pollution control projects.

2.4 Case Summary

Since the construction of Longgang International Low-Carbon City started in 2012, it has attracted a large number of high-tech industries with its superior geographical location and convenient transportation, and its GDP has nearly tripled. At the same time, it actively implements the development concept of "Green Waters

and Green Mountains", and strictly controls the ecological red line. Through green infrastructure, energy-saving renovation, waste utilization, etc., it embodies the concept of green and low-carbon everywhere. Secondly, it builds a demonstration area of green and low-carbon technologies through the application of ten technological systems such as green buildings, clean transportation, sewage recycling, waste recycling, and low-carbon energy. Finally, it also leads the new trend of green and low-carbon life by launching eight major initiatives: green institutions, green families, green schools, green communities, green businesses, green travel, green buildings, and green environment. The practical experience of Longgang International Low-Carbon City has contributed to Longgang's wisdom and the Shenzhen model for the creation and implementation of a low-carbon life demonstration block in the Guangdong-Hong Kong-Macao Greater Bay Area and a national green life.

3 Guangzhou Experience in Sustainable Development

Guangzhou, the birthplace of the ancient Maritime Silk Road, is the pivotal city of Maritime Silk Road Economic Belt. Under the call of the nation to boost cooperation within the framework of the "Belt and Road Initiative" (BRI), Guangzhou has actively involved itself in the national strategic construction and always placed high value on the idea of sustainable development during its BRI construction process.

3.1 Background

Guangzhou is located in the southern part of Chinese mainland. The city lies at the southeast of Guangdong Province, the north edge of the Pearl River Delta, adjacent to the South China Sea, Hong Kong and Macao. Guangzhou is the capital city of Guangdong Province and also its political, economic, scientific, technological, educational and cultural center. With a sophisticated transportation system and superior geographical location, Guangzhou is an excellent seaport for China's ocean shipping and an import and export port in the Pearl River Basin. The city is thus referred to as China's "South Gate". Guangzhou is also a famous historical and cultural city and the birthplace of the "Maritime Silk Road" in ancient China. Since the Qin and Han Dynasties, Guangzhou has been an important port for foreign trade for more than 2000 years. As a major Oriental port having world influence and an important hub of the Maritime Silk Road, it has played an irreplaceable role in business and cultural exchanges between the East and the West.

Today, as a frontier city of reform and opening up and a window of foreign trade, Guangzhou has reaped benefits from its rapid economic growth with comprehensive progress made in all industries. It is one of the most vibrant economic regions in China, with comprehensive economic strength ranking the top three among major cities in China. In 2020, faced with COVID-19, a pandemic rarely seen in a century, along with complex and changeable domestic and international situation, Guangzhou's economy still showed a steady trend of resilience and vitality. In 2020, Guangzhou's GDP totaled 2501.911 billion yuan, with a year-on-year increase of 2.7%. Meanwhile, Guangzhou has been increasing its bilateral exchanges and trades with the nations and regions along the BRI. From January to August, 2020, Guangzhou's import and export volume towards these nations and regions amounted to 164.47 billion yuan, with an increase of 11.5%, while the actual investment in Guangzhou from these nations and regions stood at 473 million US dollars, representing an increase of 70.9% year on year.

In recent years, Guangzhou has been working hard to implement the new development concept of "innovation, coordination, greenness, openness and sharing". It is committed to exploring a sustainable development path for this megacity with distinctive local features. In Guangzhou's BRI experience, priority has always been given to the realization of green development.

3.2 Project overview

Guangzhou has been endowed with great potential and the first-mover advantage as a business city with a thousand years of history, a major starting point of the Maritime Silk Road and a key hub for BRI. Data shows that from January to November, 2020, Guangzhou's import and export volume in foreign trade reached 864.54 billion yuan, among which the export volume was 493.95 billion yuan, up by 9.8% year on year, while the import and export volume towards nations and regions along the Belt and Road totaled 235.72 billion yuan, up by 15.1% year on year. Besides, ASEAN remained Guangzhou's largest foreign trade partner with a bilateral trade volume of 139.37 billion yuan, an increase of 23.4% year on year. Since the listing of Nansha Pilot Free Trade Zone, dividends have been continuously released. From 2014 to 2019, the number of registered enterprises increased from 8,400 to 124,000, with an average annual growth of 71.4%. A total of 172 investment projects involving the world's top 500 enterprises have been introduced. Thirty-one enterprises (or institutions) from nations along the BRI route were established in Guangzhou in the first three quarters of 2020, representing a year-on-year increase of 6.9%. The agreed investment amount from the Chinese side was 113 million US dollars, accounting for 20.1% of the China's total amount of agreed

investment in the same period. It is evident there is a strong momentum for growth in Guangzhou's foreign trade with countries along the BRI route.

In addition, Guangzhou has secured remarkable results in enhancing policy coordination, infrastructure connectivity, unimpeded trade, and people-to-people bond in the process of BRI cooperation. In terms of policy coordination, Guangzhou has built a mature system for international exchanges and effectively enhanced policy synergy across regions. In terms of infrastructure connectivity, Guangzhou has established an all-round and three-dimensional transportation hub to enhance trans-regional infrastructure connectivity. In terms of unimpeded trade, Guangzhou's uninterrupted efforts in transforming and upgrading foreign trade and foreign investment industries have facilitated unimpeded trade across nations and regions and deepened cooperation in foreign trade with the launch of events such as the Canton Fair and the Guangdong 21st Century Maritime Silk Road Port City Development Forum. In terms of people-to-people bond, Guangzhou took the lead in forming China's City Alliance of Maritime Silk Road Conservation and World Heritage Nomination which now has 26 member cities.

3.3 Green Development experience

3.3.1 Build Green Industrial Parks and Invest in Green and Environmentally Friendly Projects

As the concept of sustainable development is increasingly integrated into BRI cooperation, BRI related investment projects take on a prominent trend of "greenness". Gradually, projects with high emission and environmental pollution are replaced by environmental-friendly projects. Green BRI investment not only means to invest in new energy projects, but also requires that advanced technology is used in the projects with controllable impact on the environment, climate and carbon emissions.

Guangzhou prioritizes green development in the city with more investment and support for green industries. It has also accelerated the construction of green industrial parks. Huangpu District and the Development Zone of Guangzhou are the first batch of green industry demonstration bases in China. By the end of March 2021, there were 211 green industry enterprises above designated size in the region, with a production value of about 236.4 billion yuan. Among them, hydrogen energy is the focus of the green energy industry in the region. At present, Guangzhou is expediting the introduction of talents, technological research and development, industrialization of core equipment, as well as the planning and construction of Guangzhou International Hydrogen Energy Industrial Park and other parks.

While it strives to realize the city's own green development, Guangzhou is also engaged in a wide range of exchanges and cooperation that is rich in content and diverse in forms with BRI countries and regions to secure positive progress and remarkable effects in building a green Belt and Road.

3.3.2 Enhance Infrastructure Connectivity and Foster New Impetus for Economic Growth

By enhancing infrastructure connectivity, the Belt and Road Initiative helps to eliminate bottlenecks in economic growth and trade investment in developing countries, facilitates regional economic integration and provides new growth drivers for the world economy. Guangzhou is actively involved in fostering infrastructure connectivity for BRI countries and strives to build a transportation hub city. At present, Guangzhou has an all-round and three-dimensional transportation network, which serves to enhance trans-regional infrastructure connectivity. This effectively enhanced the city's influence and competitiveness in global resource allocation.

Guangzhou has a global competitive advantage in transportation hub infrastructures such as seaports, airports and railways. As the construction of Guangzhou International Shipping Center is pushed forward, Guangzhou port has maritime exchanges with more than 100 countries and regions in the world by 2020 and its cargo throughput ranks the fourth in the world. Guangzhou Baiyun Airport has established an airline network that covers more than 230 destinations around the globe and connects Guangzhou with 50 cities in countries along the BRI route. Its passenger throughput ranks the eleventh in the world. The three-dimensional transportation network in Guangzhou which includes subway, high-speed rail and etc. has

endowed the city advantages by connecting Guangzhou with Hong Kong, Macao and the hinterland of the Pan-Pearl River Delta, and thus effectively fostered the synergy and aggregation of resources in Guangdong-Hong Kong-Macao Greater Bay Area, mainland cities and the Maritime Silk Road. It is obvious that Guangzhou plays a pivotal role in facilitating regional transportation and has laid a solid foundation for BRI cooperation.

3.3.3 Innovate Green Finance and Support the Development of Low-carbon Economy

Finance, the lifeblood of the real economy, plays an irreplaceable role in guiding and optimizing the allocation of resources. In 2017, Huadu District of Guangzhou City was approved by the State Council as a pilot area for green financial reform and innovation. It is the first special financial pilot area in Guangzhou approved by the State Council and the only pilot area for green financial reform and innovation in South China. The pilot area has four orientations. It aims to be the test field of green financial reform and innovation, the demonstration zone for coordinated development of green finance and green industry, a new platform for the cooperation and development in Guangdong-Hong Kong-Macau Greater Bay Area and also a booster for BRI cooperation. The initiative is of great significance and far-reaching influence to the development of green finance and green growth in Guangdong Province.

The green financial reform and innovation measures adopted in Guangzhou are as follows.

First, increase financial supply, support rural revitalization and solve financing problems for enterprises. For example, we have launched the financing service system for Guangzhou's Green Finance Reform and Innovation Pilot Zone on the "Yue Xin Rong" platform (Guangdong credit financing) developed by Guangzhou Branch of the People's Bank of China, which allows 24-hour online declaration for green enterprises and projects, better synergy between industry and finance for green projects, and statistical analysis for green finance business. As of April 2021, a total of 2,544 enterprises and projects have been displayed and recommended in the financing service system, while 15 banking institutions released 92 green credit products.

Second, innovate financial products and build a carbon financial trading system. The first carbon allowance mortgage financing business was launched in China, which presents a demonstration effect for the wider implementation of carbon allowance (mortgage) financing. By the end of April, 15 carbon allowance (mortgage) financing transactions had been completed, with a financing amount of 71.7165 million yuan.

Third, deepen green finance cooperation in Guangdong-Hong Kong-Macao Greater Bay Area, explore and build a green financial service system to support the development of green buildings in the Greater Bay Area, and further deepen the cooperation and exchanges between Guangdong and Hong Kong in the fields of green finance, the alignment of green building standards, green supply chain finance, project certification for green enterprises, as well as business expansion of Hong Kong's building industry in mainland China.

3.3.4 Promote Industrial Synergetic Upgrading

Guangdong-Hong Kong-Macao Greater Bay Area is one of the regions with the highest level of openness and economic vitality in China. In February 2019, China released the *Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area*, which points out that the Greater Bay Area should be the backbone in BRI cooperation.

Guangdong, Hong Kong and Macao each has its own advantages in BRI cooperation. As one of the core engines of the Greater Bay Area, Guangzhou has an outstanding production capacity. Therefore, the major initiative Guangzhou has taken to enhance BRI cooperation is to promote synergetic upgrading for its industries. Guangzhou proposes to focus on the development of the next generation of information technology, artificial intelligence, biomedicine, new energy, new materials and other strategic emerging industries, strengthen new business forms and models such as cloud computing, digital economy and financial leasing, while scaling up efforts in developing the marine economy. As early as 2017, Guangzhou

issued the first supporting policy for the blockchain industry—"Ten Blockchain Policies", which provided that the Finance Bureau of Huangpu District will earmark 200 million yuan per year to support the development of the blockchain industry, promote the technological integration and application of block chain, AI, biomedicine, industrial Internet and the Internet of Things, help transform the manufacturing industry in the Pearl River Delta to into an intelligent manufacturing industry, and foster industrial synergy so that the area can serve as an important driver for BRI cooperation. In 2019, Guangzhou issued the "Ten Blockchain Policies Version 2.0" which stipulated that the city supports the development of the Greater Bay Area Blockchain Alliance and is going to establish a fund of 1 billion yuan for the blockchain industry to strengthen its financial support.

3.3.5 Facilitate Green Development of the Manufacturing Industry

Guangzhou takes sustainable development as the focus in the construction of a manufacturing city. By strengthening the constraint mechanism, the city aims to build a green manufacturing system, facilitate green development of the manufacturing industry and embark on a path of ecological development.

The following four initiatives are taken to enhance green manufacturing.

First, improve the green development capacity of enterprises. For example, Guangzhou has increased its support for the R&D and promotion of energy-saving and environmental-friendly technologies, processes and equipment. It encourages enterprises to engage in reforms based on environmental protection standards. As a result, all the enterprises above designated size in Guangzhou have achieved clean production.

Second, promote the development of the green manufacturing industry. For example, Guangzhou has supported enterprises to develop green and energy-saving products and actively promoted ecological design so as to reduce material and energy consumption as well as the emission of toxic and harmful substances.

Third, vigorously develop the circular economy. Guangzhou has encouraged the industrial park to promote central heating, intensive land use, waste exchange and utilization among enterprises, water recycling and other measures to promote the circular transformation of the industrial park and build a national circular economy demonstration park.

Fourth, strengthen energy conservation and environmental supervision. Guangzhou has strictly implemented energy and environmental assessment systems for projects, as well as the binding conditions that the new capacity of high-energy consumption industry should fulfill the requirement of equal or reduced energy consumption replacement.

3.3.6 Improve Environmental Quality

In recent years, Guangzhou has prioritized ecology and implemented the concept of green development. With great emphasis placed on optimizing economic development through environmental protection measures, the city launched an extensive campaign to comprehensively improve the environment by enhancing air and water quality, energy conservation and emission reduction in an effort to build a garden city where people can enjoy the comfort for living, a favorable business environment and the charm of tourism. Continuous improvement of the ecological environment is also conducive to the optimization of the city's business environment.

Guangzhou has pushed forward the actions of comprehensive air pollution control as well as joint prevention and control while strengthening the coordinated control of PM2.5 and ozone. The average concentration of PM2.5 has reached Level 2 of the National Ambient Air Quality Standard for three consecutive years. Guangzhou has also strengthened the scientific management of the whole chain of domestic waste classification. At present, Guangzhou has removed all the dustbins from corridors in all residential areas, provided harmless treatment for 100% of domestic waste, and made 99.1% of its citizens aware of waste classification requirements. The River Chief system, Lake Chief system and grid management

system for water treatment have been continuously improved, with foul water cleaned in 147 black and odorous rivers supervised by the State. The city's sewage treatment capacity has jumped to the second place in China. Guangzhou has also built 3,560 kilometers of greenways. In 2019, the forest coverage rate in Guangzhou rose to 42.31%, the forest stock volume was 17.026 million cubic meters, while the urban park green area per capita reached 17.7 square meters[1], which ranks in the forefront among similar cities in China. In addition, the 2021 government work report also pointed out that it is necessary to scientifically formulate action plans for reaching the carbon emissions peak, improve the dual control system of energy consumption, expedite the optimization of energy structure, foster and expand energy-saving and environmental-friendly industries, boost the application of energy-saving and low-carbon products, and vigorously promote the construction of green buildings.

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Chapter 3. Zero Waste City

4 Capannori, Italy: Towards a Zero Waste City

Capannori is the first city in Europe to sign a zero waste strategy. The implementation of Capannori's zero waste policy is based on a comprehensive system of waste management laws and regulations. In order to realize the concept of a zero waste city, Capannori has adopted a bottom-up approach with the participation of the government, enterprises, civil society organizations and the general public. In addition to the door-to-door waste collection system, Capannori has introduced a metering and charging system, with special emphasis on composting, recycling, reuse and upcycling, shortening the product supply chain, and reducing the use of disposable products. In addition, Capannori has established the Zero Waste Research Center to promote zero waste research.

4.1 Background

Located in the Province of Pisa, Italy (Figure 3-1), Capannori consists of a plain and a chain of hills to the north and south, with a total area of approximately 22.67 km^2 and a population of 46,177 (2017). Capannori is a commune with an economy based on agriculture and 40 hamlets under its jurisdiction.

Figure 3-1. Capannori City Map

In 2007, the Tuscan town of Capannori was the first to sign the EU Zero Waste Strategy agreement. The town launched a community campaign to stop the construction of a local incineration plant, and the municipality pledged to achieve zero waste to landfill by 2020, leading to a grassroots movement for zero waste throughout Italy. Capannori's zero waste policy is an environmental initiative designed as a large, participatory process, initiated by the mayor's cabinet.

4.2 Project overview

The Capannori’s Zero Waste development can be divided into three phases.

The first phase is the experimental phase. In 2004, the solid waste recycling rate in Capannori was only 37%. In 2005, the implementation of the new environmental policy began in a small village in Capannori called Guamo. The staff provided a door-to-door collection system to the village's 600 residents, removing the existing roadside bins in order to force the residents to use the new method of collecting and sorting their waste.

The second phase is the policy consolidation phase. On February 1, 2006, door-to-door waste collection system was extended to two additional villages, covering 10,000 residents (23% of the total population of Capannori). 9 months later, the district's waste collection rate had jumped to 82%.

The third phase is the policy deepening phase. In March 2008, a total of 26,000 residents participated in the door-to-door waste collection system, increasing the recycling rate to 82% in 18 villages (65% in Capannori). Capannori is now a pioneer and leader in Europe as a zero waste city and is the winner of the 2013 Goldman Environmental Prize.

4.3 Green Development experience

4.3.1 Institutional Design of Zero Waste City: Legal and Regulatory Basis

Italy's waste management laws and regulations provide the institutional basis for construction of zero waste city. The waste management laws and regulations at the national level are based on the relevant EU framework directives, with a comprehensive system and detailed classification. Italy has an integrated waste management policy, which basically forms the whole process of waste management from product generation, consumption and waste generation. This policy integrates waste management concepts such as waste minimization, separation and treatment, and source management, and emphasizes an integrated approach to waste reuse, recycling, energy recovery and safe disposal. Laws and regulations at the national level provide for waste separation methods and the installation of corresponding facilities. For example, Italy has a strict classification of domestic waste into six categories: paper, plastic, glass, food waste, dry non-recyclable waste, and flower and forestry waste. Each dumpster has several bins for the public to dispose of different types of garbage. Residents are punished for abandoning dangerous and special garbage. In addition, Italy food waste law creates strong safeguards against food waste and food recycling by simplifying the process of donating food that is about to expire and encouraging restaurants to provide consumers with packing bags, among other measures, to reduce food waste.

Capannori has implemented a participation mechanism involving the government, businesses, civil society organizations and people to realize the concept of a zero-waste city. A bottom-up approach is realized through cooperation with ASCIT SPA Environmental Services, local unions, city organizing committees, communities, schools, secondary markets, etc. Its waste treatment facilities are mainly invested jointly by the government and enterprises, with the government holding the shares and setting up a professional company to operate them. At the same time, the Town Council of Capannori adopted Resolution No. 44 on June 14, 2007, deciding to achieve the goal of a zero-waste city by 2020, which provides the basis for decision-making on the long-term implementation of Capannori's zero-waste strategy.

4.3.2 Public Participation via Door-to-door Collection System

The implementation of the Zero Waste strategy relies on strong policy implementation and broad community involvement. Public participation was one of the keys to the success of the program, with a focus

on communicating with residents and asking for input. When the City of Capannori initially implemented a zero-waste policy, there was public resistance due to a lack of information and other reasons. In response, the City of Capannori held several public meetings and involved local NGOs in managing the implementation of the new policy, which was generally accepted by the public. At the same time the City of Capannori will provide the necessary training to community residents on waste recycling sorting. Trained volunteers will be available to answer questions about recycling strategies during the distribution of waste separation kits at their homes.

Since 2010, the door-to-door waste collection system has been implemented in Capannori, and the wide participation of the population has made the waste collection strategy a great success and has succeeded in reducing the costs of waste collection and subsequent disposal. The zero waste policy in Capannori was extended from small villages to the entire region. In the first few weeks of a district starting a door-to-door waste collection policy, project volunteers distribute free waste sorting kits to all households, including the various garbage cans and sorting bags needed. The new recycling strategy led to a diversion of the organic waste. By 2010, 82% of the local waste could be sorted at source, with only 18% going to 60 landfills. By 2012, the region introduced a fee for discarded waste, increasing the separation rate to 90%.

Capannori's zero waste policy was designed from the bottom up. The City of Capannori took a proactive and holistic approach and involved residents in all stages of policy development. Citizens and the community are tasked with organizing and leading all sectors of the community. This bottom-up design not only improves the efficiency of waste recycling, but also allows the population to build good ecological awareness in terms of procurement, waste reduction at source, and continuous innovation, while enabling the promotion of bottom-up programs (such as the Zero Waste Household Challenge) and promoting ecological research and education.

The Zero Waste Household Challenge is a zero waste project piloted by the Capannori Zero Waste Research Center to promote public participation. The project involves 85 households with a total of 240 citizens. The project encourages citizens to further reduce their household waste production. Families participating in the challenge receive record books of varying colors corresponding to the different colors of the separate collection bags, and are asked to weigh and record that type of residual waste once a week. Throughout the year, the research center provides guidance and training to participating households on how to further reduce waste.

4.3.3 Source Reduction by Metering and Charging

Capannori's zero waste policy is a sustainable, cost-effective environmental policy. 2012 saw the introduction of a metered charging system. That is, each household's collection frequency is measured by a microchip affixed to the bag of residual waste and carried out by a reader on the collection vehicle staff by scanning the microchip on the bag (Figure 3-2). This system has brought significant changes to the town's waste management system. The new rates have incentivized better waste separation and waste reduction, increasing the local source separation rate to 90%. Economic incentives, special funds and tariffs based on tons of waste generated or landfilled were also used to identify education and training programs specifically for professionals to implement a zero waste strategy.

In 2019, the amount of waste generated in Capannori was reduced by more than 40%. 85.45 percent of

waste was collected separately, residual waste per capita was reduced by 57% and residents' waste disposal fees were reduced by 20%, while a total of 93 tons of items were recycled to reuse centers. According to statistics, the total amount of waste generated per capita in Capannori decreased from 672 kg in 2006 to 498 kg in 2019, while the amount of unsorted waste generated per capita decreased from 340 kg in 2006 to 54.56 kg in 2017.

Figure 3-2. Staff record by scanning microchips on garbage bags. Source: AIMEE VAN VLIET

4.3.4 Increasing Recycling Rate of Waste

Capannori emphasizes composting, recycling, and reusing. The program encourages residents to engage in home composting. Citizens who engage in home composting receive a 10% discount on their garbage bill. In total, 2,200 households received free composters and training in composting techniques, and data shows that as of 2019, 96% of households are still using home composters. Factories are prohibited from producing materials that cannot be reused, recycled, or composted by the community. Six repair and reuse centers have been established in Capannori. One of them is used to repair used electrical and electronic equipment and to restore and sell used products. Items repaired at the centers include furniture, old clothes and other household appliances. The Reuse and Repair Center currently has 12 employees involved in the woodworking shop, repair of furniture and bicycles, and re-retail of textiles.

The government estimates that the policy has reduced carbon dioxide emissions by 13,000 tons from 2004 to 2009, based on the results achieved by recycling materials. The program is financed by the government base funding, which makes the program economically self-sustaining by returning funds through the use of recycled waste materials (especially unsorted waste that is not disposed of in landfills). Since the policy began, the commune has hired 70 new workers to work on separate waste collection.

4.3.5 Shortening Supply Chain and Minimizing Disposables

Capannori encourages the reduction of disposables, which is also an important waste source reduction

measure. The town has built two self-service milk refilling stations that use a short supply chain. 91 percent of the residents bring their own containers to buy milk, and 200 liters of milk are sold through the stations each day, reducing the use of approximately 90,000 bottles (Figure 3-3). This innovative business model avoids the production of waste boxes, which are also used for the sale of other daily detergents, drinking water, cosmetics, etc. Capannori also encourages the sale of reusable and biodegradable personal hygiene products, such as washable diapers, to further reduce the number of disposable products. Capannori also banned the use of disposable tableware and flatware in public places and distributed canvas bags to 17,800 households and 5,000 businesses.

Figure 3-3. Self-service milk filling station Source: AIMEE VAN VLIET

4.4 Case Summary

Capannori has effectively reduced the amount of end-use solid waste by implementing a series of measures to reduce the amount of waste at source, increase waste recycling, shorten the supply chain, and reduce the consumption of disposable items. The results of the Capanolli Zero Waste City project are based on public participation and policy support. Whether it is a door-to-door waste collection system, a metered pricing system, or other zero-waste initiatives, strong policy support and community involvement are essential.

5 Zero Waste Singapore

5.1 Background

Singapore, also known as the Lion City, is an island country in Southeast Asia. It is located at the southernmost tip of the Malay Peninsula. It is separated by the Strait of Johor to the north but connected to Malaysia by two bridges, the New Johor Causeway and the Second Channel, and faces Indonesia across the Singapore Strait to the south. It guards the important waterway between the Indian Ocean and the Pacific Ocean-the southernmost exit of the Strait of Malacca. With an area of only 724.4 square kilometers (2020), Singapore consists of Singapore Island and 63 nearby small islands, of which Singapore Island accounts for 88.5% of the country's area. The total population is only 5.7 million (June 2019), with 4.03 million citizens and permanent residents. Among them, Chinese accounting for about 74%, and the rest are Malays, Indians and other races. Malay is the national language, English, Chinese, Malay, and Tamil are the official languages, and English is the administrative language. The main religions are Buddhism, Taoism, Islam, Christianity and Hinduism.

Figure 3-4. Singapore map

Singapore was once a British colony but occupied by Japan during World War II, and then it restored to British colonial rule. In 1959, it achieved autonomy and became an autonomous state. In 1963, it formed the Federation of Malaysia with Malaya, Sabah, and Sarawak. On August 9, 1965, it separated from Malaysia and established the Republic of Singapore. Since independence, a unicameral parliamentary democracy has been implemented. The People's Action Party has been in power for a long time, with outstanding political achievements and a stable position. All previous general elections have won overwhelming advantages. Lee Kuan Yew has served as prime minister for a long time since its independence in 1965, and was handed over

to Goh Chok Tong in 1990. In 1993, the first presidential election after independence was held. Wang Dingchang, the former deputy prime minister and secretary-general of the Singapore Trade Union, was elected as the first elected president. In August 2004, Lee Hsien Loong, the son of Lee Kuan Yew, succeeded Goh Chok Tong as prime minister and has been re-elected for the fourth time.

Due to its small area and lack of natural resources, Singapore's economy is dominated by electronics, petrochemicals, finance, shipping, and service industries. It is highly dependent on China, the United States, Japan, Europe and surrounding markets, which is a foreign trade-driven economy. Relying on its advantageous geographical location and open economic environment, Singapore's GDP has maintained a growth rate of 9% for a long time, and is known as one of the four Asian tigers. In 2020, despite the 8.2% economic recession due to the COVID-19, the GDP of Singapore still reach 350 billion US dollars, and the per capita GDP reached 62,000 US dollars. Singapore's Human Development Index is extremely high (0.938), and the average life expectancy is 83 years old, ranking third in the world. Singapore has a world-class infrastructure, strict financial punishment system and tens of thousands of sanitation forces. These factors have combined to create Singapore's reputation as a "garden city" and "the cleanest city". The small space forces Singapore to attach great importance to sustainable development. In 2009 and 2015, Singapore put forward the "Sustainable Singapore Blueprint", which measures sustainable performance from a series of indicators. In March of this year, Singapore issued the "Green Development Blueprint for 2030". It elaborates green concepts, creates a livable environment and enhances national competitiveness from the aspects of infrastructure, transportation, education, economic development and climate change.

5.2 Project overview

Singapore has a large population but scarce land resources, which makes the problem of "garbage siege" particularly prominent. In 2013, Singapore generated more than 7.85 million tons of garbage, enough to fill 14,950 Olympic-sized swimming pools. Although 60% of it was recycled, there were still 7,740 tons of waste that needed to be sent to the four major waste incineration power plants for incineration at that time. Moreover, the ashes and non-incinerable wastes (such as chemical waste) produced by incineration have to occupy land for landfill. However, the Semanko Landfill, which is the only existing landfill in Singapore, will soon be exhausted in 2035.

In this context, Singapore proposed to build a "Zero Waste Nation" and has gone through two important periods. One is the release of "The Sustainable Singapore Blueprint 2015" (hereinafter referred to as "Blueprint") in 2014, marking the national-level waste-free city master plan was issued. It proposes the national vision and overall goal of building a "zero waste". The second period is releasing the "Zero Waste Masterplan Singapore" (hereinafter referred to as the "Plan") in 2019 and the "Sustainable Resources Act" (hereinafter referred to as the "Act") targeting to the management of food, packaging and e-waste. These two files further strengthened the overall goals and proposed the main measures to achieve the goals.

Specifically, the Blueprint proposes to strive to achieve zero waste of food and raw materials through Reduction, Reuse and Recycle and to reuse and recycle them as much as possible. This will give all materials the second life and make Singapore a "zero waste" country. By 2030, the comprehensive waste recovery rate will reach 70%, the domestic waste recovery rate will rise from 20% in 2013 to 30%, and the non-domestic waste recovery rate will rise from 77% in 2013 to 81%. To this end, the Blueprint proposes

four measures: Introduce centralized chutes for recyclables in all new HDB flats, introduce Pneumatic Waste Conveyance in more HDB towns, build an Integrated Waste Management Facility which will have the capacity to segregate recyclables from waste, introduce more initiatives to reduce food waste in Food & Beverage businesses and improve recycling of electrical and electronic waste.

In 2019, on the basis of the Blueprint, the Plan further proposed that in order to extend the service life of the Semakau landfill, the non-recyclable waste generated per person per day will be reduced from 0.36kg in 2018 to 0.25kg in 2030, which is equivalent to reducing fly ash and landfill waste by 30% in 2018.

The Sustainable Resources Act clarifies the three priority areas of food, packaging and e-waste management from a legal perspective and proposes three specific goals: product manufacturers should bear the collection and treatment costs when products turn into garbage; encourage packaging manufacturers to implement packaging reduction, reuse and recycling; implement food waste classification and proper disposal. In addition, the Act also sets out the phased goals and roadmap for 2020-2025.

Table 3-1. The phased goals of Sustainable Singapore Blueprint

Time	Goals
In 2020	Mandatory packaging reporting system
By 2021	E-waste producer responsibility extension system
Since 2024	Food waste compulsory classification and treatment system
By 2025	Extended Producer Responsibility System in Plastics and Packaging Industry

After six years of hard work, the total amount of waste in Singapore has gradually decreased since 2016. The reduced part is mainly from recyclable waste. The non-recyclable part has also declined slightly but not significantly. The recovery rate has increased compared to 2014 and has been stable at 61%. Although it was affected by the epidemic in 2019 and 2020, the recovery rate is as high as 59% and 52%.

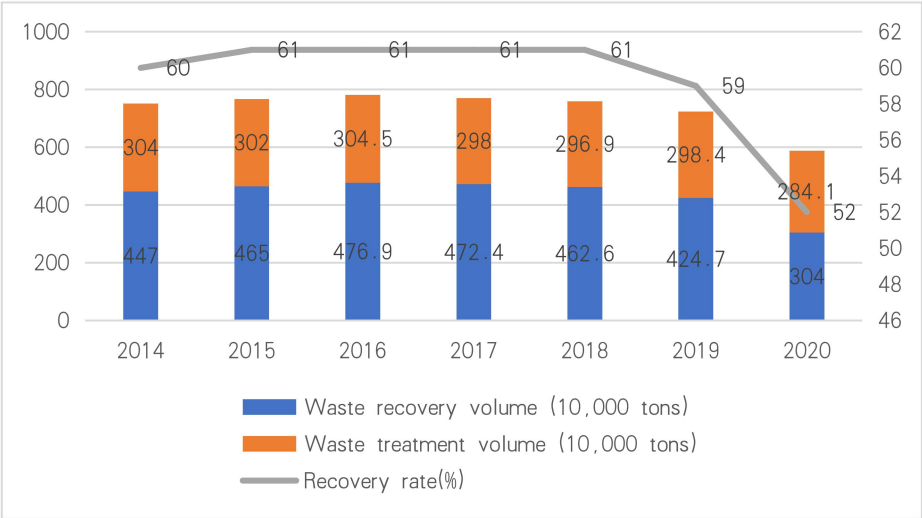

Figure 3-5. Singapore waste collection and disposal volume

5.3 Green Development experience

5.3.1 Develop Circular Economy and Achieve Source Reduction

In order to build a "waste-free city", Singapore first achieved waste reduction from the production and consumption through the development of a circular economy. On the production side, Singapore has implemented the Singapore Packaging Agreement (SPA) in response to the large amount of waste caused by commodity packaging. The agreement is a voluntary initiative of the government, industry and non-governmental organizations to reduce packaging waste, which accounts for one-third of the weight of domestic waste in Singapore. Since the first SPA was launched in 2007, more than 200 organizations have worked together to reduce packaging waste. By the end of 2019, they have reduced approximately 54,000 tons of packaging waste and saved packaging costs of US$130 million. At the same time, the Environment Agency has also implemented a mandatory packaging reporting framework in 2020, requiring packaging product manufacturers and supermarkets with an annual turnover of more than US$10 million to report their packaging data and their packaging 3R plans. There are also many unpackaged shops in Singapore, whose products are more competitive in price than those with packages, in order to encourage residents to buy unpackaged goods.

For electronic products that contain hazardous substances, Singapore has restricted six hazardous substances including hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers, lead, mercury, and cadmium since 2017 to prevent them from entering the environment due to improper disposal. Since March 31, 2018, Singapore has phased out all batteries (including button cell batteries) containing more than 5 ppm by weight of mercury. The manufacture, import and export of certain mercury-added products such as fluorescent lamps (exceeding specified mercury limits) and non-electronic measuring devices will be phased out by 1 January 2020.

On the consumption side, Singapore has relatively complete green product labels, such as the Singapore Green Label Scheme (SGLS), the Mandatory Energy Labelling Scheme (MELS) for household appliances, and reduced packaging marks to ensure that certified products have minimal impact on the environment or are made of recyclable materials. These certifications can guide consumers to preferentially purchase such green products, while government departments must follow the Public Sector Taking the Lead in Environmental Sustainability (PSTLES) and take the lead in adopting green public procurement policies. The Singapore Environment Agency also launched a food waste reduction campaign in November 2015 to increase public awareness and encourage rational consumption, thereby reducing food waste. In 2017, the "Zero Waste Bring Your Own Bag" campaign was launched to encourage consumers to use reusable bags and containers when buying food, beverages and groceries. At present, more than 400 retail stores have joined the event to provide rewards for customers who bring their own reusable items, which saved about 2 million plastic disposable products and packaging materials. The “Say Yes to Waste Reduction” campaign was also launched on June 8, 2019 to advocate the public to “make the right choices and choose reusable things”, for example, reusable bottles, bags or food containers rather than disposable items.

5.3.2 Strengthen Infrastructure and Increase Waste Recovery Rate

Singapore’s waste recovery rate is up to 60%, which is firstly due to Singapore's good waste collection infrastructure. First of all, Singapore stipulates that each floor of HDB flats must be equipped with two

centralized chutes, recyclable and non-recyclable, to make it easier for residents to throw recyclables, thereby increasing the recovery rate. Reverse vending machines have also been installed near big shopping malls to recycle PET bottles and aluminum cans and provide small rewards in return, such as discounts or redemption coupons. Secondly, because Singapore is located in a tropical area, long-term storage of garbage is prone to generate odor and insects and even cause and spread diseases. For this reason, Singapore requires that new HDB flats must be equipped with a Pneumatic Waste Conveyance System (PWCS). These systems draw air through a network of pipes hidden underground, effectively transporting waste to the center of the community or even the entire district. This will greatly reduce odors and pests, allowing residents to enjoy a more livable living environment. The intelligent pneumatic garbage conveying system can also monitor the frequency of garbage disposal to optimize the garbage collection cycle, reduce the labor and traffic of garbage collection and transportation, and save manpower and energy.

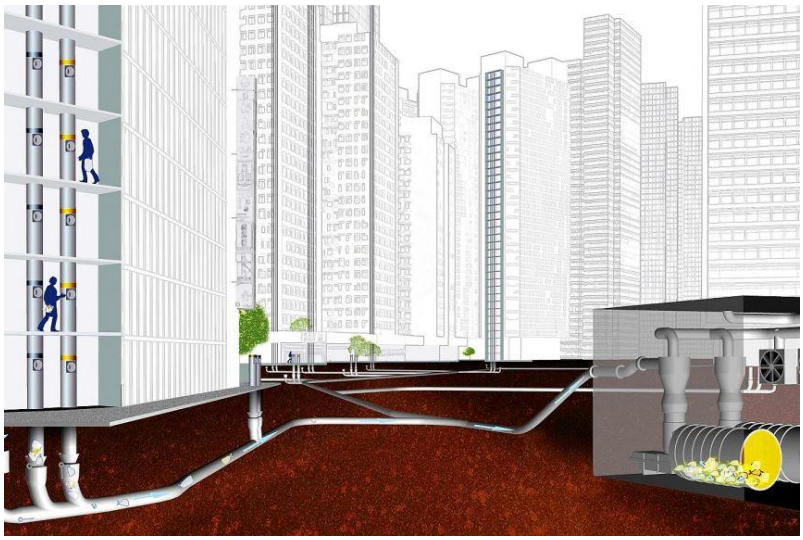

Figure 3-6. Diagram of pneumatic waste conveying system

In response to hazardous e-waste, the Singapore Environment Agency launched a program called “Recycling nation’s electronic waste, RENEW” program in 2012. By March 2019, the program has installed more than 450 trash bins in more than 400 locations and collected more than 320 tons of electronic waste. In 2018 alone, 126 tons of waste were collected, which is 2 tons more than in 2012. At the same time, Singapore has implemented the extended producer responsibility system from 2021, requiring electronic product manufacturers (including manufacturers and importers) to bear physical or financial responsibility for the disposal of their products. This means they need to collect and ensure that products are recycled by a licensed company. The operators that deal with electronic goods will be appointed by the Environment Agency to be responsible for developing the electronic product recycling system, including arranging collection time, providing electronic trash bins, transporting e-waste to licensed recyclers and reporting the tonnage of e-waste to Environment Agency. Large electronic product retailers with an area of more than 300 square meters must provide electronic waste collection points in their stores. Manufacturers of solar photovoltaic (PV) panels and servers must provide free recycling services for all end-of-life equipment based on customer needs. The recovery rate of construction waste, ferrous and non-ferrous metals in Singapore is close to 100%, which is mainly due to the Demolition Protocol implemented by the Building and Construction Authority. Under the Demolition Protocol, reusable and non-reusable parts of a building have

to be identified, then separately dismantled and removed. Reusable parts include piping and wiring, which are placed in separate bins and sent to a recycling facility. Non-reusable parts that contaminate the concrete debris, such as ceiling boards and tiles, are discarded. Only when the building has been stripped to its bare frame can demolition start.

5.3.3 Use Advanced Technology to Achieve Harmless Disposal

For food waste, Singapore requires that all new commercial and industrial sites that are expected to generate a large amount of food waste must allocate and reserve space for the food waste on-site waste treatment system in their design and planning from 2021. On-site food waste treatment systems convert food waste into non-potable water, liquid nutrient or compost. This not only saves merchants' waste disposal costs, but also produces organic fertilizer. At the same time, large commercial and industrial food waste producers must separate food waste from 2024, but they can choose the most suitable food waste treatment method, such as installing food waste on-site waste treatment systems or sending their food waste to the off-site treatment facilities.

For other garbage that cannot be recycled, Singapore mainly deals with it by incineration. In 1979, Singapore spent 130 million US dollars to build the first waste incineration power plant. Since then, four other Waste-to-Energy plants have been commissioned – Tuas Incineration Plant (1986), Senoko WTE Plant (1992), Tuas South Incineration Plant (2000) and Keppel Seghers Tuas WTE Plant (2009). Together, they incinerate about 7,600 tonnes of waste a day. These five incineration plants greatly reduce the amount of waste to landfill and thus save the land resources. Singapore is building the sixth waste incineration plant-TuasOne Waste-to-Energy Plant. The plant covers an area of 4.8 hectares and can incinerate 3,600 tons of waste per day, which will meet Singapore's waste incineration needs in the next 25 years. With a treatment capacity of 750 tonnes of waste per day per ha (t/d/ha), it will be the most compact plant in the world. It will also be the most energy-efficient among Singapore’s existing WTE plants.

Singapore will also build a factory that comprises Integrated Waste Management Facility (IWMF) and PUB’s Tuas Waste Reclamation Plant (TWRP)-Tuas Nexus. This factory can handle multiple waste streams, thus reducing unnecessary transportation and carbon footprint. For example, treated effluent water from TWRP will be supplied to IWMF for process use, while the used water sludge can be processed with food waste slurry for co-digestion. This can triple biogas yield, compared to the treatment of used water sludge alone. This biogas can be burnt in IWMF’s external biogas superheaters to increase its steam temperature to enhance overall plant thermal efficiency and maximize electricity production. Dewatered sludge will be sent to the IWMF for incineration. The electricity from IWMF will power both TWRP and IWMF. Excess electricity will be exported to the grid. The first phase of IWMF will be completed by 2024 while the second phase is estimated to be completed by 2027.

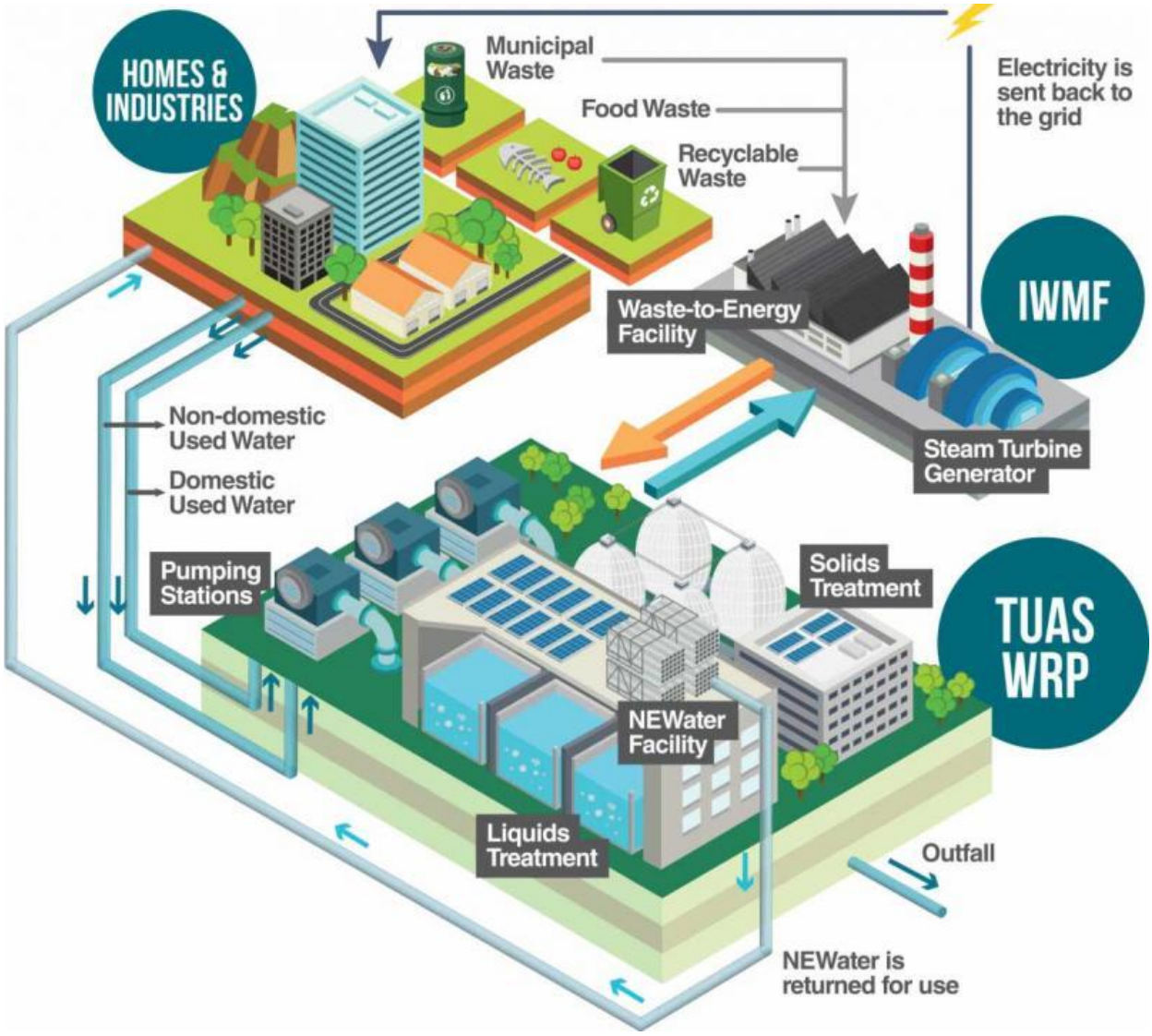

Figure 3-7. Tuas Nexus that comprises IWMF and TWRP

However, the garbage that cannot be incinerated and the fly ash generated after incineration still need to be landfilled. In the 1990s, when the space of the last inland landfill in Lorong Halus was used up, Singapore established its first offshore landfill in 1995, the Semakau Landfill. The landfill covers an area of 350 hectares and can hold 28 million m^3 of waste. Various measures were taken to minimize the impact on the environment due to construction. This included planting 400,000 mangrove saplings to replace those affected by construction works and the installation of fine mesh silt screens near work areas to reduce the impact of sediment on the corals to preserve the integrity and biodiversity of the local area.

Figure 3-8. Semakau Landfill

5.4 Case Summary

As a tropical island nation with a large population and a small area, Singapore has faced the problem of "garbage siege" early on. Since the proposal to build a "Zero Waste Nation" in 2014, Singapore has first adopted the development of a circular economy, starting from the production side and the consumption side, to reduce the amount of waste at the source. Secondly, by strengthening infrastructure, such as the establishment of recyclable and non-recyclable garbage chutes, and the establishment of a pneumatic garbage recycling system to increase the waste recovery rate. Finally, through the use of advanced technologies, such as the establishment of waste incineration plants, Tuas Nexus, and ecological restoration of waste landfills, the final realization of harmless treatment.

6 Zero Waste Shenzhen

Shenzhen Special Economic Zone, founded on August 26, 1980, is the national economic center, technological innovation center, regional financial center, and commercial logistics center. As a pioneer and experimentation area of China's Reform and Opening-up, Shenzhen has thoroughly implemented Xi Jinping's Ecological Civilization Thought, practiced the concept "lucid waters and lush mountains are invaluable assets", and explored to create a solid waste treatment model in a super-large urban city. Shenzhen has completed the pilot task of the construction of a "Zero Waste City" as scheduled and achieved remarkable results with the four major systems, six sources, and all people mobilized to participate.

6.1 Background

Shenzhen, located on the coast of the South China Sea, is close to Hong Kong and Macao, which overs an area of 1997.5 square kilometers. It has a permanent population of 17.56 million and a managed population of 22 million in 2020, and GDP reached 2.767 trillion RMB in Shenzhen. As the first special economic zone in China to implement reform and opening up with the greatest impact and well developed, Shenzhen not only plays the role of an economic engine, but has also been at the forefront of Chinese cities in terms of ecological civilization construction. In the context of the construction of "Belt and Road", Shenzhen is regarded as the "window" of China's Reform and Opening Up, and a bridgehead of the Maritime Silk Road, Shenzhen is a sample for other developing countries. Shenzhen is leading and driving the Guangdong-Hong Kong-Macao Greater Bay Area, and actively participating in the construction of "Belt and Road" with a new development concept of innovation, coordination, greenness, openness, and sharing. Since China launched the pilot project for the construction of a "waste-free city" in 2019, Shenzhen has successfully completed 100 tasks and 56 indicators with outstanding highlights and remarkable results. Its advanced experience has provided an important reference for "Belt and Road" countries and cities.

6.2 Project overview

On December 29, 2018, the General Office of the State Council of the People's Republic of China issued the "Work Plan on Zero Waste City Pilot Program", which proposed to select about 10 cities with certain conditions, foundations, and appropriate scales nationwide to carry out the pilot project for the construction of "Zero Waste City". On April 30, 2019, after discussed by 18 departments including the China Development and Reform Commission, it was finally determined that "11 + 5" pilot cities and regions such as Shenzhen should carry out the pilot project for the construction of "Zero Waste City". On December 6, 2019, Shenzhen issued the "Implementation Plan on Zero Waste City Pilot Program in Shenzhen" (hereinafter referred to as the "Plan"). The plan proposed four stages, ten tasks, and three major safeguard measures, as well as constructed 58 indicators and 100 specific tasks, which were clearly implemented in all institutions.

On January 21, 2020, in order to effectively promote the construction of a "Zero Waste City", Shenzhen set up a pilot leading group for the construction of "Zero Waste City" to coordinate and promote works, which issued the "Pilot Task Schedule of Zero Waste City" Construction in Shenzhen", "Pilot Work System of 'Zero Waste City' Construction in Shenzhen", "Pilot Publicity Plan of "Zero Waste City Construction in Shenzhen", etc., so as to orderly promote the development of various work and establish a complete organization system for the construction of "Zero Waste City".

After two years, Shenzhen successfully completed 100 annual construction tasks such as living solid waste, industrial solid waste, construction waste, hazardous waste, municipal sludge, agricultural waste, and security system on December 31, 2020. 56 of 58 construction tasks have been completed, of which 9 indicators have reached the international advanced level, and 15 indicators are ahead of the domestic advanced level.

6.3 Green Development experience

6.3.1 Improve Laws and Regulations and Build a Comprehensive Solid Waste Management System

Taking full advantage of the legislative power of the special zone, Shenzhen has formulated 4 local regulations and 3 local rules, issued 77 policy documents, compulsory promoted the domestic waste classification management and construction waste quota emission, expanded the green credit, green tax, and green bond products, and improved the whole process supervision, application, and registration, electronic receipt, and other management systems accelerated the filling of legal gaps in solid waste treatment, reformed and innovated policies and measures for solid waste administration, and provided institutional guidance for comprehensive solid waste treatment.

6.3.2 Focus on the Green Cycle Economy and Promote the Source Reduction of Solid Waste

Insisting on the source reduction. In terms of domestic waste, Shenzhen issued the "Implementation Plan on Further Strengthening the Treatment of Plastic Pollution", prohibiting and restricting the production, sales and use of non-degradable plastic products, and promoting the market application of plastic alternative products; issuing the "Guidelines and Recycling of Green Packaging Management for City Express and Packaging Operation Guidelines", launching the "Green Express" initiative; fully launched the "Clear Your Plate Campaign" to create a "Garbage Reduction Day" on November 8 and advocate frugal consumption.

In terms of construction waste, the "Construction Waste Discharge Quota Standard" and the "Construction Waste Emission Reduction and Comprehensive Utilization Technical Standard" were issued, and the construction waste discharge quota, emission reduction and comprehensive utilization design and acceptance requirement of various construction projects were clarified for the first time in China; revised the Shenzhen architectural design rules to effectively control the excavation of underground space and reduce the source emission of spoil in the project.

In terms of general industrial solid waste, Shenzhen eliminated unlicensed, high emission, high pollution, and low-end backward enterprises through industrial upgrading, created green factories, green supply chains, and green parks to promote industrial transformation, promoted the application of innovative alternative technologies, using a high-pressure water jet to replace the traditional steel grit to remove the rust from ship hull and reduce 100,000 tons of general industrial solid waste from the source every year.

Figure 3-9. Youlian Ship Repair Base, Using High-pressure Water Jet to Replace the Traditional Steel Grit to Remove the Rust from Ship Hull

In terms of municipal sludge, Shenzhen promotes the drying, volume reduction and weight reduction in the sludge plant and sewage treatment plant, and innovates three representative technical routes for deep dehydration of sludge, such as "microwave conditioning plus plate and pressure filtration", "pressure filtration plus low-temperature rapid drying" and "pressure filtration plus low-temperature condensation drying", the sludge can be reduced locally and stabilized to a moisture content below 40%. A total of 18 sludge deep dehydration facilities have been built and put into operation in 37 sewage treatment plants in the city, with a drying treatment capacity of 5635 tons per day (calculated according to 80% moisture content), which greatly reduces transportation costs and avoids drip and odor secondary pollution during transportation.

6.3.3 Implement Classified Recycling and Strive to Strengthen Resource Recycling

Giving priority to resource recycling. In terms of domestic waste, it is mandatory to carry out the classification management of domestic waste and innovate the model of "centralized sorting plus regular fixed-point supervision". Shenzhen has introduced the most stringent domestic waste administrative punishment measures in China, individuals, who violate the regulations on domestic waste classification, shall be fined up to 200 RMB, and institutions shall be fined up to 500,000 RMB. Also, Incentive measures for the domestic waste classification have been introduced in Shenzhen, and 48.35 million RMB of incentive funds have been issued to guide the whole society to actively participate in the domestic waste classification. Allocating classified collection and transportation vehicles and building classified treatment facilities, Shenzhen made 100% of the classified collection and transportation. The classified recycling volume of domestic waste reaches 9636 tons per day, and the volume of market-based renewable resource recovery is 7,300 tons per day, after deducting the part of energy incineration power generation, the recovery and utilization rate still reaches 42%, leading the domestic advanced level.

Figure 3-10. Garbage Classification in Caitian Village

In terms of construction waste, it promotes the local resource utilization of construction waste by carrying out the construction waste emission reduction and utilization project, the pilot of comprehensive utilization of residue and soil, the pilot of on-site treatment of Engineering mud, construction of fixed comprehensive utilization facilities of construction waste, etc.

In terms of general industrial solid waste, Shenzhen develops new low-carbon industries such as bio-medicine, new energy vehicles, and electronic information, strengthens energy cascade utilization, resource recycling, waste harmless treatment and recycling, and completes the recycling transformation of 5 national parks, 7 enterprises were selected as the typical model of the recycling and utilization of the power battery of new energy vehicles by the Guangdong Provincial Department of Industry and Information Technology. Based in Shenzhen, BYD builds a nationally-operated 4S store, park, and base multi-level recycling system. Qiantai Industrial Park has a capacity of 120 new energy vehicles per day and 50 tons of battery packs per day.

In terms of municipal sludge, the combined power generation project of coal-fired mixed sludge in China Resources Haifeng Power Plant has completed, the energy-based mixed burning capacity of sludge reached 6000 tons per day (calculated at 80% moisture content), making it the world's largest combined power generation plant of coal-fired mixed sludge power, the 5300 tons per day sludge is 100% resource utilization and zero landfills, which truly realizes the local resource and energy utilization of sludge.

Figure 3-11. China Resources Sludge Mixed Burning Project in Haifeng

In terms of agricultural waste, the matching rate of livestock and poultry manure treatment facilities and equipment in the large-scale farms has reaches 100%, the comprehensive utilization rate of livestock and poultry manure has reached 75%, and all the straws are mechanically crushed and returned to the field for utilization. It scientifically sets up recycling facilities for pesticide and fertilizer packaging waste, and incinerate all the recycled waste.

Figure 3-12. Agricultural Waste Sorting Collection Point

6.3.4 Strengthen Infrastructure and Improve the Capacity of Various Waste Disposal

Completed harmless treatment. In terms of construction waste, 4 fixed disposal sites have been built with 52.5 million tons of construction waste processed, and the remaining storage capacity is about 11.85 million

tons. 9 water transport transfer facilities have been built with a designed transfer capacity of 87 million tons per year. Cooperation agreements have been signed with the Management Committee of Cuiheng New District in Zhongshan city and the Management Committee of Tonghu Ecological Smart District in Huizhou to strengthen the coordination and supervision mode of cross-regional balanced disposal of earthwork.

In terms of domestic waste, five energy ecological parks in Bao'an, Longgang, Nanshan, Pinghu, and Yantian have been built and put into production. The domestic waste incineration capacity will reach 18,000 to 20,000 tons per day. The primary domestic waste is completely incinerated without any landfill and 100% harmless disposal of domestic waste. Shenzhen introduced the world's most stringent domestic waste incineration power generation air pollutant emission control standard, and provided ecological compensation fees to surrounding communities based on the amount of incineration treatment, provides surrounding communities with low-cost energy for combined heat and power and helped them use slag to start environmental protection Brick production plants, also, invests in the construction of mountain trails, swimming pools and popular science exhibition halls for all community residents, innovates the corporate community co-construction model to realize the neighborhood harmony.

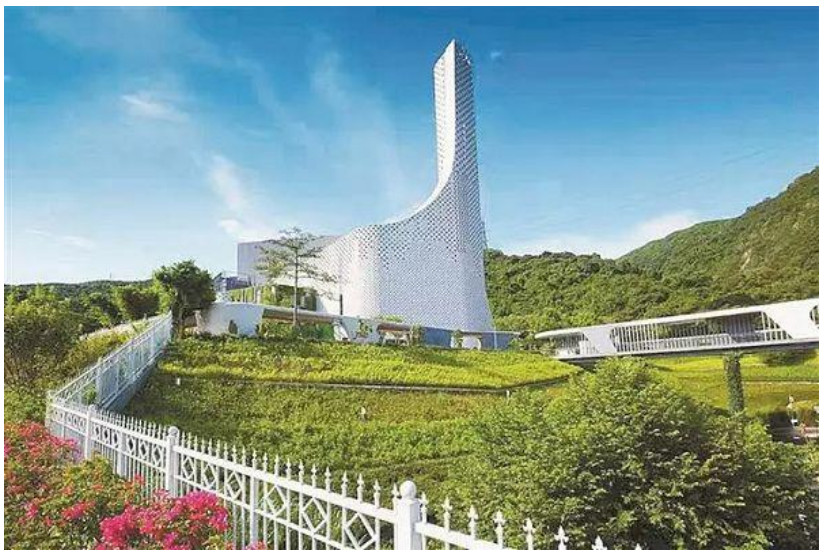

Figure 3-13. Yantian Energy Ecological Park

In terms of hazardous waste, Shenzhen built new hazardous waste collection, utilization and disposal facilities to increase the collection and disposal amount. It comprehensively carries out cooperation in the co-processing of urban hazardous waste in the Guangdong-Hong Kong-Macao Greater Bay Area, sharing hazardous waste disposal facilities, reducing the disposal price of incineration hazardous waste to 3000-4500 RMB per ton, and reducing the price of heavy metal sludge disposal to 1300-1800 RMB per ton. Prices have dropped by more than 50% year-on-year, greatly reducing the production costs of enterprises.

6.3.5 Technological Empowerment and Building a Closed-loop Smart Supervision System

Shenzhen has invested 158 million RMB to build a smart environmental monitoring platform and complete a GPS plus video full coverage and process smart monitoring system for hazardous waste, medical waste, general industrial solid waste, construction waste, and municipal sludge. It has developed a remote video

law enforcement system for solid waste, which allows law enforcement officers to check the standard management status of enterprise and solid waste management storage rooms via synchronized videos, when problems come out, they will be assigned to rectify immediately, enterprises rectification will be submitted online to law enforcement officers for review and confirmation, forming a closed-loop of the whole chain with the efficiency of law enforcement supervision greatly improved, and the demand for law enforcement personnel has been reduced by 80%, at the same time, the proportion of random inspections by enterprises has been increased to improve the standardized management of enterprises. Specifically, in terms of hazardous waste, Shenzhen has built hazardous waste disposal and trading platform to provide enterprises with online services for signing, testing, and payment; in terms of general industrial solid waste, it is the first to carry out declaration and registration and electronic combined management; In terms of construction waste, it builds a smart supervision system to realize the real-time monitoring and electronic joint management of the whole process of construction waste discharge, transportation and disposal; in terms of sludge disposal, it builds sludge treatment, transportation scheduling, and supervision information platform, established systems of qualification recording, inspection and assessment, on-site supervision, transfer order, notification and punishment, and intelligent supervision technology "5+1" sludge supervision system.

Figure 3-14. Implementation Plan on Zero Waste City Pilot Program in Shenzhen

6.4 Case Summary

In short, Shenzhen solves the six wastes, domestic waste, construction waste, general industrial waste, municipal sludge, hazardous waste, and agricultural waste, from three aspects, source reduction, resource utilization, and final treatment. It comprehensively promotes the treatment of solid waste, giving full play to Shenzhen's innovative advantages in this field, applying technologies, and realizing smart, efficient, and full life cycle management of waste treatment and supervision. After just two years, Shenzhen has successfully completed the construction of a "Zero Waste City", providing an important reference for other cities and countries along the "Belt and Road".

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Chapter 4. Pollution Control and Environmental Improvement

7 Comprehensive Air Pollution Control in Beijing

Beijing is the capital of China and an international metropolis. The great economic prosperity and urban growth have also resulted in the deterioration of the city's environment, especially air quality. To tackle severe air pollution, Beijing has launched comprehensive air pollution control programs in phases. With the constant efforts in air pollution control, air quality has improved significantly, and energy consumption per unit GDP and emission intensity has decreased year by year. The experience of air pollution in Beijing has been recognized as a "case of good practice" by the United Nations Environment Programme (UNEP) that needs to be shared by other cities, especially those in developing countries, around the world.

7.1 Background

As the political and cultural center of China, Beijing is also a hub for international exchange and technological innovation, and a pilot in implementing the Belt and Road Initiative (BRI), playing a crucial role in the development of BRI. With the establishment of an open and inclusive cooperation mechanism, the cooperation between Beijing and major cities in BRI participating countries has huge potential.

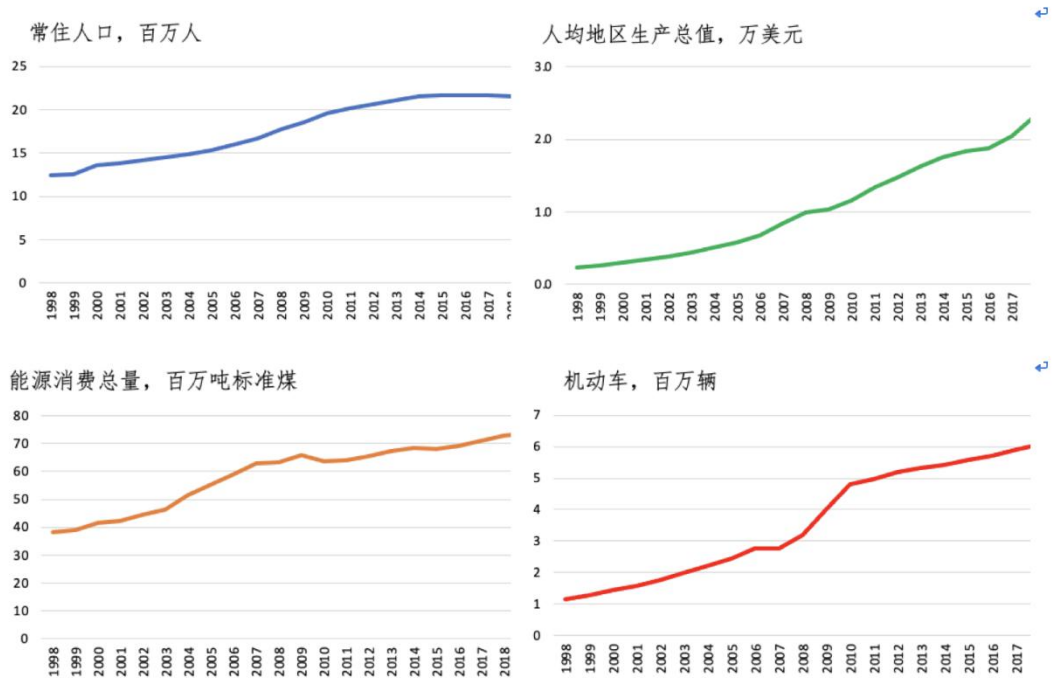

Figure 4-1 Scio-economic development of Beijing (1998-2019)

Source: Beijing Municipal Statistics Bureau

In the past 20 years, Beijing experienced rapid development. At the end of 2019[2], the permanent resident pollution reached 21.537 million and Gross Domestic Product (GDP) per capita reached 24,000 US dollars; registered vehicle ownership was 6.365 million and annual energy consumption reached 73.60 million tons of coal equivalent (tce) (Figure 4-1). Relative to 1998 levels, growth of these indexes was 1035%, 76%, 447%, and 93%. The great economic prosperity and urban growth have also resulted in the deterioration of the city's environment. The characteristics of combined coal-vehicle pollution are unceasingly apparent and heavy-pollution episodes occurred regularly, with negative effects on public health.

Environmental protection started in the late 1970s in China and Beijing. At local level, end-of-pipe pollution control measures (mainly in industrial sources) were implemented following government regulations until the late 1990s. By the late 1990s, the ambient concentrations of pollutants including sulfur dioxide (SO_2) and total suspended particles (TSP) in Beijing seriously exceeded Chinese national air quality standards. In response, in 1998 the Beijing Municipal Government published *Announcement of Urgent Measures to Control Air pollution*. This document announced Beijing's war against air pollution.

7.2 Project overview

In 1998, Beijing launched the first local government air pollution control program in China. Hundreds of concrete measures were implemented targeting at key pollution sources of particulate matter (PM) and soot, namely coal consumption, industrial emissions, motor vehicle emissions, and dust. With these measures, the annual average concentration of SO_2, TSP, PM_{10} and CO_2 were significantly reduced. The 29th Summer Olympic Games held in Beijing in 2008 was a catalyst for Beijing's air pollution control, which accelerated the implementation of more intense measures. End-of-pipe air pollution control measures were gradually replaced by integrated measures related to structural adjustment, achieving positive outcomes. Beijing also began regional cooperation during the 2008 Olympic Games period. Air quality continued to be improved.

During the autumn and winter of 2012, heavy $PM_{2.5}$ pollution episodes frequently occurred in Beijing and the surrounding regions, with a maximum $PM_{2.5}$ concentration of 867 μg/m^3 in the city district. The Chinese central government took immediate actions to address the challenge. The *Chinese National Ambient Air Quality Standard* was revised, the threshold of $PM_{2.5}$ was added. In 2013, Beijing unveiled the *Beijing Clean Air Action Plan 2013-2017* in accordance with the requirements of the national *Action Plan for Air Pollution Prevention and Control*. In this five-year period, aiming at $PM_{2.5}$ pollution control, comprehensive measures were implemented, focusing on coal consumption reduction, vehicle emission control, industrial emission control and fugitive dust mitigation. In 2015, the Chinese government issued the Plan for Coordinated Development of Beijing-Tianjin-Hebei Region. Several new plans were developed to reinforce this regional strategy and respond to the mid-term assessment conducted by the former Ministry of Environmental Protection. For Beijing, the enhanced measures include the *Beijing Plan for Implementing the Strengthened Measures for Air Pollution Prevention and Control in Beijing-Tianjin-Hebei Region 2016-2017*.

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[2] By the completion of the report, the latest edition of *Beijing Statistical Yearbook* published by Beijing Municipal Statistics Bureau is the 2020 edition, which covers the statistics of 2019.

In May 2018, the National Conference on Eco-Environmental Protection was held in Beijing. The Conference officially established President Xi Jinping's Thought on Ecological Civilization and proposed a series of new philosophies and strategies, including "lucid waters and lush mountains are invaluable assets", "use rules and laws to supervise eco-environmental protection" and "jointly promote global ecological civilization construction", providing guidance for enhanced measures in eco-environmental protection, especially air pollution control. The Conference made it clear that decisive measures must be taken to fight air pollution with the goal of significantly improving air quality and reduce the number of days with heavy pollution to zero.

In June 2018, the State Council issued *Three-Year Action Plan to Fight Air Pollution* in a bid to improve air quality. It was aimed at reducing emissions of major air pollutants and greenhouse gases, seeing a marked drop in the density of PM 2.5, and decreasing the number of seriously polluted days. In March 2018, The people's government of Beijing Municipality released *Three-Year Action Plan for Protecting Beijing's Blue Skies*, proposing concrete measures for transportation structure for lower mobile source emissions, dust pollution control, improved industrial structure for green production, improved energy structure for clean energy consumption, and control of non-point source pollution and reduction of emissions from agricultural and residential sources. In February 2020, the *2020 Action Plan on Pollution Prevention and Control* was issued by the Beijing Municipal Government, which identified the control of heavy-duty diesel vehicle emissions, dust, and emissions from production and daily activities as the priority area for "protecting Beijing's blue skies" with further measures to increase joint prevention and control across regions and provide sound institutional support.

Since 1998, with the intensified efforts on air pollution control in the city, monitoring data shows that annual average concentrations of major air pollutants in Beijing maintained a decreasing trend. Concentrations of SO_2 met national ambient air quality standards in 2004 and declined even further since then; PM_{10} and NO_2 met national standards in the year 2019-2020. In 2020, with joint prevention and control efforts across regions, Beijing made breakthrough progress in air quality improvement. The concentration of $PM_{2.5}$ registered a record low of 38 μg/m^3, the first time for level of $PM_{2.5}$ to drop to below 40 μg/m^3. The concentrations of PM_{10} and NO_2 met national standards for two consecutive years. The annual average concentration of SO_2 remained at below 10 μg/m^3, well below the national air quality standard. The number of days with good air quality registered at 276, accounting for 75.4% with a drastic decrease in the frequency of occurrence, peak pollutant concentrations and duration of heavy pollution episodes.

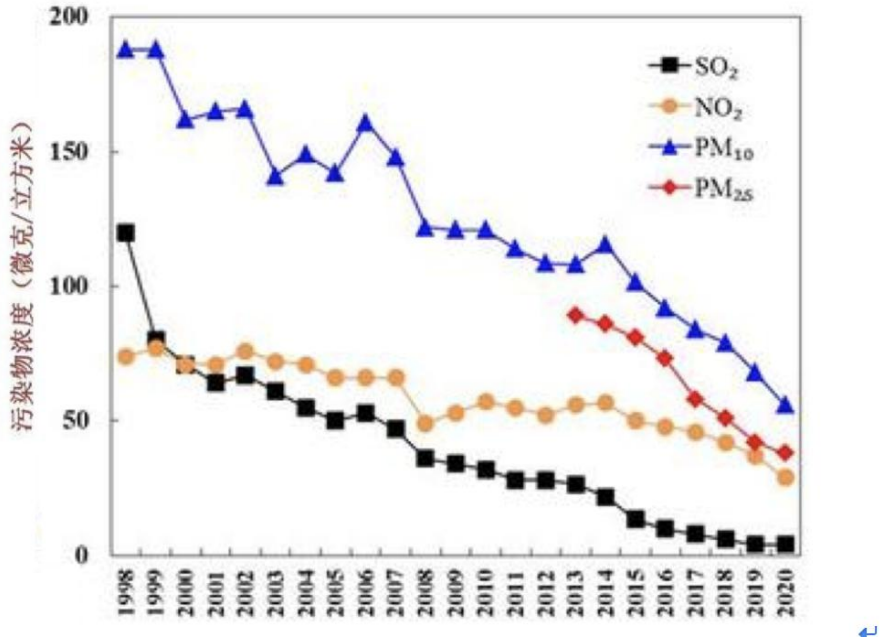


Figure 4-2 Changes in annual average concentrations of major air pollutants in Beijing (1998-2020)

7.3 Green Development experience

7.3.1 An effective air quality management system

Focusing on the priority areas for air quality improvement, Beijing established an integrated work mechanism with implementation and supervision at district, county (street) and village (community) level under the guidance and coordination of the municipal government. With such efforts, businesses are actively promoting the transition to energy-saving and environmental-friendly business models, and the public are actively participating in ecological and environmental governance and exercising green ways of life. An environmental governance system with “government leadership, corporate implementation, and public engagement” has been gradually formed.

During the air pollution control process, Beijing established a comprehensive air quality management system that suits its own circumstances. A continuous air pollution control campaign was successfully implemented, including energy structure optimization, vehicle emission controls, industrial structure upgrading, city management enhancement, ecological restoration, and rising public environmental awareness. The system is characterized by: (a) complete legislation and enforcement mechanism; (b) systematic planning; (c) powerful local standards; (d) strong monitoring capacity; (e) high public environmental awareness.

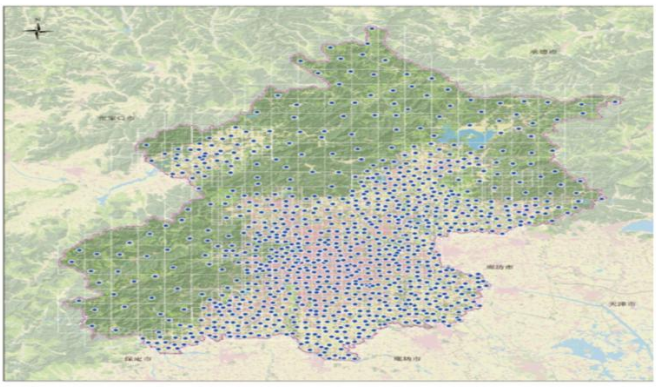
7.3.2 Economic incentives and financial support

Beijing has gradually established a number of local environmental economic policies, including subsidies, fees, pricing and other financial practices, to provide economic incentives for the effective implementation of various measures on the control of emission from coal, vehicles, industrial sources and dust. Meanwhile,

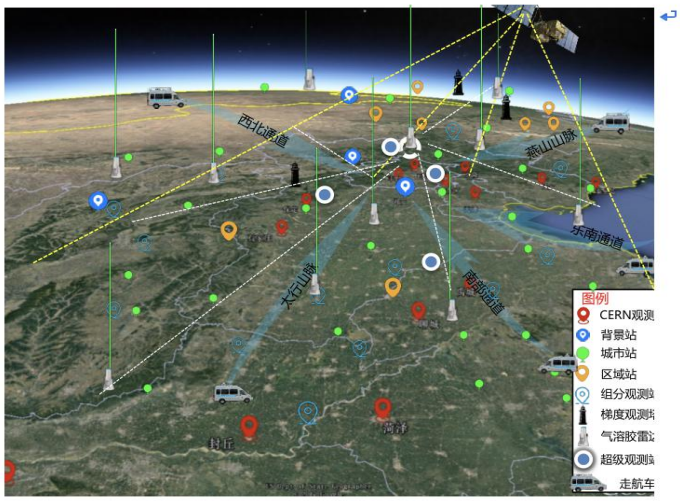
the spending on air pollution control has also been increased with the investment from all sectors, which manifest great ambitions of the government on air pollution control.

7.3.3 Sophisticated air quality monitoring system

Beijing started to build the air quality monitoring (AQM) system in the 1980s. By 2013, 35 ambient AQM stations which can monitor 6 major pollutants such as $PM_{2.5}$ and O_3, had been established across Beijing. In 2016, combining advanced technologies like high resolution satellite remote sensing and laser radar, a new generation of integrated air quality monitoring network was established. A high-density $PM_{2.5}$ monitoring network has been established in Beijing, which deployed over 1000 $PM_{2.5}$ sensors throughout the city, covering over 300 streets (counties and villages). The AQM network provides accurate identification of high-emission areas and periods and enables three-tier real-time air quality monitoring on the municipal level, district level and street level.



(a) Beijing's high-density sensor-based $PM_{2.5}$ monitoring network



(b) The integrated AQM network covering the "2+26" cities in Beijing-Tianjin-Hebei and Surrounding Areas.

Figure 4-3 Development of the AQM network system

7.3.4 Emission reductions from coal combustion sources

Coal combustion has always been a major air pollution source in Beijing, and the city has continuously promoted end-of-pipe control and energy structure adjustment over the past 20 years. Focusing on power plants, coal-fired boilers and residential coal use, the pollution sources were controlled simultaneously, achieving remarkable progress.

Take coal-fired power plants as an example. Beijing has implemented a “coal-to-gas” policy since 2005 and reduced coal combustion by nearly 11 million tons by 2017. High-efficiency terminal treatment facilities were continuously renovated and ultra-low emission standards were enforced during this period. In 2017, emissions of $PM_{2.5}$, SO_2, and NO_x were reduced by 97%, 98% and 86% respectively compared with 20 years earlier (Fig5), resulting in significant environmental and health benefits.

7.3.5 Vehicle emission control

The prevention and control of vehicle pollution have long been a critical task in Beijing’s air pollution control. Focusing on new vehicles, in-use vehicles and fuel quality, Beijing has implemented a series of local emission standards and comprehensive control measures; as well as strengthened traffic management and economic incentives continuously. The integrated “Vehicle-Fuel-Rod” framework was developed. Main emission control measures include: adopting stricter emission standards, in-use vehicle upgrade (the equipment of diesel particulate filters (DPF)), driving restrictions, scrappage of older vehicles, improvement of fuel quality and the development of new energy vehicles. Meanwhile, a large-scale public transport system has been built to allow gradual formation of a green and low-carbon in-city travel habit by people. Although the number of vehicles increased three-fold in Beijing during the last two decades, the total pollutants emissions decreased remarkably.

7.3.6 Coordination between Beijing and its Surrounding Areas

Besides enhancing local air pollution control, Beijing also actively sought to coordinate air pollution control measures with the surrounding areas. At the end of 2013, Beijing was asked to lead the establishment of the mechanism for Coordinated Prevention and Control of Air Pollution in Beijing-Tianjin-Hebei and Surrounding Areas with the support of the State Council. The mechanism was established by National Development and Reform Commission (NDRC), Ministry of Finance, Ministry of Ecology and Environment, Ministry of Industry and Information Technology, Ministry of housing and Urban-Rural Development, China Meteorological Administration and National Energy Administration in collaboration with the government of Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia and Shandong. In 2017, the Ministry of Ecology and Environment identified the 28 cities in the Beijing-Tianjin-Hebei and Surrounding Areas as air pollution transportation channel. Through collaborative planning, unified standards, joint emergency response, and information sharing, the air quality of the whole region was significantly improved.

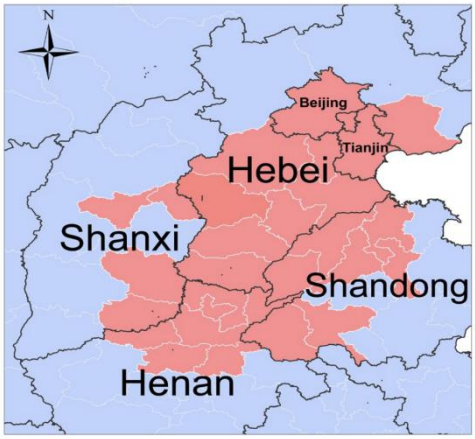


Figure 4-4 Distribution of the "2+26" cities (the red areas) in Beijing-Tianjin-Hebei and Surrounding Areas
(Source: Former Beijing Municipal Environmental Protection Bureau)

7.4 Case Summary

Substantial air quality improvement has been made under the rapid social and economic development in the capital city. Clean air actions contributed to the high-quality and sustainable development of the economy and the society. The environmental sector keeps growing along with the intensified pollution control campaign in China, creating new employment opportunities. While the complexity of air pollution in Beijing is unique to its stage of development, the achievement may attribute to its governmental structure to some extent, there are several commonalities. We have found that the keys to local sustainable development are the strong willingness, clear goal, supportive legislation, plan and policies, implementation and enforcement arrangement. Engaging the public in these objectives will strengthen environmental protection even further and increase social harmony. Even though great air quality improvement has been made, Beijing and the surroundings still face pressures and challenges in future air pollution control. In 2017, PM2.5 concentration in Beijing was still higher than the National Ambient Air Quality Standard of China, and even higher than the World Health Organization guideline. In addition, heavy pollution episodes still occur from time to time during autumn and winter. The continuous improvement of the atmospheric environment still needs unremitting and extra efforts in the future.

8 Israel: Wastewater Treatment and Reuse

Israel has a Mediterranean climate, with limited land area and water resources, yet it is one of the most successful countries in terms of water management. The management of water resources in Israel is based on a mechanism involving the government, businesses, and people. Israel invests special funds in water policy every year for the construction and operation of water supply and drainage infrastructure, and has a tariff policy. Water resources are managed in parallel through wastewater treatment, reuse, and water conservation and precise irrigation. At the same time, the Israeli government also attaches great importance to the scientific and technological innovation of wastewater reuse, and focuses on raising the awareness of water conservation among people.

8.1 Background

Located in the Middle East, Israel has one of the world's most scarce freshwater resources, with more than 60% of its territory covered by desert and drylands. Currently, Israel's total annual water availability is 1.8 billion cubic meters, while water consumption is approximately 2.2 billion cubic meters per year. In addition to groundwater and ocean desalination, approximately 400 million cubic meters of municipal wastewater is the largest potential water resource for the city. After effective treatment, a large amount of municipal wastewater is recycled for agricultural irrigation and other uses. Israel has become one of the most successful countries in the world in the efficient management of water by constantly exploring ways to develop new freshwater resources, improve the efficiency of water use, and avoid water pollution and waste. Today, Israel has not only solved the problem of urban water shortages, but has also become an important European exporter, exporting large quantities of vegetables, fruits, flowers and other water-consuming agricultural products to all parts of Europe.

Figure 4-5. Israel Location Map

8.2 Project Profile

Israel's regulations on wastewater treatment and management date back to the enactment of The Water Law in 1959. 1962 saw the introduction of the Local Authorities (Sewerage) Law, which set out the rights and obligations of local governments in the planning, construction and management of wastewater treatment systems. 1973 saw the first development of drip irrigation technology by Netafim to address the problem of water shortages. 1977 saw the construction of the country's first and largest wastewater treatment plant, the Shafdan Wastewater Treatment Plant. In 1981, the Public Health Ordinance further regulated wastewater treatment and introduced a specific list of crops to which irrigation wastewater was applied. 1991, an amendment to the Water Law added water pollution prevention. In 2001, under the Water and Wastewater Corporation Law, Israel reformed its water management responsibilities by separating water supply and sewerage responsibilities from government functions and forming a municipal water and sewerage company. 2006 saw the establishment of the Water Authority in response to amendments to the Water Law in the same year. 2010 saw the adjustment of water prices, with an average increase of 40 percent, to further promote water conservation throughout society. Today, Israel recycles nearly 90 percent of its wastewater, runs a national water surplus and exports water to its neighbors.

8.3 Green Development experience

8.3.1 Participation of Government, Enterprises, and the Public

The management of water resources in Israel is based on a participation mechanism involving government, business, and people. The Israel Water Authority, the Mekorot National Water Company, and the regional water companies form a complete system of water production, supply, and wastewater treatment, and together they implement the Israeli government's water policy. There is also a policy of advocacy and incentives to mobilize the public to conserve water.

In the Israeli government structure, water is administered by the central government, and in 2007, a deliberative decision-making committee was formed with senior representatives from the Ministries of Finance, Energy, Environmental Protection and Interior to develop policies and institutions related to water management and to directly supervise the Water Authority. The Authority is a cross-governmental organization responsible for the operation, development, rehabilitation, regulation, distribution, and supervision of Israel's water resources. Its responsibilities include protecting and restoring natural water sources, developing new sources, and supervising producers and consumers in order to effectively provide high quality and reliable water and wastewater services, while maintaining water sustainability and ensuring the quality of life of Israel's residents. The Ministry of Environmental Protection is responsible for setting drinking water quality standards, and the Finance Ministry is responsible for taxation and investment policies.

The Israeli government has established a comprehensive system of water resources management laws and regulations. In addition to the draft Water Law, which was prepared at the early stage of the establishment of the State, Israel passed the Water Resources Law in 1959, which established that water resources are owned by the State. The state manages water resources nationwide and makes uniform arrangements for water rights and water quotas. The Water Resources Law was amended in 1971 to prohibit anyone from polluting water resources directly or indirectly. The Israeli government has also introduced detailed laws and regulations such as the "Regulations for the Protection of Water Resources from Heavy Metals and Other Pollutants by Limiting the Discharge of Wastewater from Sources of Pollution". In order to promote the implementation of the various systems in Israel's Water Law, a special water court was established to handle legal matters related to water law, such as administrative penalties for companies or individuals who violate water law, providing comprehensive and systematic legal protection for water resources management and protection.

From the perspective of enterprises, Israel's water market is relatively concentrated, mainly including the Mekorot national water company and 52 regional or municipal water companies. Mekorot National Water Company established in 1937 is Israel's earliest and largest water state-owned enterprises, responsible for the operation of about 3,000 water treatment implementations throughout Israel. It serves about 80% of Israel's residents and supplies about 70% of the country's water. In addition to providing drinking water services, the Mekorot National Water Company is responsible for 40% of the country's wastewater treatment services. Israel also has relevant association bodies that unite professionals, businesses, and government agency staff to provide legal technical support for water management.

Along with good institutional safeguards, the Israeli government also pays great attention to developing and raising awareness of water conservation among the entire population. It is stated in the Water Law that "everyone must treat water in the most cost effective way". The Israel Water Authority and the Ministry of Environmental Protection call on the entire population to save water and build a water-saving society through posters, newspapers, websites, slogans, and other promotional activities. At the same time, Israel has taken water conservation into the church through awareness and educational rainwater harvesting programs.

8.3.2 Financial Incentives

Israel's fiscal and tax incentives for water services are mainly in the form of financial investment and tax and price policies. In terms of financial investment, the Israeli government invests at least $245 million per year in the construction and operation of water supply and drainage infrastructure. Local municipalities also invest in some of the water supply networks and sewage treatment facilities under their management.

In setting water-related tariff policies, the Israeli government follows the principle that all services are based on actual costs incurred and fully recovered. In 2010, water prices in Israel increased by an average of 40%, and the price of water has decreased significantly in agriculture, industry and domestic use, saving approximately twice the amount of water previously saved.

8.3.3 Wastewater Treatment and Water-saving Irrigation

Nearly 90 percent of Israel's wastewater is recycled. This is about four times higher than the wastewater utilization rate of other countries in the world. Nearly 50% of the recycled water is used for agricultural irrigation, and the remaining small portion (10%) is used for environment-related purposes, such as supplementing river flows and fire suppression; only 5% is discharged into the sea. Israel's wastewater reclamation rate reaches about 86%, the highest in the world.

Since 2000, Israel has invested more than $750 million in centralized water recycling, adding 51.8 billion cubic meters/year of water, most of which is treated at the tertiary level. Israel now has 67 large wastewater treatment facilities covering 80 towns and other settlements, with the 10 largest wastewater treatment plants capable of treating more than 56% of the country's wastewater. Wastewater treatment facilities use a combination of size to their advantage. Huge centralized plants can take advantage of economies of scale, while smaller decentralized plants sited near the point of use have efficiencies comparable to large plants and avoid the significant risks of overbuilding. Israel's network of aqueducts throughout the country connects different regions and allows for rapid distribution of surplus water when needed, and for the first time, Effluent Quality Standards and Rules for Sewage Treatment, introduced in 2010, include standards limiting salinity and toxic metal content. Recycled water now supports economic growth and makes Israel more resilient to the ongoing drought caused by climate change.

There are more than 500 wastewater treatment facilities in Israel, of which nearly 30 are wastewater treatment plants. Among them, Shafdan wastewater treatment plant is the largest wastewater treatment plant of the Israeli National Water Company, bearing the domestic and industrial wastewater of about 2.5 million residents in the Tel Aviv area, treating more than 300,000 tons of wastewater per day. The project began in 1977, after several renovations and upgrades, in 2003 the project was designed to treat 14 million cubic meters of wastewater per year, with a total of about 70 kilometers of underground pipelines, the diameter of the main and secondary carrier pipes ranging from about 0.6 to 2.2 meters, with an investment of about $150 million. The goal of the project is to remedy the shortage of water resources in Israel and prevent pollution of the Toraviv coast. The plant uses the latest biological wastewater treatment technology, consuming biological waste through biomass carrier equipment. The municipal wastewater is treated by the activated sludge method including nitrification/denitrification process at the mechanical biochemical wastewater plant. Soil aquifer treatment systems are able to further remove pollutants through physical/chemical processes. The treated reclaimed water is rapidly and naturally filtered and directed through designated pipelines to an underground reservoir for agricultural irrigation, where it is used for

large-scale agricultural irrigation in the local and southern regions.

Data from Israel's Ministry of Industry, Trade and Labor shows that Israel's average annual wastewater volume reaches 520 million cubic meters. Currently, treated wastewater accounts for approximately 21% of Israel's total water use and 45% of agricultural water use. According to data from 2015, Israel produced about 510 million cubic meters of wastewater that year, of which 97% was collected, about 91% was reused (475 million cubic meters) and 75% was recycled for irrigation (about 360 million cubic meters). After pretreatment, sedimentation tanks, biological reactions, spiral pumps, anaerobic decomposition tanks and other treatment steps, the purified wastewater can even reach drinking water level.

Figure 4-6. Shafdan Wastewater Treatment Plant Source: Xinhua

8.3.4 The Use of New Technologies

The Israeli government attaches great importance to scientific and technological innovation in wastewater reuse and provides financial support for the research and development of original and breakthrough technologies, with the government sharing the risks of research and development and supporting up to 50% of the project's research and development costs. Israel's scientific and technological innovation is not only applied in the field of water conservation, but also in the development of further desalination and wastewater treatment technologies. Breakthrough wastewater treatment solutions developed by Israeli companies include: wastewater pumping and scanning technology, laser analyzers, microbial fuel cell technology, oxygen-lift reactor technology, wastewater recycling systems, microporous aeration systems, filters and filter membranes, etc.

Israel's national policy supports smart water management. To improve the efficiency of the water system, Israel mixes groundwater, fresh water from the lake, sewage, and seawater. The percentage of salt and minerals in the water is precisely monitored by computers to reduce the risk of excessive salt and mineral concentrations to meet the water needs of the population. In the field of drip irrigation technology, Israel uses technologies that can precisely control micro-irrigation by computers. This technology determines plant

irrigation spacing by detecting changes in the diameter of plant stems and fruits. At the same time, agricultural experts can adjust the amount and frequency of drip irrigation through this system in a timely manner based on parameters such as meteorological conditions, soil water content, and crop water requirements, to achieve efficient use of water resources and avoid wasting water resources.

8.4 Case Summary

Israel has successfully established a highly efficient water resources management system in the geographical conditions of water scarcity through institutional design, fiscal policy, sewage resource utilization, water-saving irrigation, and new technologies, which have prevented water pollution and waste, improved water utilization efficiency, solved the problem of water stress, and realized the optimal utilization of water resources.

9 "Black and Odorous" Water Bodies Treatment of Nakao River, Nanning

The Nanning Model of "black and odorous" water bodies treatment has been fully mirrored in the Nakao River basin's comprehensive treatment project. The project fully leverages the PPP model, implements whole-basin management, and adopts an ecological, scientific and systematic model of water treatment, turning the former stinky ditch into a leisure waterfront landscape with clean river, green shore and enchanting scenery. The treatment of "black and odorous" water bodies of Nakao River has been widely recognized, providing replicable and transferable experience for water treatment in Nanning City and other areas.

9.1 Background

Nanning City is located in the south central of Guangxi Province, facing Southeast Asia, backed by the southwest of China, east to Guangdong-Hong Kong-Macao, and south to Beibu Gulf. It is located in the important node of the "Belt and Road Initiative", the intersection of the South China Economic Circle, Southwest China Economic Circle, and China-ASEAN Circle, a very outstanding geographical location. Nanning is the capital city of Guangxi Zhuang Autonomous Region, the region's center of politics, economy, culture, education, science & technology, and finance. It is the permanent venue for China-ASEAN Expo, the core city of Beibu Gulf Economic Zone, and the important gateway city for the linkage of Silk Road Economic Belt and the Maritime Silk Road.

With the accelerated development of urbanization in Nanning, the hardened area of land and population in central urban area of Nanning have increased rapidly, and the ecological environment of the city's inland rivers has deteriorated seriously. Compared with the speed of urbanization, the construction of the city's pipeline network was relatively lagging behind, and the construction of sewage-interception pipelines along the water system and the scale of sewage treatment plants were unable to meet the increasing urbanization requirements. The inland river water bodies were seriously polluted. To develop the city in a sustainable way, and improve the urban environment, the Nanning Municipal Government started to apply for the construction of "sponge city" to the central government from 2014, so as to transform the engineering water management to ecological water management.

In 2015, Nanning City was selected as one of the first "sponge city" pilot cities in China, and at the same time, the government vigorously promoted the PPP model in the field of public services. After careful research and preparation, the treatment model of Nakao River's "black and odorous" water bodies were born. In March 2015, the "black and odorous" water bodies treatment of Nakao River in Nanning, which adopted the innovative concept of combining "whole-basin management" and "sponge city", became the first PPP project of water basin management initiated in China, and the first PPP project integrating basin management and sponge city construction in China. The successful experience of the project has become a significant model for the application of PPP model in river basin management and the effective integration of basin management and sponge city construction.

9.2 Project overview

Nakao River is located in the northeast of Nanning City, and is an upstream tributary of Zhupai River, the

main inland river of the city. It originates from Gaofeng Mountain in the northeast suburb of Nanning, and has a long basin. It undertakes a variety of functions, including flood control and drainage, water system ecology and landscape recreation, etc. Meanwhile, Nakao River is also the part where the inland river of Nanning City intersects with the natural landscape of the suburbs, and is located within the sponge city demonstration area. Before the implementation of the comprehensive treatment of Nakao River, there were 40 direct sewage outfalls along the river, and the water quality was mostly Poor V. The water source was severely polluted, the natural vegetation along the river was declining, the aquatic biodiversity was dropping sharply, and the environmental problems were prominent.

The "black and odorous" water body treatment of Nakao River is a key demonstration project in the construction of sponge city pilot project in Nanning City, Guangxi Province. It has a total project area of 71.9 hectares and a total length of 6.35 kilometers of treated rivers. The project started on March 31st 2015, with a total investment of 1.19 billion yuan, a project concession period of 10 years, including 2 years for construction and 8 years for operation. The whole project includes river remediation and sewage interception, river purification and water replenishment, the construction of sewage treatment plant and landscape along the river, the demonstration construction of the sponge city, information monitoring integration, etc.

After comprehensive treatment, the ecological environment protection of Nakao River has achieved obvious results. According to the test of the professional testing agency, the water quality indicators of Nakao River have basically met the Class IV standards of surface water quality, the flood discharge capacity can meet the requirements of the level of once-in-50-year flood, and the ecological environment has also been greatly improved. According to the re-evaluation report of basin management service fee performance of Nakao River basin PPP project, the on-site verification has shown that the sewage treatment rate within the scope has reached 100%; the average daily intake of sewage pumping stations exceeded 30,000 tons, which means more than 10.8 million tons of purified water resources available for the city each year; the amount of water recharged to the river exceeded 90%; the annual reduction of chemical oxygen demand reached 12,000 tons annually, and ammonia nitrogen 0.1 million tons. That means after the comprehensive treatment of the basin, the degree of water quality pollution by reducing substances is being lessened.

Since the Nakao River project applied the PPP model to basin management, it has achieved certain effects in improving the city's inland water system and introducing social capital to participate in urban construction, further promoted the transformation of the government's water management function, created a better water ecological environment for the general public, and generated significant social and economic benefits.

9.3 Green Development experience

9.3.1 Comprehensive Treatment Model of the Whole Basin

Due to the complexity of the water system and river network, the government cannot adopt the same treatment plan for multiple rivers during the process of ecological restoration, nor can it treat river by section. Instead, it had to comprehensively treat the inland city rivers in a systematic, professional, holistic and well-targeted way. For the treatment measures, it had to flexibly connect the "source control and sewage interception" of the upstream and the source and the "treatment of black and odorous water bodies" of the middle and lower reaches, promote the water environment treatment by comprehensively considering the source, the process and the end, so as to fundamentally restore the natural ecology.

Whole-basin comprehensive treatment is the obvious feature of the management of Nakao River basin. It has taken the pollution features of different sections into consideration for the whole-basin management, and carried out the treatment in different sections simultaneously. It adopts the technical path of "source control and sewage interception, inner source treatment and water recycling, clean water recharge and water quality management, ecological restoration and information monitoring". The sewage treatment plant in the upstream is responsible for treating the sewage and black and odorous water bodies, making the water quality reach Class A discharge standards through the membrane bio-reactor and advanced ecological treatment technology, and recharging the water purified by the ecological wetland back into Nakao River as a supplementary water source; the middle reaches of the river are responsible for the transfer and purification of water, strengthen the function of the supporting pipeline network to alleviate the problem of river water pollution; in the downstream of the river, the government has established additional sewage treatment facilities in public areas like green areas, parks and squares for pollution control. The simultaneous and coordinated development of water conservancy, urban pollution control, water ecology, sponge city construction, landscape building, information management and other inland river management has realized the water control of the whole basin.

9.3.2 PPP Model

In order to enhance the efficiency of project construction and give full play to the role of social capital, the Nanning Municipal Government decided to adopt the PPP model for the treatment. After competitive negotiation and procurement, Beijing Drainage Group won the bid as a social investor, and it established Nanning North Drainage Environment Development Co., Ltd. (the project company) together with Nanning Jianning Water Affairs Investment Group. The project company undertakes the construction and operation of Nakao River Project, with a total investment of 119,000 *yuan*, and 10 years of project period (2 years for construction and 8 years for operation).

Compared with the traditional model, the PPP model changes from a single government action to a combination of government action and market action, with social capital and government working together on basin management. For the government, this kind of model frees them from the lengthy and busy business of financing, investment and construction. All the government needs to do is to hire qualified third-party institutions to regularly monitor and assess the project according to the previously determined assessment indicators of water quality, water quantity and flood control, and pay quarterly based on the results. By adopting the PPP model and allowing the professional social capital to carry out the basin treatment, the government has transformed from the previous builder to a manager, achieving better efficiency of public services and a win-win situation for both the government and enterprises.

9.3.3 Construction of Sponge City Facilities

In addition to creating a beautiful wetland landscape, the Nakao River Wetland Park is also important for its "spongy" design, which allows for graded purification and storage of rainwater. For example, under the subsurface wetland planted with plenty of canna and sedge. There are two layers of deep-buried pipes, the bottom of which is for the supplementary water source discharged from the sewage treatment plant. There are small holes in these pipes, and the water discharged from the small holes is infiltrated and purified by the subsurface wetland, and then goes to the upper pipes. There are some small holes in the upper pipes as

well, from which the infiltrated water goes into the river. Meanwhile, the beautiful vegetation of the subsurface wetland also has the function of removing the phosphorus and nitrogen in the water. In addition, the green belts of layered terrace landscape along the riverbanks can absorb, store, infiltrate, slow release and utilize the initial rainwater along the banks, playing the function as a natural rainwater purifier.

Through technologies of “infiltration, retention, storage, purification, utilization and discharge”, the sponge facilities can absorb, store, infiltrate and purify rainwater, replenish groundwater, and regulate the water cycle when there is a rainfall; in times of droughts and water shortage, the stored water can be conditionally released, thus making the migration of water in the city more “natural”, and saving the energy consumption for urban water replenishment. The construction of sponge city facilities enables the absorption, storage infiltration, slow release and utilization of the initial rainwater along the riverbanks, which could improve the ecology of the river and build a harmonious ecological environment for Nakao River.

9.3.4 River Interception and Water Quality Purification

Based on the technical path of “source control and sewage interception, dredging, water quality improvement, water circulation, clean water replenishment, ecological restoration”, Nakao River treatment project has established an interception dam on the upstream of Nakao River, and set an MBR sewage treatment plant with a daily treatment capacity of 50,000 cubic meters on the upstream of the main river, which can block the sewage from the upstream into the sewage-interception pipes along the river. Meanwhile, sewage-interception pipes are laid under the walkway of the river to collect sewage and initial rainwater to ensure that those within the treatment basin are not discharged directly into the river. Through the construction of sewage-interception pipelines, the sewage along the river and the surrounding areas can be absorbed by the pipelines nearby into the plant for treatment and ecological purification to meet the Class IV standards of surface water. Then it can be turned into water source replenishing Nakao River after the purification of the wetland, achieving the goal of “clean source and clear flow”. While treating the water bodies, the project has also realized the organic unity of the water ecology, water circulation, water landscape, and water security of the upstream and the downstream of Zhupai River, and enabled the coordinated development of Nakao River’s environment and the sponge city construction of the whole basin.

9.3.5 Introducing Professional Basin Management Company and Employing Professional Consultants

Nakao River treatment project involves multiple system projects, and requires high-level expertise and management capability for the overall manager. When the project feasibility study was completed, the project was tendered to the public in October 2014, and four social investors passed the preliminary qualification review, two of which were then admitted to the competitive negotiation bidding stage. Through the study of the project’s regional features and the surrounding environment, Beijing Drainage Group provided a design with the theme of “Color and Fragrance of ‘Na’”, which was very characteristic of Nanning’s “Na” culture of the local Zhuang ethnic group, stood out among many bidders and won the bid in February 2015. At the end of that month, the Nanning Municipal Inland Waterway Management Office (NMIWMO), Beijing Drainage Group (BDG), Nanning Jianning Water Investment Company (NJWIC) jointly singed a PPP project contract, and established Nanning North Drainage and Environment Development Co., Ltd, the project company, with 90% of the equity belonging to BDG and 10% to NJWIC. Based on the contract, the basin management service fee will be paid on a quarterly basis when the project enters its

operation period.

Due to the PPP model, the project control has been basically handed over to the social capital; the construction does not require bidding, and the settlement method has also changed. Therefore, the government investment control department has put forward higher requirements and new challenges for the argument depth of the feasibility study stage and the preliminary design and budget estimation stage. In view of its weakness in technologies, NMIWMO has hired qualified third-party professional consultants, Shanghai Jumbo Consulting Co., Ltd and Tsinghua Holdings Human Settlements Environment Institute Co., Ltd to check on the project for owners from the early stage of the project, which has ensured the reasonable stability of the technical program, construction standards, quality and engineering investment of this project to a very large extent.

9.3.6 Ecological Restoration of the River

Through the ecological design of riverbank protection and embankments, and the use of technical measures such as river-type wetlands, wetland parks and biodiversity reconstruction, the project has created various ecological and natural landscapes based on local conditions, and built a water environment where man and nature exist harmoniously. For example, there are four overflow dams, one storage gate, one floodgate and one connecting gate on the upstream of Nakao River. The establishment of overflow dams enable the water from the upstream to form a normal water level of 0.5-2.0 meters and diffuse into a wider area of water landscape. In case of urban water logging, the connecting gate in the retention area will be opened to empty the storage, and meanwhile the floodgate will be opened to retain part of the flood water, which will be discharged downstream to Yongjiang River after the flood peak. In addition, in order to create a vibrant water environment, the project has also built a riverbank landscape mainly located in the green areas that are 8-120 meters from the bank, covering an area of 44.77 hectares, creating an ecological path with diverse plants and integrated functions of flood control, tourism, culture and leisure.

9.4 Case summary

The City of Nanning experienced rapid urbanization in recent years. However, due to underdeveloped municipal pipe network, river bodies in Nanning are seriously polluted. To tackle the problem, the government took a series of measures to improve urban environment and carried out black and odorous water bodies treatment of Nakao River through adopting the innovative concept of combining “whole-basin management” and “sponge city”. The program is the first PPP project of water basin management initiated in China, and the first PPP project integrating basin management and sponge city construction. The project effectively improved the water quality of inland rivers and attracted social capital to engage in urban construction, creating a better environment for local residents and generating considerable socio-economic benefits.

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Chapter 5. Green Energy

10 King Salman Energy Park of Saudi Arabia

King Salman Energy Park (SPARK) is located in the eastern province of Saudi Arabia, which is rich in oil and natural gas. It is an important measure taken by Saudi Arabia to meet local energy needs, localize its energy supply chain, and derive benefits from it. It is also an important part of its "Vision 2030". The project realizes the localization, high efficiency and intensification of the industry by gathering the entire petrochemical industry chain. At the same time, it will also attract related industries and promote the diversified development of Saudi Arabia's economy. The SPARK has not only industrial zone, but also commercial and residential zones, and provides complete supporting facilities, realizing the green and sustainable development of industry-city-people integration.

10.1 Background

The Kingdom of Saudi Arabia (hereinafter referred to as "Saudi") is located in the Arabian Peninsula of West Asia, bordering Qatar, Bahrain and the United Arab Emirates in the east, Oman and Yemen in the south, Egypt, Sudan and Eritrea in the west across the sea, and Jordan, Iraq and Kuwait in the north (see Picture1 below). It is the only country that has both the Red Sea and the Persian Gulf coastlines, where the geographical location is extremely important. The country covers an area of 2.25 million square kilometers, second only to Algeria in the Arab countries. The population is about 34.81 million, of which Saudi citizens account for about 62%. Islam is the state religion. Sunnis accounted for 85%, while Shiites accounted for 15%. Saudi Arabia is rich in oil with proven crude oil reserves of 36.35 billion tons, accounting for 16% of the world's reserves. The reserves are second only to Venezuela and rank second in the world. Saudi Arabia is also the largest oil exporter in the world. The natural gas reserves are 8.2 trillion cubic meters, ranking sixth in the world. Petroleum and petrochemical industries are the lifeblood of Saudi Arabia's economy. Petroleum revenue accounts for 87% of national fiscal revenue and 42% of GDP. Because of this, Saudi Arabia is listed as one of the high-income economies with a very high human development index. It is the only Arab country in the G20.

Figure 5-1. The location of Saudi Arabia

However, because it is located in the desert and heavily relies on the petrochemical industry, Saudi Arabia is facing environmental problems such as water shortages, air pollution, climate change, and land desertification. In recent years, in order to get rid of its high dependence on the oil industry and promote a diversified development strategy, Saudi Arabia launched the *Saudi Vision 2030* and the *National Transformation Program 2020* in 2016 to make full use of the country's rich oil and natural gas resources, actively introduce foreign advanced technology and equipment, vigorously develop non-oil industries such as iron and steel, aluminum smelting, cement, seawater desalination, power industry, agriculture, and service industries. The single economic structure that relies on petroleum has been changed. At present, Saudi Arabia has become the world's largest producer of desalinated seawater, and its production of desalinated seawater accounts for about 20% of the world's total. At the same time, Saudi Arabia is also vigorously developing renewable energy and strives to realize the energy transition. For example, in the Saudi Vision 2030 released in 2016, Saudi Arabia proposed that the installed capacity of renewable energy will reach 9.5GW by 2023. In 2018, the National Renewable Energy Program issued by Saudi Arabia raised this target to 27.3GW (including 20GW photovoltaic and 7GW wind energy) and proposed to reach 58.7GW (including 40GW photovoltaic and 16GW wind energy) by 2030. Also, it will increase the proportion of natural gas and renewable energy in electricity production to 50%.

10.2 Project overview

Demand for energy-related goods and services in Saudi Arabia and throughout the region is high and continues to expand. In order to meet the local energy demand, realize the localization of the energy supply chain, and obtain benefits from it, Saudi Arabia has decided to establish an energy city. As the "Saudi Vision 2030" said, " As well as creating a new city dedicated to energy, we will double our gas production, and construct a national gas distribution network. We will also make use of our global leadership and expertise in oil and petrochemicals to invest in the development of adjacent and supporting sectors." Thus, King Salman Energy Park came into being.

King Salman Energy Park (SPARK) is strategically located between Dammam and Al-Ahsa in the Eastern Province of Saudi Arabia, a region known for its unmatched oil and gas resources. It will be operated and anchored by Saudi Aramco. It is expected that the project will be developed over three phases across a 50-square kilometer area and be completed by 2035. On December 10, 2018, HRH Crown Prince Mohammed bin Salman bin Abdulaziz today broke ground on the King Salman Energy Park. The first phase covers an area of 17 square kilometers, with more than 120 investments and a value of 1.6 billion U.S. dollars. It is expected to be completed by 2021, and 80% of it has now been completed now. The second and third phases occupies an area of 18 square kilometers and 15 square kilometers respectively.

Figure 5-2. The area of I, II, and III phases of King Salman Energy Park (blue, yellow, and green respectively)

SPARK is being developed to capture the full economic value from the increasing energy demand — localizing value creation through dedicated industrial development, as part of the Kingdom's Vision 2030. Its vision is

to be the preeminent integrated global energy and industrial hub founded on innovation, collaboration, and strong governance. Its mission is to place our tenants at the heart of the energy market, by providing a platform with world-class infrastructure and services that helps facilitate the growth of our customers'

businesses, and brings sustained value to our communities. In short, SPARK will become a 21st century ecosystem for the energy sector, a vibrant international industrial community built on excellence and innovation, and at its heart a world-class workforce. It is also expected to contribute more than $6 billion to the Kingdom's GDP and create up to 100,000 direct and indirect jobs at the maturity stage.

10.3 Green Development experience

10.3.1 Build the Entire Industry Chain and Realize Industry Localization

King Salman Energy Park will focus on the energy industry and attract industrial investors across five strategic sectors: Upstream, Downstream, Petrochemicals, Power, Water and Wastewater, focusing on drill pipes and tubular goods, electronics & control systems, drill fluids & chemicals, cooling systems, vessels & tanks, energy related building materials. Through the infrastructure in the SPARK, investors in these industrial chains will fill up the gaps in the local industry as well as gather together and form a complete industrial chain there to provide sufficient energy for the local area. Saudi Aramco is at the heart of SPARK's development, helping bring businesses together to drive efficiencies and promote technological development, manufacturing and exports, as well as build a world-class energy supply chain. H.E. Khalid A. Al-Falih, Minister of Energy, Industry and Mineral Resources and Saudi Aramco chairman, said: "The energy park's unique value proposition makes it an ideal destination for companies looking to invest in the thriving Saudi Arabian energy services market." Saudi Aramco President and CEO Amin H. Nasser said: "The King Salman Energy Park will start a new era of growth for one of the Kingdom's thriving sectors. It will serve as a central gateway to the region's economies, with Saudi Aramco continuing to be at the heart of the global oil and gas industry. We're looking forward to collaborating with our first anchor partners at SPARK, as we are investing in business opportunities for international investors and private-sector companies in the Kingdom. Together, we are building a world-class energy hub that will accelerate solutions across the value-chain for generations."

Figure 5-3. The locations of different industries in SPARK

10.3.2 Attract SMEs and Promote Economic Diversification

In addition to attracting manufacturing, petrochemical and energy industries, SPARK will also develop other relevant industries such as modern logistics, and cultivate small and medium-sized enterprises to stimulate innovation and entrepreneurship in the energy sector and make important contributions to a more diversified economic structure. The SPARK will include five major zones: industrial zone, dry port & logistics zone, residential & commercial zone and training centers. The industrial zone will be divided into five specialized zones: general manufacturing, electrical equipment, liquid chemicals, metal processing, and industrial services.

The Logistics Zone will include an inland dry port, a bonded area, and a logistics park with warehouses and other logistics services. At maturity, the dry port will have a capacity of 8 million metric tons of cargo annually with high levels of automation. Residential will include apartments, villas, compounds, high-quality educational facilities, hospitality units, a health complex, schools, and recreational facilities. The city will also offer staff accommodation facilities within the designated areas to support industrial requirements. It is estimated that at maturity the total residential offering will reach 15,000 units and 400 hotel rooms. The commercial area will be mainly occupied by Saudi Aramco's Drilling & Workover Headquarters and Procurement & Supply Chain Management Center. Commercial real estate will be available in the business district with offices, restaurants, and retailers. Finally, ten specialized training centers will be developed in the SPARK, to serve the expanding manpower needs of industrial tenants.

10.3.3 Industry-city-people Integration to Achieve Sustainable Development

SPARK not only includes industrial areas, but also logistics areas, residential areas, commercial areas, and training areas. It not only realizes the integration of industry, city, and people, but also embodies the concept of greening everywhere. For example, King Salman Energy Park (SPARK) has become the first industrial city in the world to receive Silver Level accreditation for Leadership in Energy and Environmental Design (LEED). SPARK President & CEO, Saif S. Al Qahtani, said: "SPARK is distinguishing itself as a leading global energy, industrial and technology hub, cementing Saudi Arabia's position as a progressive innovator in these fields on the international stage. The certification reaffirms our commitment to reducing the city's carbon footprint. LEED communities are in high global demand, as they offer better rates of profitability, productivity and quality of workplace. Our goal is to create an ecosystem for energy-related companies to grow with minimum environmental impact, and we encourage other industrial cities to follow our lead." On 30 June 2021, SPARK has signed a Memorandum of Understanding (MoU) with King Faisal University, the oldest university in Saudi Arabia, in Al Ahsa for collaboration on environmental preservation and renewable energy studies. The agreement will aid in the development of innovative solutions for renewable energy and their application to the Kingdom's distribution grids, sustainable landscaping, minimizing environmental impact and dedicated studies on sand movement and irrigation. In addition, China Railway Construction Corporation is also actively practicing environmental protection concepts in the construction of infrastructure and pipelines to contribute local green development. For example, the project department changed more than 5,000 concrete into the well to FRP into the well, greatly reducing the amount of concrete; the 1,900 streetlights in the project all use solar power; plastic light-transmitting roof panels are used in the material warehouse to contribute to local green projects.

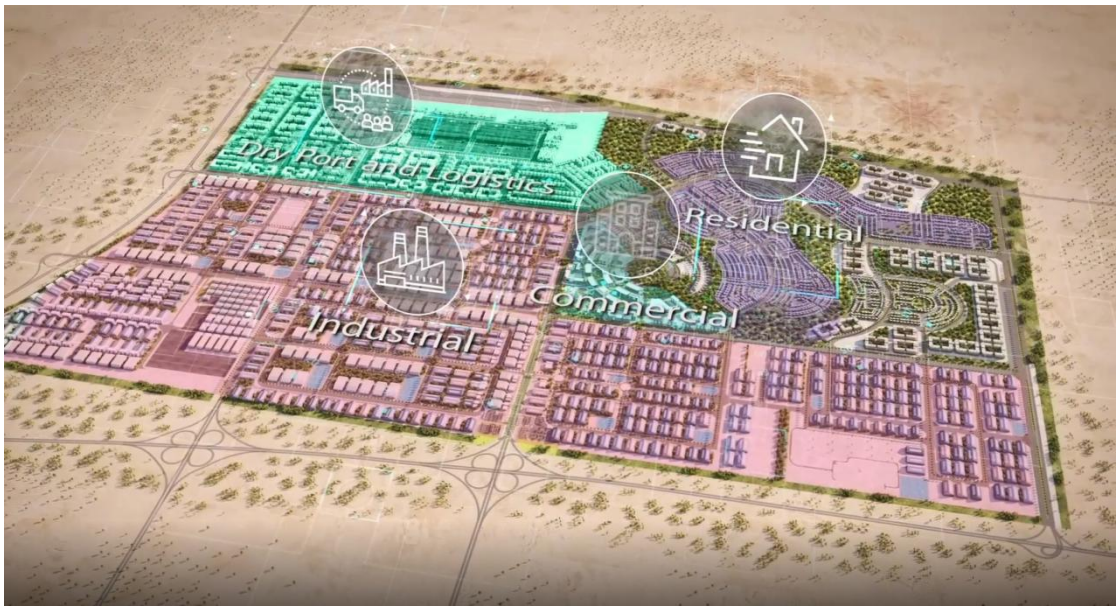

Figure 5-4. King Salman Energy City Division of Functional Zones

Figure 5-5. SPARK has signed a MoU with King Faisal University

10.4 Case Summary

SPARK is still an industrial park based on traditional fossil fuel energy. However, it brings together companies and related elements in the entire energy industry chain and connects different links through modern logistics and intelligent infrastructure to develop the traditional energy industry in a new way. Therefore, it achieves the goals of reducing costs, improving efficiency, reducing energy consumption and achieving green and sustainable development while ensuring energy supply and economic growth. This provides valuable experience for other developing countries along the “Belt and Road” that depend on resources and energy.

11 Dunhuang: Build a 100% Renewable Energy City

Dunhuang, a city of Gansu Province located in Northwest China, has rich solar and wind resources and sufficient desert and semi-desert land resources, and it is an ideal place to develop the renewable energy industry as it has good power grid output conditions. In 2009, the first large-scale photovoltaic power station was built here, and since then, the renewable energy market has been developing rapidly; in 2011, Dunhuang began the journey to build a new energy demonstration city, and in 2015, it was proposed to build a 100% renewable energy city. At the moment, relying on the on-going work on creating a new energy demonstration city, Dunhuang will build a comprehensive new energy base featuring a balanced energy mix.

11.1 Background

Dunhuang is located in the western part of Gansu Province, the extreme west of Hexi Corridor[3], and at the intersection of Gansu, Qinghai, and Xinjiang. It is a county-level city under the jurisdiction of Jiuquan City of Gansu Province, with a total area of 31,200 km^2 and a population of 200,000. The tertiary industry, led by the tourism industry, accounts for over 50% of the Dunhuang's economy. Dunhuang, a throat transit in the ancient Silk Road and an oasis in the Gobi Desert, is a key node city in China's BRI strategy.

Since Dunhuang is poor in fossil energy resources, it relies heavily on the external supply of coal, petroleum, natural gas, etc. However, it is rich in solar power and wind resources and has sufficient desert and semi-desert land resources, so it has good power grid output conditions and thus has great potential to develop and apply renewable energies on a large scale. Dunhuang, with its abundant solar energy resources, belongs to the Category I region in China with rich solar energy resources. Its annual sunshine hours can reach 3,257h (daily sunshine hours about 8.9h), and the total annual solar radiation is 1754 kWh/m^2. Dunhuang is windy in all four seasons, and at the height of 70m, the average wind speed can be as high as 6.9 m/s. The area of the Gobi Desert which is suitable for constructing photovoltaic and wind power stations is about 4000 km^2, with a potential installed PV capacity of 120 million kW.

Over the years, Dunhuang has been devoted to promoting the application of renewable energies, and is among the first group of new energy demonstration cities and is the first mega-kW photovoltaic power generation demonstration base, a national pilot zone for sustainable development and a demonstration zone for circular economy of Gansu Province. At present, new industries with clean energies and the resource recycling as an advantage have accounted for 1/3 of Dunhuang's total economic output.

11.2 Project Overview

In 2009, Dunhuang seized the opportunity to settle the first 20 MW PV grid-connected concession demonstration project in China, and launched the mega kW-level photovoltaic power generation base construction project. In May, 2010, the General Office of the State Council stated clearly in *On Supporting the Economic and Social Development of Gansu Province* that "we will construct a solar power generation

[3] Hexi Corridor refers to Jiuquan, Zhangye, Wuyi etc. of Gansu Province today. It has been part of the Silk Road since the Han and Tang Dynasties.

demonstration base with a capacity of over one million kilowatts with Dunhuang as the center". As of the end of 2015, the grid-connected installed photovoltaic power capacity reached 663,000 kW, and the registered installed capacity was 969,000 kW. In late 2018, the first 100 megawatt-level molten salt tower photothermal power station in China, the Shouhang High-Tech Energy 100-Megawatt Tower Photothermal Power Station, was put into use and connected to the grid, and realized its full capacity in June, 2019. The power station was designed to generate 390 million kWh annually, which can reduce CO_2 emissions by 350,000 tons/year and bring environmental benefits equivalent to that of 10,000 mu of forests.

Figure 5-6 Shouhang High-Tech Energy 100-Megawatt Tower Photothermal Power Station

While greatly promoting the construction of photovoltaic power stations, starting from 2011, Dunhuang has begun to build itself as a national new energy demonstration city. In June, 2011, the National Energy Administration approved the *Development Plan of Dunhuang as a New Energy City*, supporting Dunhuang to build a national new energy demonstration city. Therefore, Dunhuang becomes one the earliest approved national new energy demonstration cities. According to the *Plan*, Dunhuang would focus on multiple utilization of solar energy, and orderly promote the application of various new energies in urban power supply, heating, building energy conservation, etc. Besides, it also set the goal of renewable energy production exceeding the city's total energy consumption in 2015. In 2012, the National Energy Administration started to build new energy demonstration cities. Based on the guidance and requirements from the state, Dunhuang adjusted its goals concerning the development of renewable energies and the local consumption ability.

In January, 2015, Dunhuang was selected into the "Sino-Germany Renewable Energy Demonstration City Planning and Research Projects"[4] co-sponsored by the National Energy Administration of China and BMU, becoming one of the three demonstration cities. In December, 2016, the National Energy Administration issued the *Reply on Establishing High-proportion New Energy Cities in Dunhuang, Shigatse, and Yangzhong*

[4] Co-initiated and sponsored by BMU, aiming to find out which areas are willing to make long-term efforts to completely transform their energy supply to renewable energies and then help them to achieve the goal.

(NEA [2016] No.319), supporting Dunhuang to build a 100% renewable energy demonstration city. As a result, Dunhuang became one of the 3 Chinese cities selected to build 100% renewable energy demonstration cities.

In July, 2017, Chinese and German experts jointly completed the *Integrated Energy Planning Scheme of Dunhuang City*, proposing the application scenarios and an implementation plan to achieve 100% renewable energy in the power sector, the thermal industry and the transportation industry. In the research, 5 types of application scenarios were proposed, including the common scenario, the clean scenario, the energy efficiency scenario, the heat pump scenario, and the difficult scenario. In addition, Dunhuang's energy demand of end-users, energy supply and installed capacity of energy equipment in different scenarios in 2025 were estimated respectively. In the common scenario, the situation in 2025 will be a continuation of that in 2020, which means from 2020 to 2025, the expansion of wind power plants and photovoltaic power plants will be conducted on a steady pace; in the other 4 scenarios, the goal is to fully satisfy Dunhuang's energy demand with renewable energies in each hour of the year, and different development routes and measures are designed accordingly. The research shows that, with the rapid development of and progress made in renewable energy technologies and energy synergy, by 2025, from the perspective of energy utilization and energy technologies, it is feasible to achieve 100% local supply by renewable energies in each hour of the year.

Table 5-1. Energy Supply-Demand Scenarios of Dunhuang, 2025

Project	Common Scenario	Clean Scenario	Energy Efficiency Scenario	Heat Pump Scenario	Difficult Scenario
Proportion of renewable energies in the energy demand of end-users (%)	66~76	100	100	100	100
Total energy demand of end-users (0,000 tce)	81.6~122	113.1	81.6	81.6	122
Energy supply (0,000 tce)	207	814	535	255	873
Installed capacity of energy equipment (GW)	8.64	45.79	27.8	11.82	49.43

During the 14th Five-Year Plan period, Dunhuang has been continuously promoting the construction of new energy bases featuring a balanced energy mix, aiming to construct great channels, integrate into large grids, and promote the deployment of new energy resources of Dunhuang on a large scale. By June, 2021, Dunhuang has complied the *Report on the Planning of a Comprehensive New Energy Base Featuring a Balanced Energy Mix*, the *Planning of New Wind Power Stations* and the *Planning of Photo-thermal and Photovoltaic Synergy Demonstration Bases*. According to the planning, the installed capacity of the newly added wind power, photovoltaic, photo-thermal and electrochemical energy storage, etc. can reach 3-5 million kilowatts, and by 2030 when the comprehensive base is completed, the total installed capacity of

that base would be around 17 million kilowatts.

11.3 Green Development experience

11.3.1 The development philosophy of new energies continues to improve.

The idea to build Dunhuang into a 100% renewable energy city has gone through three stages, including infrastructure construction, initial concept formation, and proposing the target. At present, the city is steadily moving towards the target of building a 100% renewable energy city.

The first stage began in 2009 when the construction of million kW-level solar power stations started. The concept was to greatly promote the construction of large-scale photovoltaic power stations and wind power plants, and then connect all the electricity generated into the grids. The target was to ensure the capacity of the newly added photovoltaic and wind power stations exceeded 1 million kilowatts. At this stage, the focus was mainly on green power generation and grid-connection and transmission, and not much attention was paid to the end market.

The second stage began in 2011 when Dunhuang started to build the national new energy demonstration city. The concept was to drive the large-scale application of various renewable energy technologies in the city, and the target was to ensure that by 2020, the share of renewable energies in total energy consumption could exceed 28%. While energetically pushing forward the construction of photovoltaic power stations, Dunhuang also realized that though large-scale photovoltaic power stations could increase the share of green power from the perspective of energy production, in terms of energy consumption, connecting those stations to medium and high voltage grids would not contribute much to local energy consumption, as the latter still relied heavily on fossil energies. Therefore, at this stage, the focus was mainly on the local production and consumption of renewable energies (the end market), especially the development and utilization of distributed projects in urban built-up areas. The city started to think about the scale of local consumption of renewable energies, but the coordination of the renewable energy system with the conventional energy systems, energy conservation system and urban planning still needed to be strengthened.

The third stage began in 2015 when Dunhuang started to build itself into the 100% renewable energy city. The concept was to increase the proportion of renewable energies in the total energy consumption of Dunhuang (including electricity, heat and transportation fuels) by introducing relevant policies and measures on energy conservation and renewable energy development, and then achieve the target of building a 100% renewable energy city. At this stage, the city conducted an in-depth planning on the application of renewable energies in urban planning, construction, transportation, industries, etc. and researched relevant implementation plans, striving to achieve the target of 100% renewable energies in electricity generation, heat power supply and transportation fuels. The research result indicated that around 2030, the electricity generation, heat power supply and transportation fuels will 100% rely on renewable energies.

11.3.2 The organizational management and supporting measures are strengthened.

Dunhuang has strengthened the leadership of building the national new energy demonstration city, and established the “Leading Group of Building Dunhuang into a National New Energy City” with the executive vice mayor as the group leader, and heads of relevant authorities as members. The Group is responsible for the overall coordination of the construction of the new energy city, and it has established a new energy city

evaluation system, which will be assessed as an indicator in the responsibility system of comprehensive social management, so as to ensure the practical implementation of various tasks related to building the new energy city.

Measures taken include: establishing a strong supporting policy system, and incorporating the construction of the new energy city into Dunhuang's long-term development planning; setting up special funds for new energy city construction, to ensure the construction, operation and maintenance of key projects; strengthening the overall planning of special funds for the city's new energy projects, increasing investment in the application of new energy technologies in urban infrastructure, and optimizing the information-based fund structure; establishing and improving the enterprise-bank communication mechanism, fully utilizing the clean energy investment and financing platform of Dunhuang, improving the diversified investment and financing mechanism, and attracting more diversified social capitals to participate in this great undertaking.

Establishing a scientific and effective comprehensive performance evaluation system; building a hierarchical responsibility system for scheme implementation, and taking the work of party and government leaders on new energy construction as a key part in their performance evaluation; enhancing supervision and inspection to ensure the effect of benefiting the people; issuing documents including the Performance Evaluation Indicators and Management Measures of New Energy City Construction in Dunhuang, establishing a strict and scientific annual/monthly evaluation system, refining evaluation targets, and ensuring the steady progress of the new energy city's construction.

11.3.3 Adhering to the principle of "application-first" and "project-driven", and promoting new energy construction in all areas.

Dunhuang has been comprehensively promoting the application of new energies. For example, the promotion of solar water heaters. Large-scale solar water heating systems are installed on the roofs of hotels, restaurants, dormitories and residential areas in the city where conditions permit, so as to reduce the consumption of fossil fuels (mainly natural gas). With the reservoir of the water company as heat storage medium, the WSHP project is built to provide heating and cooling to office buildings, residential buildings, and commercial residences in the surrounding area. Photovoltaic agricultural greenhouses in rural areas are demonstrated and promoted, combining agricultural production with the new energy industry. Those contiguous greenhouses concentrated in the rural area of Dunhuang are transformed as a whole, and distributed photovoltaic agricultural greenhouse demonstration parks are built. In this way, the power generated can not only meet the power demand of electric devices such as the shutter doors and automatic controllers, but also can increase local farmers' income.

The city has been vigorously promoting the green transformation of urban facilities. Solar energy is applied in street lamps, billboards, traffic lights, etc., with an investment of around 8 million yuan. 3071 street lamps are installed in 8 towns/villages. Since 2017, the 50 buses in the urban area have all gradually been replaced by BEVs, making Dunhuang the only city in Gansu Province where all urban buses are NEVs. At present, about 340 NEVs of various types have entered people's daily lives.

Dunhuang also continues to construct microgrids. In scenic spots where there is no electricity, such as Yumen Pass, Hecang city, the Great Wall of Han Dynasty, Site of Xuanquan, etc., distributed photovoltaic power stations of a micro-grid are constructed, and solar field test stations and distributed power stations

on the roofs are deployed. Besides, township-level solar microgrid demonstration and comprehensive utilization of solar energy projects are carried out, and distributed rooftop-photovoltaic systems are introduced to rural households. The model featuring "centralized peak shaving, and household-based metering" is adopted to provide farmers with green power.

11.4 Case Summary

Dunhuang is a throat transit in the ancient Silk Road and a key node city in China's BRI strategy. Since Dunhuang is poor in fossil energy resources, it relies heavily on the external supply of coal, petroleum, natural gas, etc. However, it is rich in solar power and wind resources and has sufficient desert and semi-desert land resources, so it has good power grid output conditions and thus has great potential to develop and apply renewable energies on a large scale. For years, Dunhuang has been making full use of its resource advantage and favorable policies to develop new energy. In the process of developing renewable energy cities, Dunhuang established a strong policy support system and a scientific and effective evaluation and assessment mechanism, providing valuable experience for the construction of new energy cities.

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Chapter 6. Biodiversity and Nature-based Solutions

12 Rosario, Argentina: Building Urban Agriculture for Resilience and Green Space

Launched in February 2002, Rosario's Programa de Agricultura Urbana (PAU) has evolved into a cornerstone of the city's inclusive climate action plan. The project's original purpose was to alleviate urban food shortages through the strategic reuse of public land and peri-urban space, helping to improve food security and nutrition for low-income residents and providing them with employment opportunities. In the process of implementation, the project uses urban vacant land to create productive green space, increase the urban green belt and make the city more resilient to climate hazards, while also contributing to the improvement of the ecosystem.

12.1 Background

Rosario, located on the west bank of the Paraná River in Santa Fe Province, central Argentina, is the third largest city in Argentina, with a population of about 1.75 million (2020). As the industrial center, transportation hub and port complex of Argentina, Rosario's economy is based on services and industry, with agro-industry, petro-processing, chemical and mechanical industries as its four main pillars.

Figure 6-1. Rosario city map

The launch of the Urban Agriculture Project (PAU) was linked to the economic crisis that hit Argentina in 2001. Argentina's economic collapse in 2001 left a quarter of the labor force in Rosario unemployed and

more than half of the population fell below the poverty line. To help the unemployed, the municipality launched this Urban Agriculture Project. The project has two main partners, the Center for the Study of Agroecological Production (CEPAR), a Rosario-based NGO, and the national Pro Huerta programme. The former has been promoting vegetable cultivation in poor areas of Rosario since 1987, while the latter is a national project established to promote the production of small-scale, self-sufficient fresh food in low-income areas of Argentina.

12.2 Project overview

While the immediate goal of the Rosario Urban Agriculture Project is to meet the the emergency needs of unemployed slum-dwellers, its project vision is more permanent, aiming to make urban agriculture a permanent urban activity and to mitigate risks posed by climate disasters. Rising temperatures and flooding have exacerbated the legacy damage of the 2001 economic crisis in Argentina, exacerbating urban inequalities. In 2002, the Urban Agriculture Project was launched to develop an inclusive climate adaptation program by reusing underutilized public land to mitigate flooding and expand the urban green belt. In 2011, the Rosario City Council adopted a land use ordinance for the Green Belt Project, which was included in the strategic plan launched in 2015. After nearly 20 years of development, the project has provided healthy and nearby produce for residents, provided livelihoods for low-income families, improved urban land use and reduced carbon emissions, while increasing the city's resilience to flooding and extreme heat. The Rosario Urban Agriculture Project has also had a demonstration effect, providing a model for citywide remediation of vacant land, with influence extending to the city's surrounding areas.

12.3 Green Development Experience

12.3.1 Increasing the Income and Livelihood of Vulnerable Groups

The main mission of implementing the Rosario Urban Agriculture Project is to increase the income of vulnerable groups, such as small producers, and to strengthen food production and commercialization, while developing the productivity of the small producers. The basic means of strengthening food production is the organization of training courses to train unemployed people in technical and practical knowledge. The Rosario Urban Agriculture Project, in collaboration with the Pro-Huerta Program, has created an urban network of producer groups and a training area called "eco-huertas". Residents can learn at home the basics of organic food production, safety, hygiene and product quality control, and receive training in market analysis, business management and project development. Also relevant technicians and extension workers provide technical assistance to producers as well as quality seeds and compost. Residents are trained to set up small-scale industries for short-term production programs and continuous production programs throughout the year. In addition to the training, the Rosario Urban Agriculture Project is commercialized through the establishment of a farmers' market, a Rosario community home delivery program, and mass media campaigns.

At the same time, the city has developed a system of "social certification" to replace the certification of private agencies. The system involves the participation of the municipality, the Gardeners' Network, Pro-Huerta and a network of 450 consumers called Vida Verde, with the aim of guaranteeing the safety and quality of products and promoting fair trade in local organic food.

Figure 6-2. Residents buy locally produced produce at a community fair. Source: prizeforcities.org

12.3.2 Utilizing Vacant Land for Urban Agricultural Production

The efficient use of urban land resources is another important tool of the Rosario Urban Agriculture Project. The city government conducted a joint study with the UN-Habitat's Urban Management Program and the National University of Rosario to inventory the underutilized urban land. The survey revealed that 36% of urban land is suitable for agricultural conversion including land along railroads and highways, low-lying and flood-prone peri-urban land, and segregated green belts that have not materialized due to lack of funding.

To guarantee security of tenure to gardeners, in September 2004 the mayor approved a municipal ordinance formally granting residents temporary access to vacant urban land for urban agriculture. The Secretariat of Municipal Planning then worked with international partners to draft proposals to integrate urban agriculture into the Rosario Urban Development Plan, including the inclusion of urban agriculture in the Urban Development Plan and the Social Housing Plan, the exemption of landowners from property taxes, and the creation of Municipal Land Bank. To achieve its long-term strategic goals, the Rosario City Council has also created space for a number of permanent and pop-up markets to operate throughout the city, where urban farmers can sell locally grown produce and homemade goods such as pickled vegetables, sauces, syrups, organic cosmetics, and preserved fruit and jams.

In 2014, more than 30 hectares were used to grow vegetables, fruits, and medicinal and aromatic plants. The planting area includes a green corridor along the railway line through the northern part of the city. These fruit and vegetable gardens have an average size of 2 hectares and are divided into plots of 500 to 1,000 square meters each, with each plot being the responsibility of a gardener or a family unit. Each productive fruit and vegetable garden provides employment for about 20 people. Flowers, vegetables, herbs and medicinal plants are grown on small plots of land called vegetable gardens and gardens.

Figure 6-3. Local residents carry out urban agricultural production on unused land. Source: prizeforcities.org

12.3.3 Increasing Urban Climate Resilience

While urban agriculture projects have helped address poverty and food insecurity, extreme flooding events have created a new crisis for Rosario. In 2007, record rainfall forced the city to evacuate more than 3,000 residents. To address the flooding problem, which has worsened with climate change, the water management department created a flood risk map to identify flooding problem areas. The flood risk information also serves the Rosario Urban Plan (2007-2017). By incorporating urban agriculture into the city's strategic plan, the Municipality of Rosario has embedded urban resilience in the future development of the city. The creation of fruit and vegetable gardens strengthens the city's flood resilience while providing additional land for urban agriculture; converting underutilized land into green space while absorbing excess water and preventing flooding.

The resilience of cities depends not only on the land conversion of their internal communities, but also on the preservation of the surrounding environment in their rapidly urbanizing areas. Urban agriculture projects have gradually expanded into the suburban areas of Rosario. To facilitate this expansion, in 2011 the Rosario City Council adopted a land use regulation, the Green Belt Project, designating 800 hectares of land on the outskirts of the city for permanent for eco-agricultural fruit and vegetable production. Formally incorporated into the city's strategic plan and launched in 2015, the Green Belt Project helps curb urban sprawl while restoring land in an ecologically sensitive manner. It has also improved Rosario's resilience to flooding and expanded the total amount of land available for food production.

12.3.4 Participation of Government, Enterprises and Civil Organizations

PAU focuses on broad participation of government, business, and civil society organizations. The financial and human support for the project is made up of multiple parties. The municipal government is the main source of financial resources. The Social Promotion Secretariat of the Municipality of Rosario provides the logistic support, technical assistance and training, input supply and infrastructure for the project. In addition, the project used the prize money from the Dubai Award for Best Practice from

UN-Habitat to purchase gardening equipment for the collective use of the residents. Pro Huerta Programme provides seeds for food crops to the residents. In addition to this, NGOs, educational institutions and local consumer networks also provide professional technical support to the project.

In terms of increasing participation, the Municipality of Rosario has expanded urban agriculture into public spaces, schools, markets and various social programs, especially for youth and the elderly, building an urban culture around food production. Fruit and vegetable gardens in low-income neighborhoods have become key areas for other social programs, including education and youth development programs. For example, city staff have trained more than 2,400 families and 40 schools in ecological agricultural production so that they can start their own fruit and vegetable gardens.

12.3.5 Increasing Environmental and Social Benefits

Over the past 20 years, Rosario's Urban Agriculture Program has grown from a pilot to a citywide program and has become a model for municipalities to integrate and promote urban agriculture. From mere food production, Rosario's urban agriculture program has evolved into a job creation opportunity and then into a strategy to combat climate change that has been fully integrated into the city's various plans, including the 2007 Rosario City Plan, the 2008 and 2018 Ten-Year Strategic Plans, and the 2015 Environmental Plan. The Municipality of Rosario has incorporated urban agriculture into state-funded neighborhood construction and improvement projects, and constitutes a household income generator.

First, urban agriculture projects provide a source of livelihood for local residents, improve their production skills, and play an important role in food security, job security, and empowerment of vulnerable groups. More than 10,000 families have participated in the Rosario Urban Agriculture Project, producing more than 2,500 tons of fruit and food crops annually and ensuring food supply for about 40,000 residents of Rosario. To date, 791 fruit and vegetable gardens, 7 farmers' markets and 342 registered businesses have been established in Rosario and nearly 2,000 citizens have been employed in the project. A total of 800 women play a special role in the Rosario Urban Agriculture Project, and they bring dynamism to the project.

Second, Urban Agriculture Projects generate important ecological and climate benefits. If the city were to source other food products from more than 400 kilometers away, it would create a supply chain that would generate significant greenhouse gas emissions. Rosario now produces nearly 2,500 tons of fruits and vegetables locally each year through ecological farming methods. According to a study by the National University of Rosario and RUAF Urban Agriculture and Food Systems, localized vegetable production generates 95% less greenhouse gas emissions than imports of agricultural products from Rosario. Also, the conversion of unused land into agricultural land and its integration with the Green Belt projects can effectively mitigate the effects of adverse climate hazards such as floods and high temperatures, generating climate adaptation values.

Third, the project enhances livability for the city through the effective use of unused urban land. The project creates five large landscaped green spaces (garden parks) with a total area of 72 hectares to support agriculture and activities such as culture, sports and education. Residents participate with the architects and landscape architects in the design of the garden parks. The project has also improved the living environment of settlements by relocating residents from marginal urban neighborhoods exposed to climate hazards, not only increasing their ability to cope with climate hazards but also improving the urban environment and quality of life.

12.4 Case Summary

The Rosario Urban Agriculture Project (PAU) is not only an environmental infrastructure initiative, but also a socio-economic one. It improves food security and nutrition for low-income residents through the strategic reuse of unused urban land; reduces carbon emissions from food production and transportation by shortening the food supply chain; and restores and enhances urban ecosystems by strengthening urban green space systems and increasing the resilience of cities to extreme weather events.

13 Kunming City Takes Multiple Measures to Protect Biodiversity

Kunming City prioritizes ecological conservation and conducts biodiversity protection from three aspects. First, promote ecological and environmental protection in a top-down manner by establishing a leading group for biodiversity protection to coordinate the work of biodiversity protection in Kunming. Second, take multiple measures to establish and improve the ecological protection and compensation mechanism, reform the damage compensation system for the ecological environment, and put in place overall incentives for biodiversity protection. Third, strengthen the protection of various habitats, build Dianchi Lake Wetland and urban green space systems, and improve the entry-exit inspection system for biological species. Kunming has yielded remarkable results in biodiversity conservation, while the rich biodiversity resources have in turn laid a solid foundation for the green and high-quality development of the city.

13.1 Background

Kunming, the capital city of Yunnan Province, is located in the central part of the Province. It is also the political, economic, financial, cultural, scientific, technological and educational center of Yunnan. Besides, it is the transportation and communication hub of Yunnan and one of the central cities in Southwest China. As its altitude ranges from 800 to 1,800 meters above sea level, Kunming is endowed with abundant animal and plant resources due to rich environmental diversity and varied weather resulting from huge differences in elevation.

The overall biodiversity status in Kunming can be summarized into three features: rich species, various types of ecosystems and extremely rich biodiversity in certain areas. In terms of plant resources, Kunming has 9 types of vegetation, with 20 subtypes, 56 formations and 118 clusters, accounting for 75% of the total vegetation types, 59% of subtypes, 33% of formations and 56% of clusters in Yunnan Province. In terms of animal resources, there are at least 500 kinds of vertebrates in Kunming, including around 50 kinds of fish, 22 kinds of amphibians, 26 kinds of reptiles, 300 kinds of birds and 100 kinds of mammals. Among which, about 61 kinds of animals are under state protection. In addition, Kunming is home to many species with ornamental or economic value. It is also rich in wild animal resources.

Biodiversity is essential to human survival. It is also the basis for regional ecology, food security and sustainable economic and social development. During the 13th Five-Year Plan period, Kunming puts ecology first and has carried out a variety of effective measures aimed at biodiversity protection, sustainable utilization of resources and benefit sharing so as to develop a green economy and enhance the capacity in biodiversity protection.

13.2 Project Overview

Biodiversity is an ecological complex formed by organisms and their environment with various ecological processes related to each other. It is the basis for human survival and development. Therefore, it is of great significance to protect, cultivate and enrich urban biodiversity. In recent years, Kunming has taken many measures to promote the protection of biodiversity with phased results.

First, the quality of the ecological environment has been continuously improved. The water quality of Dianchi Lake has been improved from Class V (which indicates poor quality) to class IV in 2015, and that of Yangzonghai Lake has been improved from class IV to class III in 2015. In 2020, the water quality compliance

rate of surface water section in the national (provincial) examination for Kunming reached 100% for the first time. The water quality of all the 17 centralized drinking water sources in Kunming at both city and county levels that receive direct assessment from Yunnan Province has reached or surpassed Class III. Kunming was also selected as a national demonstration city for the treatment of black and odorous water bodies. It took the lead in establishing a ecological compensation mechanism for rivers in the whole province. Besides, the city has scaled up its efforts in urban and rural greening, with a total of 3.176 million *mu* (or 2117.3 square kilometers) of land being afforested, and 1,691 square kilometers of soil erosion land being treated. Now it has a forest coverage rate of more than 52% and enjoys good air quality on more than 98% of days, ranking among the top five in the provincial capitals in China.

Second, Kunming has formed a preliminary nature reserve system with wide layout, complete types and excellent management. In recent years, Kunming has continuously strengthened the construction of nature reserves. At present, the city has built protection areas at all levels and of all types, including nature reserves, small reserves, forest parks, wetland parks, geological parks and scenic spots. There are altogether 6 nature reserves at all levels in Kunming and planning has been compiled for these reserves. The establishment of these reserve has helped the city enrich species and preserve plant community types in Kunming.

Third, animal and plant resources are enriched. At present, there are more than 20 forest types in Kunming, of which Yunnan pine has the widest distribution and largest volume, accounting for 57.0% and 53.3% respectively. There are 195 families, 1,099 genera and 3,229 species of seed plants in the city, accounting for 73% of the 266 families of seed plants in Yunnan Province and 67% of the 291 families in China. Kunming is also home to 11 species of protected wild plants such as Himalayan yew and Cycas panzhihuaensis, one special local species named Poncirus polyandra, about 460 species of terrestrial wild animals, and more than 30 species of terrestrial wild animals under state protection, including black-necked crane, forest musk deer, eastern imperial eagle, black stork, Lady Amherst's Pheasant and common kestrel.

13.3 Green Development experience

13.3.1 Long-term Management Mechanism to Strengthen Organization, Leadership and Coordination

Kunming Municipal Government has established several leading groups for biodiversity protection to coordinate related work in the city. It also hired experts to provide decision-making consultations.

First, the city has established a Kunming Biodiversity Protection Leading Group and released the *Implementation Plan of Kunming City for the Biodiversity Conservation Strategy and Action Plan During the 13th FYP Period*. Secondly, professionals in areas such as plants, animals, ecology and forestry in Kunming have been hired to form an expert committee on biodiversity protection. Besides, other organizations such as Kunming Wildlife Protection Expert Committee, Kunming Nature Reserve Expert Committee and Kunming Wetland Protection Expert Committee have also put forward policy suggestions on biodiversity protection, and provide decisional counseling for biodiversity conservation and management in the city. The Leading Group for the Ecological Construction Pioneers headed by the main leaders of the Municipal Party Committee and the Municipal Government was set up, along with leading groups for the rectification for problems identified in central environmental inspections, for the River (Lake) Chief System, and for the prevention and treatment of environmental pollution, to facilitate ecological conservation and environmental protection in Kunming City. In addition, Kunming Biodiversity Protection Expert Committee

was established and staffed with professionals on plants, animals, ecology and forestry in Kunming to provide decisional counseling for biodiversity conservation and management in the city.

13.3.2 Combining Situ Conservation with Ex-Situ Conservation

The most effective way to protect biodiversity is on-site conservation (or situ conservation), and building nature reserves is the main approach for that goal. Kunming has made much efforts to promote the construction of nature reserves. For example, the construction of Dianchi Lake Wetland has yielded remarkable results as the ecosystem there has been preliminarily restored with continuous improvement in the ecology. Birds and fish that once disappeared in Dianchi Lake for many years have now come back again. Its biodiversity has been enriched. The vegetation coverage of Dianchi Lake Wetland has grown from 13.1% in 2007 to about 81% now, and the number of plant species has increased from 232 to 303.[5] In addition, necessary measures such as ex-situ conservation shall be taken for some key protected species without bringing adverse impact on biological species, populations or natural habitats. Continuous efforts have been made on the breeding and multiplication of indigenous fish and species with extremely small population in Dianchi Lake with the support from Kunming Institute of Zoology and Kunming Institute of Botany under the Chinese Academy of Sciences (CAS). For example, 6,390 plants of Poncirus polyandra, an endangered species that had been extinct in the wild on earth, survived in Poncirus polyandra base through artificial breeding, thus the species returned to the wild in its original habitat with possibilities of realizing self-reproduction and getting rid of its endangered status.

13.3.3 Building Urban Green Space Systems

In the process of urbanization, it is important to include green space and landscape in the city's overall planning to satisfy animals' needs of survival, which is also critical for the long-term development of the city's animal diversity. At present, all counties and cities in Kunming have compiled and implemented their urban green space system planning. During the 13th Five Year Plan period, the Greening Department of Kunming enhanced the construction of urban landscapes. It aims to build green landscape every 300 meters and gardens every 500 meters in an effort to create a beautiful living environment and build a "garden city" where people can enjoy the harmony between man and nature and where biodiversity is preserved and development is secured.

13.3.4 Reforming the Compensation System for Ecological and Environmental Damage

Since the "national trial" of the Compensation System for Ecological and Environmental Damage started in 2018, Yunnan Province has taken forceful measures to accelerate and deepen ecological reform. Against this context, much progress has been made in the pilot reform on the compensation system for ecological and environmental damage. Yunnan Province has established a leading group on the above reform headed by the vice governor in charge. It has also formulated and issued the Implementation Plan for the Reform of the Compensation System for Ecological and Environmental Damage, refined its scope of application for ecological environment damage and compensation cases throughout the province, and clarified the division of responsibilities of relevant departments. Kunming City has also released documents such as the Work Plan for Further Reform of the Compensation System for Ecological and Environmental Damage in 2020 and

[5] https://baijiahao.baidu.com/s?id=1692544277546265966&wfr=spider&for=pc

Measures for the Management of Compensation Funds in Kunming (for Trial Implementation). By the end of March 2021, Kunming had started to handle two cases of eco-environmental damage compensation.

13.3.5 Establishing and Improving the Ecological Protection and Compensation Mechanism

Kunming innovated and promoted the ecological compensation mechanism for Dianchi Lake Basin, improved the ecological protection and compensation mechanism for forests, and made explorations on the ecological compensation mechanism for drinking water sources. Taking the ecological compensation mechanism for Dianchi Lake Basin as an example, in 2017, Kunming issued the Measures on the Ecological Compensation for Dianchi Lake Basin (for Trial Implementation) and started to facilitate ecological compensation in Dianchi Lake Basin. The work is carried out in line with the principle of "those who pollute the environment should be responsible for pollution treatment and any loss incurred." Kunming City strengthened water environment conservation and treatment of Dianchi Lake Basin, and actively explored the establishment of a fair, just and effective ecological compensation mechanism for rivers. It allows counties (districts) that produce water pollution with unsatisfactory results in pollution treatment to offer economic compensation to neighboring counties (districts), while encouraging areas that benefited from the reform, along with ecological protection areas as well as the upstream and downstream of the river, to launch pilot projects on trans-regional ecological protection and compensation. Through ecological compensation, the government can provide financial support for the protection and treatment of water resources, emphasize territorial responsibility, and mobilize enthusiasm for pollution control in the region so as to ensure continuous improvement of water environment.

13.3.6 Highlighting the Prevention and Control of Invasive Species

Yunnan Province has a special geographical location. As an important gateway for alien species invasion, Yunnan suffers from frequent occurrence of alien forestry pests. Kunming City attaches great importance to the prevention and control of alien species invasion with measures taken from three aspects. First, scientific research institutes such as Kunming Institute of Zoology and Kunming Institute of Botany under the Chinese Academy of Sciences (CAS) worked with relevant departments at municipal level to conduct research on invasive species monitoring, prevention and control, and guided all localities to scale up their efforts in the prevention and control of invasive species. Second, the government prioritized the prevention and control of alien invasive pests such as pine wilt disease, yellow-spined bamboo locust, fall armyworm and red imported fire ant with strict control at the source and quick responses to any outbreak so as to effectively prevent the invasion and spread of alien pests. Third, Kunming Customs strengthened the inspection and quarantine at the port to prevent any invasion of pests.

13.3.7 Strengthening Law Enforcement and Supervision on Biodiversity Preservation

On the basis of relevant laws and regulations of the state and of Yunnan Province, Kunming has formulated a series of local regulations, measures and rules based on the actual situation. For example, Regulations of Kunming City on the Protection and Management of Jiaozi Snow Mountain, Measures of Kunming City on the Management of Funds for the Compensation for Ecological Benefits of Non-Commercial Forests, and etc. Secondly, the city established a coordination mechanism for departments responsible for public security, customs, ecological environment, forestry, grassland, agriculture and rural areas, and strengthened the crackdown on illegal activities that damage biodiversity as well as the law enforcement and inspection of the

entry and exit of species. In addition, Kunming has implemented the remote sensing and monitoring system for nature reserves and natural areas under state or provincial protection with rectifications on any problems identified in inspections and enhanced related policies and regulations so that biodiversity protection can be brought under the legal framework.

13.4 Case Summary

Kunming, a city endowed with rich natural resources, has also adopted a series of biodiversity conservation measures. Through establishing long-term management mechanism, reforming the compensation system for ecological and environmental damage, building urban green space system, establishing and improving the ecological protection and compensation mechanism, highlighting the prevention and control of invasive species, and strengthening law enforcement and supervision on biodiversity preservation, Kunming has always been regarding eco-environmental protection and biodiversity conservation as a priority task with significant progress having been made.

14 Lisbon Green Corridor Strategy

14.1 Background

In Lisbon the municipality has developed a comprehensive strategy for sustainable land use promotion via the establishment of coherent and interlinked urban green infrastructure (UGI) not only within the municipality but also aligned with the UGIs of surrounding municipalities.

In response to continued urban development, the challenges brought by the urban heat island effect, flooding, and air pollution, in combination with the need to enhance the city's climate change resilience and mitigation actions, a citywide Biodiversity Action Plan has now been implemented under the auspices of the city's Master Development Plan. In combination, these actions have resulted in the implementation of green infrastructure and nature-based solutions, including a Green Corridors Strategy to create continuous natural structures, enhance access to green space, and bring coordinated ecological systems into the city's interior against an historic backdrop of car centric urban development.

14.2 Project Overview

Between 2009 and 2017, about 190 ha of new green areas were created in Lisbon, spread over a total of 9 main green corridors, with clear environmental indicators. As a result, the city has seen a 16% increase in new and renewed green space. According to Lisbon's Climate Action Plan, by 2030, 9 green corridors will be completed, representing more than 25 major new park interventions, 10 new bicycle and pedestrian bridges (5 already completed), and a total of 220 km of cycle paths, connecting the entire city with a main green structure. Urban planning and re-zoning of ecologically sensitive areas to curtail excessive construction first laid the groundwork for the Green Corridor strategy, which was also designed to preserve and increase permeable areas and rehabilitate underground waterways. As well as focusing on green corridors, the city has also developed an urban agriculture strategy, integrating this with green areas and corridors. Furthermore, several urban parks have been created, with associated amenities to improve citizen wellbeing (lawn areas, playground, kiosk, fitness equipment, bike lanes).

These actions are now integrated into the city's ecological structure, as defined in Lisbon's Master Development Plan. The plan sets out guidelines and objectives for specific planning and local development. In particular, the municipal ecological structure takes into account ecological principles and the importance of preserving natural, forest, agricultural and cultural heritage. Together with the Biodiversity 2020 Strategy, the city also approved a Biodiversity Action Plan in 2016, putting implementation actions in the context of green infrastructure and climate change adaptation and mitigation.

14.3 Green Development experience

14.3.1 Project Highlights – Monsanto Green Corridor

Connecting green spaces by creating **green corridors** have been one of the main priorities under the plans outlined above. One of the most visible examples of this is the main green corridor connecting Monsanto Forest Park to the city centre through Eduardo VII Park, created in 2012.

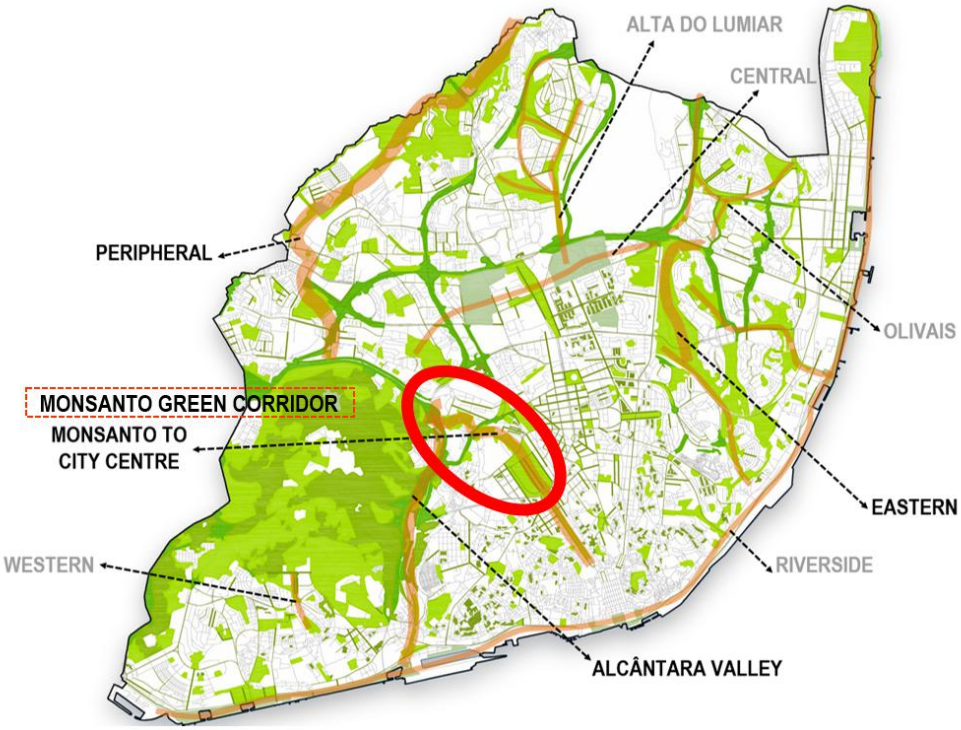

Figure 6-6 Monsanto Green Corridor among the other Lisbon´s green corridors and green infrastructure

Monsanto Forest Park is the largest green area in Lisbon, covering 1123 ha (approx. 10 km^2). The 2.3 km Monsanto Green Corridor now connects this park with the city centre and is considered one of the city's largest green infrastructures. In specific areas, extensive and biodiverse meadows were created instead of lawns. These offer a greater diversity of species, making the green area more ecologically balanced, as requiring less water and fewer nitrogen fertilizers in maintenance.

Creating these green areas and green connections has a cooling effect that counteracts the 'urban heat island' effect typical of southern European cities. Studies showed that even small green areas, such as trees along the streets, contribute to significantly mitigating the 'heat island' effect.

Figure 6-5 Schematic diagram of the area covered by Monsanto Green Corridor

14.3.1.1 Project objectives

The Monsanto Green Corridor was initiated with a range of objectives, including:

- To improve quality of life in the city by solving urban challenges such as the urban heat island effect, floods, air pollution and unequal distribution of green spaces
- To enhance city attractiveness by offering recreation and a healthy lifestyle space
- Regulating air quality
- Creating and improving ecosystems and connections

14.3.1.2 Implementation activities

The Monsanto Green Corridor is made up of a variety of units, including Avenida da Liberdade; Eduardo VII Park; Jardim Amália Rodrigues (Alto do Parque); Ciclopedonal Bridge over Marquês da Fronteira Street (inaugurated in 2012); a zone of meadow next to the Palace of Justice with about 1ha of biodiverse meadow; a skateboard park; two fitness areas; a range of viewpoints; Ciclopedonal Bridge "Gonçalo Ribeiro Telles"; Gardens of Amnesty International; Horticultural Park Jardins de Campolide; Infantile and Juvenile Playground, and the José Pinto Quinta Urban Park. All of these are now connected via a pedestrian and cycling connection:

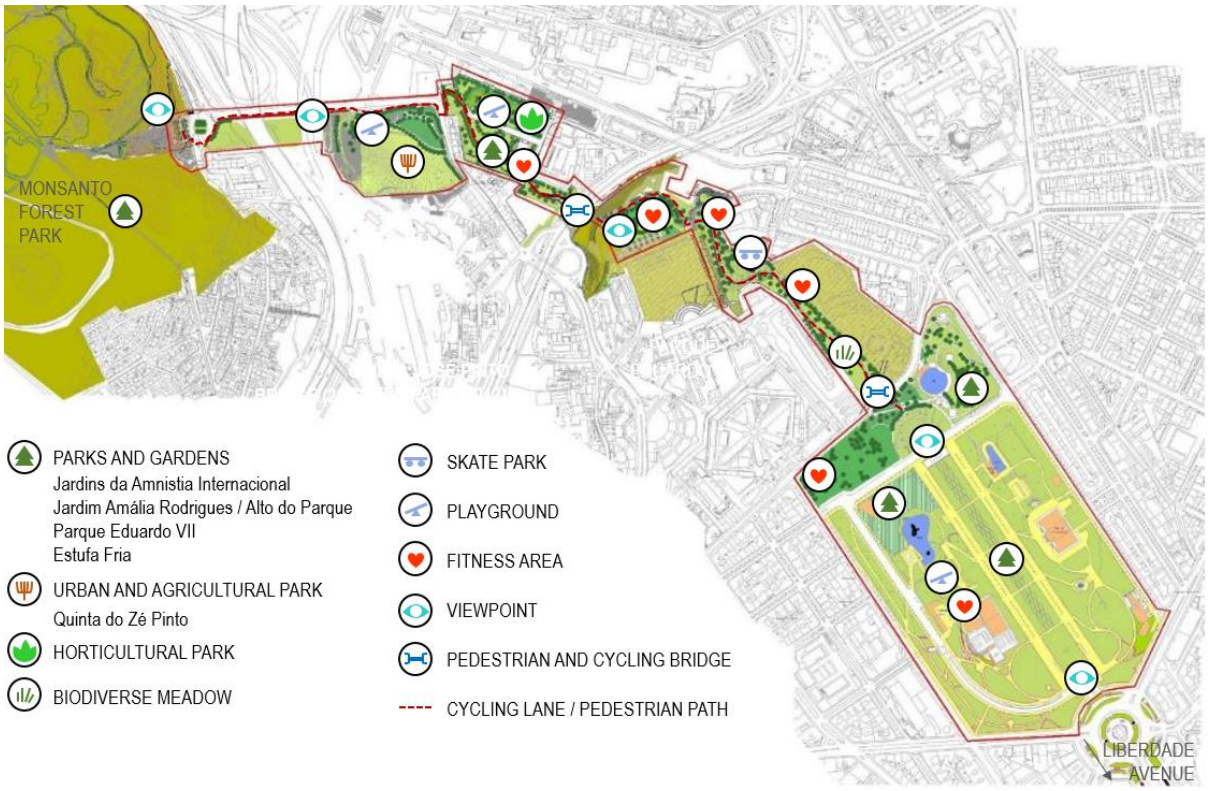

Figure 6-6 Monsanto green Corridor schematic

14.3.1.3 Financing

This project involved a core intervention area of 10,7 hectares, with a total budget of 3.3 million euros, from different financing sources: municipal budget, Lisboa Casino obligations and private partnerships.

14.3.1.4 Monitoring & Evaluation

The ecological connection of the city has been measured under the monitoring of the Biodiversity Action Plan, through connectivity indicators (tree canopy and permeable soil). Regarding the specific evaluation of the Monsanto Green corridor, the achieved results to highlight are the following:

- It was created a pedestrian and cycling access from the city centre to the forest park, with activation of a service area, a justice campus and a university campus;
- A rainfed biodiverse meadow was planted for the first time in Lisbon, acting as a pilot test, and it was later replicated as a good practice in another areas;
- The trees were planted with citizen volunteers, enabling social involvement, and native species were chosen;
- The urban agriculture was raised and gained visibility, with urban gardens and planting of fruit trees.

14.3.2 Expected Impacts (environment, economic, social etc.)

Lisbon's Green Corridors strategy, has been designed to address two primary Sustainable Development Goals (SDG's):

- Green space, habitats and biodiversity (SDG 15)

- Health and well-being (SDG 3)

The impacts on green infrastructure of the Monsanto Forest Park are to provide the city with 1123 ha of green area, and its cultural uses such as the possibility to enjoy a network of mixed pedestrian and bicycle paths, today with up to 220 km. This helps reduce traffic, giving pedestrians and cyclists more space. Greening these infrastructures makes better ecological connections possible and contributes to air pollution control. Street trees make the city more attractive, better connect green spaces and provide shade for cyclists. As part of its Green Plan (2008), Lisbon also set up a working group to promote and enhance **urban agriculture**, emphasised in the Biodiversity 2020 Strategy.

While these measures have been planned separately at different times, taken together, they can be seen to have clearly enabled synergies in tackling a series of social challenges by providing key ecosystem services.

Overall assessment:

- Recognition by the citizens of the green importance in the city
- Added-value for the city and co-benefits: ecology, health, new uses, real-state valorization
- Higher rates of implementation (cheaper, then resulting in more area achieved) but slow consolidation (losses)
- Innovative, sustainable and replicable strategy; more ecosystem services provided
- Dynamic and evolutionary landscape, open to be adjustable

+ Positive outputs:

- Fast and recognizable implementation, nature & biodiversity improvement, natural base solutions (NBS) adoption, city resilience increase
- Open, democratic and socially relevant (recreation, mobility, etc) strategy, tackling social isolation
- Useful to public health (sport, relaxation, active recreation)
- Establishment of an integrated and consolidated network of bicycle lanes and urban allotment gardens

+ Negative outputs:

- Rainfed and climate adapted green areas (e.g. biodiverse meadows) frequently not accepted as “1st green class”
- Consolidation of the green structure more difficult >>> Threat of reversibility if citizens don´t realize the importance of a NBS landscape
- Not applicable to intensive use or small urban spaces

Figure 6-7 Actual view of Monsanto Green Corridor

14.4 Case Summary

Lisbon has implemented a citywide Biodiversity Action Plan, which has resulted in the implementation of green infrastructure and nature-based solutions, including a Green Corridors Strategy to create continuous natural structure, enhance access to green space, and bring coordinated ecological systems into the city's interior.

15 Comprehensive Renovation Project of Wuqing Dike River Beach[6]

15.1 Background

Located in central China on the east of the Jianghan Plain, Wuhan is divided into three towns by the Yangtze River, forming the geographic pattern of Wuchang, Hankou and Hanyang. As one of China's central transport hubs (land, river and air), Wuhan is also the geographic center in China, connecting east to west and south to north. In this sense Wuhan has always been called the "thoroughfare of provinces". As such, Wuhan sits at the strategic intersection of the Yangtze River Economic Belt and the Belt and Road Initiative, incorporating national transportation channels for railway, waterway, highway and aviation. In terms of overland traffic, the Beijing-Guangzhou high-speed railway and Wuhan-Shanghai high-speed railways meet in this city, as well as 14 national highways connecting the Wuhan urban economic zone with Beijing-Tianjin-Hebei, the Yangtze River Delta, the Pearl River Delta and the Chengdu-Chongqing economic zone. Today, the Wuhan-Xinjiang-Europe international freight train departs from Wuhan acting as a trade bridge from Hubei Province to the west, placing Wuhan as a global freight operation center. In terms of water transport, Wuhan is the hub port of the "golden waterway": the Yangtze River. Wuhan New Port has become the first 100 million ton port in the middle reaches of the Yangtze River and is now the destination port and transit port for domestic and foreign trade containers in Sichuan, Chongqing, Shaanxi, Henan and Hunan provinces, as well as acting as the largest container port in the upper middle reaches of the Yangtze River. The city's port has developed into a first-class inland container facility and is currently trialing routes to four ASEAN countries, making Wuhan an important node in implementing national strategy for a 21st Century Maritime Silk Road.

In recent years, so as to efficiently facilitate the development of the Yangtze River Economic Belt, Wuhan has placed an emphasis on achieving high-quality green development, driving economic transformation and upgrading, and innovation in old industrial areas. Qingshan District, where the Wuqing Dike River Beach project is located, is one of the seven central districts of Wuhan. The district had a traditional old industrial base with heavy chemical industries such as metallurgy as pillars of the local economy. Responding to socio-economic conditions, Qingshan District has actively explored coordinated green and economic development, setting up an example of district level green transformation and development of an former heavy chemical industrial zone. In 2017, the 'Comprehensive Renovation Project of Wuqing Dike River Beach' won the C40 City Global Award in the "Cities4Tomorrow" category.

15.2 Project Overview

As a key project in Wuhan's "two rivers and four riverbanks" landscaping scheme, the Comprehensive Renovation Project of Wuqing Dike River Beach represented a total investment of 1.084 billion yuan. The project is located on the south bank of the Yangtze River in Qingshan District, comprising a total length of 7,503 meters, a total area of 135.48 hectares. The renovation project started on October 22, 2013 and was

[6] The main references of this case are the data and materials regarding the Wuqing Dike's application for C40 City Award" provided by Wuhan Ecological Environment Bureau. This case study is prepared by C40 Cites Climate Leadership Group and C40 partner, Zhao Guangjie, Head of Green Development Department of China Quality Certification Center, Wuhan Branch.

completed on June 26, 2017. The project consists of six characteristic landscape areas for sporting activities, urban fashion, rain-water gardens, eco-streams, grasslands and green hills. The renovation was designed to be a comprehensive landscaping project integrating flood control, ecological protection and people's well-being, with the theme of "inheriting Qingshan culture and highlighting ecological features." Furthermore, implementing the concept of "Yangtze River ecological protection" was seen as fundamental to project success. For the first time, "semi-dike" micro-topography technology has been adopted in the main levee of the Yangtze River. On the premise of ensuring flood control, and emphasizing the sponge city concepts of "seepage, stagnation, storage, purification, use and drainage", ecological landscaping has taken place to set a clear example from the first batch of sponge city approaches in China. At the same time, the project has demonstrated a successful attempt at innovation in the construction of ecological river beach areas, breaking with traditional dike formations that act as a block between people and water.

15.3 Major Achievement

15.3.1 River environment and water source protection

Targeting high-pollution enterprises and facilities with sand yards, docks, freight yards and factory buildings, systematic efforts were made to eliminate sewage outlets directly discharged into the Yangtze River and reduce non-point source pollution of rainwater runoff through sponge city renovation measure; playing an important role in effectively protecting the river environment of the Yangtze.

15.3.2 Carbon sink enhancement and urban heat island alleviation

The total area of the project covers 135.48 hectares and the newly landscaped area now covers 94.8 hectares with 70% of this accounted for as ‘green’ areas, thus increasing the carbon sink capacity of the urban environment. Multi-layer plant systems have been put in place. These planting systems help consume incoming solar radiation by absorbing heat, providing shading and transpiration, which significantly reduces the urban temperature and helps alleviate the "heat island effect". It has been estimated that the temperature in the project area has been reduced by up to 3 degrees Celsius. The riverside green belt also brings natural air flow into the inner city, creating desirable conditions for ventilation in hot summer periods. In winter, it can reduce wind speeds and serve as a wind protection barrier.

15.3.3 Flood risk reduction

31,500 square meters of water-blocking structures were demolished on the renovated beach area and the floodplain area of the Yangtze River was effectively increased to ensure proper flood discharge. By utilizing mixed piles to build a new cement cutoff wall, the dike’s cross-sectional area is increased, so that the overall flood control capacity is improved. Now the dike has been modelled to withstand extreme flood events, providing enhanced protection and reassurance. The gently sloping dike has organic green infrastructure that works in combination with the beach of the riverbank. Sponge city facilities such as plant buffer zones, ecological grass belts, rainwater regulating ponds and permeable pavements help achieve the goal of "no water accumulation in light rain, no waterlogging in heavy rain, no muddy water with odor and less heat island effect." In combination, these facilities can effectively resist flooding caused by heavy rainstorms and reduce associated damage to riverbank facilities. They also help prevent the waterlogging that may occur, modelled against once in fifty years events.

In 2016, Wuhan was struck by a Super-Strong El Nino event and average rainfall across the rainy season was

959.2 mm, 2.5 times of the average amount - an historic record. The maximum rainfall in 7 days was 733.7mm and the maximum rainfall in 24 hours was 370.6mm, both figures exceeding the modelled intensity of once in a hundred year rainfall events. In such a heavy rainstorm there was no waterlogging at the project site. This storm event also proved the capacity of the project site to withstand flooding that has been modelled to happen only once in fifty years.

15.4 Green Concept Practice & Environmental and Social Benefits

15.4.1 The trinity system: city, river beach and dike

A bird's eye view of the Qingshan River beach is like a green belt, which organically combines the Yangtze River with the city. The construction concepts of sponge city approaches has now been fully implemented in the renovation process. Facilities such as plant buffer zone and ecological grass belt have been set up to construct a "trinity system of city, river beach and dike." Arguably, the original beauty of the Yangtze River has restored to the maximum extent while creating a leisure space through the river beach at the same time as improving flood resistance capacity. Qingshan River Beach, which integrates the concepts of greening, ecological uplifting, sponge city approaches and flood control, now stands as an exemplary project within Wuhan's wider Yangtze River protection strategy and the "Water Governance in Four Aspects" action plan.

15.4.2 Beach greening and actions to increase carbon sink capacity

The total landscaped area of the project is 700,000 square meters and involved the planting 45,000 trees, 325,000 square meters of shrubs and 387,000 square meters of flowers and lawns. According to the IPCC's (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol.4 AFOLU) minimum net growth value of above ground biomass of tropical and subtropical plantations and the net growth value of above ground biomass in subtropical grassland (6 tons of dry matter/ha/year and the dry matter carbon fraction (CF) 0.47 tons of carbon/ton of dry matter) it is calculated that the project can increase carbon sink capacity in the city by 723.8 tons every year.

15.4.3 Dismantling high energy-consuming enterprises, reduce emissions and improve the regional environment

As part of the project, 21 sand yards, 4 wharves, 2 freight yards and 2 factory buildings were dismantled, reducing carbon dioxide emissions by 29,000 tons. This also increased park areas by 135.48 hectares which greatly improves the urban environment of the Qingshan riverside area. These improved environmental conditions also helped raise the water quality standards of the Yangtze River.

15.4.4 Improving the urban environment and citizens' quality of life

The Comprehensive Renovation Project of Wuqing Dike River Beach closely combined engineering technology with landscaping design to provide citizens with places for leisure, entertainment and water-related activities downtown, improving the living conditions and quality of life for local residents.

A total of 15 kilometers of footpath, various squares covering a total area of about 50,000 square meters, 7 swimming pools, 13 football fields, a beach volleyball center and various fitness equipment facilities have been built, providing leisure and entertainment places for citizens in the city center; all this contributing to national goals for improving physical fitness.

Since its opening in June 2015, Wuqing Dike River Beach Park has attracted more than 10 million visitors and organized thousands of cultural and sports activities such as Children's Day Creative Graffiti, Family Race Walking, the second Square Dance Competition, and the Zhongyi Cup Sponge City Competition, an international half marathon (March 2019), the men's beach volleyball competition of the Military Games (October 2019), a National Beach Volleyball Competition in 2021, as well as much more.

15.5 Mechanisms of Cooperation and Communication

Qingshan District Government manages and coordinates the project in terms of government functions such as demolition, landscaping and urban management. As a water administrative body, the Wuhan Water Authority provides technical and policy guidance on flood control in construction processes and adjustments. As the project construction's proprietor, Wuhan Bishui Group provides funds and construction management. China First Metallurgical Group (CFMG) provides site management and engages in construction work.

During the project implementation period, the examination and approval authority, management organization, project headquarters and lead design company organized more than 20 review meetings and expert consultation sessions. The Urban Management Department of Qingshan District Government organized more than 50 coordination meetings for land expropriation and demolition. The project also set up its headquarters as a focus for more than 30 meetings, with members including the Municipal Water Affairs Bureau, the district government, the Municipal Water Investment Company, China First Metallurgical Group investors, as well as construction, design and supervision institutions.

In order to strengthen public engagement in Wuqing Dike River Beach and call on the general public to actively participate in the project construction process, an open solicitation was held for sculptures in the main square and the river beach LOGO scheme, with more than 10 design companies and individuals participating.

15.6 Case Summary

Wuqing Dike is the first ecological river beach that integrates "river, beach and city" in Wuhan, and the first "sponge river beach" in Hubei Province. Energy-saving green materials were selected for landscaping and building materials. The ground simulates a 'sponge' which absorbs water when it rains and spits out the absorbed rainwater when it is dry, thus improving the utilization rate of water resources. As one of the main parts of the Yangtze River in Wuhan, Wuqing Dike has a total length of 7.5 km, accounting for 14% of the total length of the Wuhan Yangtze River dike. After the renovation, the total length of Wuhan river beach parks will reach 102 kilometers (from the current 58 kilometers), making the city home to the world's largest urban river beach park area.

Wuqing dike fully demonstrates Wuhan's firm determination to transform to a low carbon, ecological city. As a successful attempt in innovative ecological river beach construction, this project not only breaks the pattern of dikes that segregate people and water, but also introduces new concepts of urban development and river beach construction. The successful practice of ecological construction has provided a new example for the world in terms of river beach construction.

(a) Football field in Wuqing Dike River Beach Park

(b) The Wuqing Dike River Beach Park, a green corridor between river and city

(c) Sights along the river in Wuqing Dike River Beach Park

(d) Places for leisure and relaxation along the Wuqing Dike River Beach Park

(e) Citizens in morning exercises in Wuqing Dike River Beach Park

Figure6-8 Sights along the river in Wuqing Dike River Beach Park

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Chapter 7. Sustainable TransportationSantiago, Chile: Cleaning Urban Mobility by Electric Buses

Transportation is an important source of greenhouse gas emissions and air pollutants in cities. The development of a green and clean transportation system is of great importance to the green development of cities. Santiago, the capital of Chile, has adopted a vigorous development of clean electric buses and plans to fully electrify public transportation by 2035. The project is based on a small pilot, focusing on appropriate charging stations, an innovative investment and financing model, and a financial incentive mechanism to encourage the implementation of clean electric vehicle projects. The electric bus project has produced positive results in terms of sustainability and emission reduction, while the bus riding experience and service level have also been improved.

16.1 Background

Santiago, the capital of Chile, is the fourth largest city in South America, located on the banks of the Marble Bridge River, surrounded by the Andes and the coastal mountains of Chile's Central Valley, and home to 40% of the country's population (more than 7 million people). In the second half of the 20th century, Santiago's economic growth, urban sprawl, and exponential growth in private vehicle ownership created serious congestion, air pollution, and carbon emissions problems for the city. According to statistics, the transport sector accounts for approximately nearly 25% of Chile's total CO_2 emissions (2018), mainly from private cars, aviation and, to a lesser extent, operational vehicles. Meanwhile, by the early 1990s, the city of Santiago had become one of the most polluted capitals in Latin America. From 2011-2012, San Diego's transportation sector accounted for about 40% of the city's total fine particulate matter (PM2.5) emissions, while from 2004-2014, the city's nitrogen dioxide showed a substantial increase of 28.6 ± 13.8%.

Figure 7-1. Santiago City Map

16.2 Project overview

To address carbon emissions and pollutant emissions from the transportation sector, Chile monitors air pollution, regulates emissions from the transportation sector, and consolidates Santiago's public transport operations system, unifying public transport operators under the jurisdiction of the public transport authority. In 2018, Santiago became the first Latin American city to implement Euro VI emissions standards for its public transport system city, setting the stage for its electric bus deployment. Since the beginning of 2019, Santiago has had the largest fleet of electric buses outside of China. By March 2020, San Diego has deployed nearly 600 buses that meet Euro IV emissions standards and more than 400 electric buses (about 6% of the fleet). To reduce the carbon emissions associated with transportation, San Diego has set a goal to achieve full electrification by 2035.

16.3 Green Development experience

16.3.1 Electrification by Phases

In 2007, Santiago launched the reorganized public transportation system "Transantiago" (now known as the Red Metropolitana de Movilidad (RED)). Today, the network consists of 380 bus lines operated by six private operators, with 6,756 buses covering more than 2,946 km of the network and carrying 690,000 passengers. To correct some of the institutional deficiencies of San Diego's transit system, the city has undertaken ongoing reforms since 2011, including the separation of fleet supply and fleet operations, streamlining of operational departments, shorter contract periods, and incentives to operate electric buses.

In November 2017, Metbus, Santiago's bus operator, partnered with The Enel Group and BYD. Two 12-meter BYD K9FE electric buses were purchased by Enel and leased to Metbus for operation. The two K9 electric buses will run on route 516 for one year on a pilot basis. The route takes about 4 to 4.5 hours and is staffed by five trained drivers. During the one-year pilot run, the two electric buses traveled more than 100,000 kilometers and carried more than 350,000 passengers.

Through the pilot, Metbus has measured the operating costs of the vehicle. Calculations found that, compared with traditional diesel buses, pure electric bus operating costs can be reduced by 70%. According to the price of $ 0.10 / kWh and 1.006 kWh / km of energy consumption, the operating cost of electric buses is about $ 0.10 / km. In comparison, the operating cost of a diesel bus with an energy consumption of 0.5 liters/km is $0.43/km. As a result of this pilot, Metbus has partnered with BYD and Enel X, a subsidiary of Enel, to expand operations by adding 100 and 150 BYD electric buses in 2019 and 2020, respectively.

In addition to Metbus, other bus operators use similar modes to procure and operate electric buses. In 2017, Gildemeister co-led a pilot operation of a 12-meter low-floor Yutong E12 electric bus with Engie from December 2017 to May 2018. During the pilot period, the electric bus completed 1,173 trips and traveled more than 22,000 kilometers at an operating cost of approximately $0.05 /km. As a result of the pilot, 2 subsidiaries of the Urban Mobility Network provided a total of 100 electric buses at a total cost of approximately $30 million.

In January 2019, 100 electric buses developed and manufactured by Chinese enterprise Yutong Group Co., Ltd. (hereinafter referred to as “Yutong Group”) were put into operation in Santiago, Chile. The 100 Yutong electric buses boast comfortable interiors, long driving range and ultra-low energy consumption. Matched with 150KW DC charger, it takes only 2.5 hours to fully charge the vehicle, which is 3 hours faster than that

matched with 60KW charger of European standards. It can meet the daily driving range of 300km, making operation easier and more flexible. For local people, Yutong buses provide environmental-friendly, comfortable and safe transit experience; for local operators, Yutong buses improve efficiency and reduce cost. Currently, Yutong has seven service stations in Chile, covering the major cities in the country with the capital city of Santiago as the center. The service stations are evaluated, renovated and upgraded on a yearly basis to ensure good service for every bus.

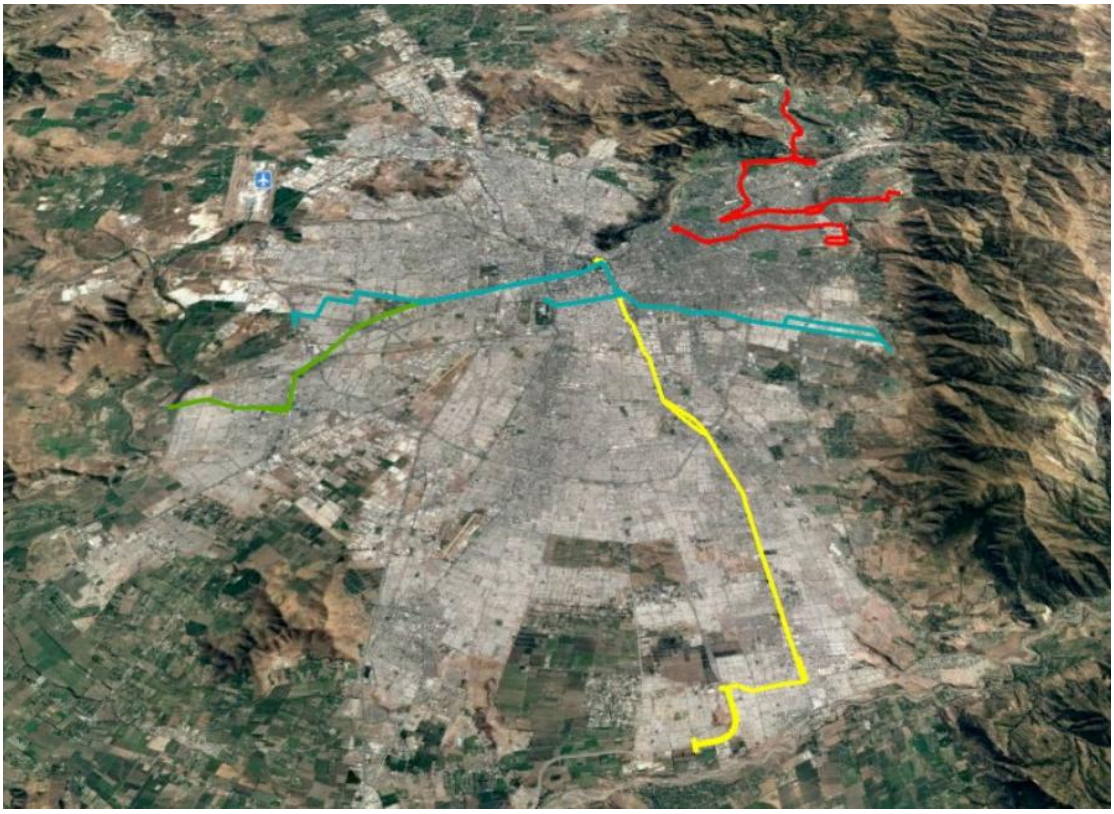

Figure 7-2. Bus lines in Santiago that use electric buses, with different colors representing different operating companies.

16.3.2 Well-supported Infrastructures

Electric buses require appropriate charging and intelligent equipment to form a feasible and attractive bus operation model. The project between Metbus and BYD resulted in a total of 100 BYD EVA 080KI AC charging station with an output of 80 kW. The AC charging station are equipped with a combined charging system and have an estimated charging time of 3 to 4 hours. A bus station owened by Engie and Metbus has 13 150-kW DC chargers to operate 25 electric buses. The Rinconada Buses Vule terminal, which opened in March 2019, includes 37 150-kW DC chargers capable of handling the operation of 75 electric buses.

In addition to charging equipment, electric bus lines are fitted with green, smart, and user-friendly amenities to further enhance the user experience. For example, the Avenida Grecia electric bus line includes 40 new state-of-the-art bus stops, including free Wi-Fi, USB chargers, bus arrival time panels, solar panels for power needs, LED lighting, wheelchair access, and exclusive payment zones at some stops.

Figure 7-3. Electric buses and bus stop in Santiago. Source: MARCELA CASTILLO

16.3.3 Innovative Investment and Financing Model

San Diego's electric bus investment and financing model is key to enabling rapid fleet expansion. An innovative financing model was developed with the participation of multiple parties, including energy service company, bus operators, bus procurement companies, and the government, in the investment and financing. The City of Santiago subsidizes the renewal of the fleet, while the ownership and operation of the electric buses are separated between the energy company and the bus company, respectively. Specifically, bus operators do not need to purchase buses, but are only responsible for bus operation and basic maintenance, leasing instead of purchasing, and may choose to obtain bus ownership at the end of the lease term. A third party (energy service company) acts as the financial agent and energy supplier, purchasing and leasing electric buses to the bus operator and overseeing the construction of the charging infrastructure and electricity supply. The government, in turn, guarantees the purchase of electric buses and provides operating subsidies for electric bus operations. Responsibility for maintenance of the electric buses will depend on specific contracts between stakeholders.

Under the contract between Metbus, BYD and Enel, Enel acts as the financial agent and energy provider for the buses leased to Metbus for a period of 10 years. Metbus is responsible for operating the bus fleet and providing basic maintenance, while BYD is responsible for the more important maintenance and repair operations, including battery packs and electric drive systems. Metbus has a fixed maintenance fee of $0.09/km with BYD and a clause stipulating that if the manufacturer's electric buses do not meet the frequency requirements, they will be subject to fines. The agreement between Metbus and Enel for a total of approximately $40 million, includes the financing lease of 100 buses and charging infrastructure for 10 years, after which the assets will be transferred to the lessee, Metbus. The assets will then be handed over to the lessee Metbus.

In an agreement between Engie and two subsidiaries of the Metbus, Engie will act as financial agent to provide charging infrastructure and certified renewable energy for the two bus operators. Engie will provide 3.3 million kWh of electricity per year and 8.8 million kWh of electricity per year for the two subsidiaries respectively.

In March 2020, NeoT Green Mobility, an investment platform dedicated to financing zero-emission transportation, financed 25 12-meter Golden Dragon DM2800 electric buses for Transdev. The agreement also follows the business model of Enel or Engie, which provides local bus operators with separate asset ownership of infrastructure and buses.

16.3.4 Government Incentives

Meanwhile, in addition to high subsidies, the government offers specific incentives for purchasing electric buses. Typically, bus suppliers purchasing conventional internal combustion engine buses are offered a 10-year bus lease contract, while the contract period can be extended to 14 years for those who choose electric buses. Transit companies sign a 5-year lease contract with a bus supplier, which can be extended for an additional 5 years based on performance and other factors. If electric buses account for more than 50% of the operating fleet, the lease contract can be extended to 7 years and extended for another 7 years based on performance indicators.

Although Santiago has put in place many policies and measures to promote electric buses and is now the city with the most electric buses in South America, challenges remain. The first is to clarify regulatory requirements for charging standards and charging facility compatibility; second, the current highly subsidized system in Santiago is already under high pressure, and a significant expansion to electric buses would require further study of economic feasibility; and third, there are infrastructure challenges. To increase ridership and improve the capacity of the entire bus network, Santiago will need to equip more bus lanes and upgrade the grid to accommodate peak loads. Finally, pollution from electricity and battery waste needs to be further addressed. Cleaner sources of electricity should be used to reduce the environmental impact and greenhouse gas emissions of electricity production. Battery recycling and environmentally sound disposal are also critical to reduce the full life-cycle emissions of electric buses.

16.3.5 Environmental and Social Benefits

Santiago's electric bus program is producing positive results in terms of sustainability and emissions reduction. Preliminary calculations show that by 2019, 100 electric buses from Metbus have reduced a total of 2,564.1 tons CO_2e from 3,658,388 kilometers. The World Resources Institute (WRI) calculates that if the 670 buses were completely replaced with electric buses, it would reduce annual CO_2 emissions by about 44.7% (about 27,957.5 tons), carbon monoxide emissions by 337.5 tons, hydrocarbon emissions by 2.67 tons, nitrogen oxide emissions by 626.8 tons, PM2.5 by 70% (17.8 tons) and PM10 by 56%. The reduction of air pollutants and carbon emissions brings significant social benefits at the same time. WRI estimates that the electric bus project will result in approximately $10 million in health benefits and $1 million in avoided social costs of carbon emissions because of the reduction in air pollutants.

In addition to the environmental impact, the introduction of electric buses has improved the environment and service of the bus through technological upgrades. For example, electric buses provide passengers with

amenities such as Wi-Fi, air conditioning and more comfortable seats. According to metrics provided by operators, the operational reliability of electric buses is in line with, or even better than, that of conventional buses. In addition, electric buses produce less noise. Studies show that electric buses produce 25 to 70 percent less noise than buses with internal combustion engines. Overall, transit users rate electric buses better than conventional buses, thus indicating that the introduction of electric buses has increased the attractiveness of the transit system.

16.4 Case Summary

Chile's clean electric bus program has been a demonstration for electric buses in Latin America since its pilot in 2017. Chile's innovative electric bus investment and financing model has been a key factor in the rapid expansion of the fleet. As of March 2020, Chile has more than 400 electric buses, making it the country with the largest electric bus fleet in Latin America. The project follows a step-by-step model of piloting and then scaling up, with innovative financing and government financial incentives to procure electric buses, as well as improved charging, smart and user-friendly infrastructure. The project brings significant environmental benefits, promotes public transportation development, reduces carbon emissions, creates health benefits for residents, and provides important lessons for other countries along the Belt and Road to promote clean electric buses.

17 Hybrid Meter-Gauge EMUs in Malaysia

Green development, energy conservation and environmental protection are the future trends for technological development in high-speed EMUs. On April 11, 2021, the hybrid meter-gauge EMU specially designed for the non-electrified line on the east coast of Malaysia by CRRC Zhuzhou Locomotive Co., Ltd. (CRRC ZELC) was put into operation. The EMU embodies the design concept of "green + intelligence" with advanced technologies such as "Super Capacitor + intelligent maintenance". New technologies such as in-car intelligent operation and maintenance monitoring, super capacitance and big data remote diagnosis are also applied with advantages in energy saving, environmental protection, noise reduction and work efficiency.

17.1 Background

Malaysia is located in the central part of Southeast Asia. Situated along the Strait of Malacca, it shares both land and maritime borders with many ASEAN countries. Therefore, Malaysia is endowed with prominent regional advantages. Its infrastructure construction is better than the global average, and its domestic infrastructure can provide a full range of public services. However, its infrastructure construction is far more balanced, with huge gaps in certain fields, especially in the railway system. Recognizing the existing problems, the Malaysian government has issued corresponding plans for infrastructure construction, which brings opportunities for foreign countries to participate in infrastructure projects in railway and other fields in Malaysia. The Malaysian railway network runs through the peninsula, from the north to the south. It connects Thailand in the north and Singapore in the south. In 2018, the passenger traffic on Malaysian railways amounted to 3.527 million while the freight traffic stood at 5.944 million tons.

China's contracted projects in Malaysia mainly focus on infrastructure construction. It has taken the initiative to realize integrated transformation in engineering and operation. China's contracted projects are distributed across the territory of Malaysia, covering both the East and the West. The projects under construction mainly include hydropower stations, bridges, railways, real estate and other fields. According to the statistics of China's Ministry of Commerce, by the end of 2019, Chinese enterprises had accumulated a contract value of USD 83.72 billion and a turnover of USD 48.27 billion in Malaysia, both ranking second among ASEAN countries following Indonesia. In 2019, China's direct investment to Malaysia was USD 810 million. According to the statistics of Malaysia Investment Development Authority (MIDA), in 2019, the investment of Chinese enterprises approved by MIDA in Malaysia's manufacturing industry was USD 3.74 billion. From 2016 to 2019, China has been the largest source of foreign capital in Malaysia's manufacturing industry for four consecutive years. Among them, CRRC's ASEAN Manufacturing Center is one of China's important cooperation projects in Malaysia.

17.2 Project Overview

Hunan has three world-class industrial clusters for construction machinery, advanced rail transit equipment and aero engines. A number of leading manufacturing enterprises in Hunan have continued to enhance their competitiveness in the global market through innovative advantages. Among these enterprises is a key player—CRRC Zhuzhou Locomotive Co., Ltd. (CRRC ZELC). CRRC ZELC has carried out several cooperation projects with Malaysia. The products that have been put into operation in Malaysia include SCS intercity EMU, ETS meter-gauge EMU, ETS 2 meter-gauge EMU and hybrid meter-gauge EMU.

In 2012, the SCS intercity EMU which is independently developed by CRRC ZELC was put into operation in Kuala Lumpur, the capital of Malaysia. In 2016, ETS meter-gauge EMU was locally produced and put into operation in Malaysia, mainly between Kuala Lumpur and Padang Besar on the border of Malaysia and Thailand, with an average passenger traffic of more than 10,000 per day. In 2019, ETS 2 meter-gauge EMU produced locally in Malaysia rolled off the assembly line, becoming the first EMU with business cabins in Malaysia.

On April 11, 2021, the hybrid meter-gauge EMU developed by CRRC ZELC for Malaysia was put into operation. The train adopts a four-car formation and runs at a speed of 120 km/h. It is specially designed for the non-electrified lines on the east coast of Malaysia and manufactured based on the successful experience of SCS EMU, ETS EMU and other projects under CRRC ZELC in Malaysia.

Figure 7-4 High-speed meter-gauge EMUs exported from China to Malaysia

17.3 Green Development experience

17.3.1 Energy Consumption Reduced Through Advanced Technologies

This EMU uses a hybrid power system of “Internal Combustion Power Pack + Super Capacitor Energy Storage Power Supply”. When the train is in traction, the super capacitor can provide high-power current for the train to start and accelerate in a short time. When the train is braking, the super capacitor can absorb and store more than 85% of the braking energy which can be used in the next start. Therefore, energy is recycled and energy consumption reduced. The train uses super capacitor energy storage power supply as one of the power sources, which saves more than 20% of fuel consumption compared with traditional internal

combustion EMUs.

As the Malaysian EMU is a meter-gauge EMU, the space under the vehicle is narrow with strict requirements for the overall dimension of the power pack. In response, CRRC designed a power pack with a small size, low emission and high level of integration. When the power pack is assembled on the train, it works and provides traction and auxiliary power source for the EMU only after fuel pipelines and cables are connected. The plug and play function make the operation convenient and efficient.

In addition, the EMU adopts a fully streamlined body design to meet the requirements of high-speed operation. This design not only makes the train more dynamic and beautiful, but also reduces the air resistance at high speed and thus brings down energy consumption.

17.3.2 Green Technologies Applied to Reduce Noise, Conserve Energy and Protect the Environment

Interior noise performance is one of the comfort indexes for high-speed trains. In order to reduce noise for passenger comfort, the north-south EMUs in Malaysia have adopted a series of advanced technologies including low-carbon and energy-saving technologies, electric drive, network control and lightweight design to reduce noise.

First, the ventilation design on the trains puts supply vents at the top and return vents at the bottom to reduce wind speed and noise while improving ventilation effect and passenger comfort. Second, the front shape and body design of the trains are optimized so that the surface of the whole vehicle is smooth, while the aerodynamic noise on the vehicle surface is also reduced with structures such as a full windshield. Third, sound insulation components are used to block both structural and aero noise transmission paths and reduce in-car noise. Fourth, the sealing performance of the whole vehicle is enhanced to block the transmission of external noise into the interior.

17.3.3 Intelligent Operations Guarantee Safety and Reliability

Safety is the top priority of high-speed EMUs. The EMU applies intelligent operation and maintenance technologies to collect and transmit information such as operation status or operation failures in real time, automatically diagnose vehicle operation status, and guide or conduct corresponding maintenance work. At the same time, through on-board equipment, vehicle-ground data transmission and the ground system, a full life cycle management platform featuring vehicle-ground synergy can be built to provide suggestions for operation and maintenance decisions and realize proactive safety control and intelligent maintenance. In addition, advanced safety equipment such as axle temperature alarm system, fire alarm system and external condition monitoring system are integrated in the train's control system, which, combined with the safety oriented design in vehicle control, can greatly enhance the safety of vehicle operation.

17.3.4 Convenience and Efficiency

With better performance and in-car facilities compared with existing trains, this EMU will greatly enhance the convenience and comfort of travel for people living in Kelantan or other cities in the east coast of Peninsular Malaysia.

First, compared with traditional trains with an average speed of 50-60 kilometers per hour, this EMU runs at a speed of 120 kilometers per hour, which shortens the commuting time by a large margin and can greatly

facilitate the convenience of travel. Its high operation efficiency also serves to ease the pressure of existing highway and railway transportation in Malaysia. Second, the EMU fully considers the Islamic religious culture in Malaysia. The train is equipped with prayer rooms and hijab dressing rooms. The seats in the passenger compartment can be adjusted flexibly. It is also equipped with lower height and wider pedaling ladders, which can adapt to various platform requirements.

17.4 Case Summary

The hybrid meter-gauge EMU specially designed for the non-electrified line on the east coast of Malaysia by CRRC Zhuzhou Locomotive Co., Ltd. (CRRC ZELC) embodies the design concept of “green + intelligence” with advanced technologies that could effectively reduce energy consumption and construction and operation cost. Green noise reduction technologies and intelligent operation and maintenance were applied to provide environmental-friendly and comfortable transit experience for local people.

18 Hangzhou Public Bike Sharing and Biking Culture Promotion[7]

18.1 Background

As the capital city of Zhejiang Province, Hangzhou has a long history of more than 2,000 years of city construction as well as a rich city culture. The construction of the Beijing-Hangzhou Grand Canal has made Hangzhou an important node city of the Belt and Road region, connecting the Maritime Silk Road and the Land Silk Road. Under the background that the country is actively promoting the Belt and Road initiative, Hangzhou has actively taken responsibility and striven to contribute to its implementation. Over the years, Hangzhou has seized opportunities of the initiative to develop the economic exchanges and trade with member countries, conduct dialogues and technical cooperation with related cities in various fields such as urban governance, people wellbeing improvement and ecological and environmental protection, jointly discuss with them about the establishment of policy systems for new technologies and industrial revolution, and explore the development pathway of the city for people's better life.

In the 1970s, China was known as the Kingdom of Bicycles, but like in many other countries, its cities have experienced a decline in bicycle use since. An increase in wealth meant an increase in car ownership, especially in affluent cities such as Beijing, Shanghai and Hangzhou. Simultaneously, a focus on bicycles within traffic planning was reduced in favor of cars (and public transport). However, in recent years a renewed focus has once again been devoted to the bicycle and how to optimize its potential in the overall mobility system. This has occurred at both a national level and at City level in the case of Hangzhou.

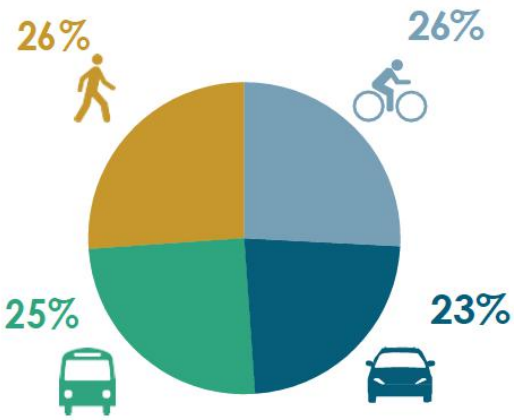

Figure 7-5 Modal split in Hangzhou

Hangzhou is one of the leading cities in China for biking development. The key reason for promoting cycling in Hangzhou has been the recognition of the fact that it can play an important role in expanding the catchment area of public transport. It has been shown that the bicycle, in combination with train and metro,

[7] The main references of this case come from the relevant data and materials provided by Hangzhou Transportation Department and Hangzhou Public Transportation Group Co.. This case study is by C40 Cities Climate Leadership Group China, Climate Action Planning China program and C40 partner Mr. Andreas Røhl and Mr. Rasmus Duong-Grunnet from Gehl Copenhagen.

is a highly effective product that combines the passenger capacity and speed of the rail with the individual flexibility of the bike. Another reason for the focus on cycling has been the positive impact on tourism. As the capital city of Zhejiang Province, Hangzhou is home to many world-renowned attractions including West Lake and has a long history in promoting cycling into tourism and daily life. In addition, in recent years the positive health impact and the impact on reducing CO_2 emissions has contributed to the rationale and motivation for promoting cycling.

Figure 7-6 Biking around the West Lake

18.2 Project Overview

The publicly owned Hangzhou Bikeshare program is world-class and the volume of units on the street is second to none. The bikeshare program has by far been the most important measure to increase cycling in Hangzhou within the last 15 years. The project was launched in 2008 and is led by the Hangzhou Municipal Government. It starts with planning, finance, and regulations, and the Hangzhou Public Transport Group Corporation is the main operating body responsible for the construction, operation and management of Hangzhou public bicycles.

The project is mainly positioned as a public welfare project, with a free rental rate of more than 98%, while adopting market operations at the same time. The Hangzhou Municipal Party Committee and the Municipal Government have incorporated public bicycles into Hangzhou's "four-in-one" large public transport system, which provided the project with a good policy guarantee. At the same time, the project regularly organizes volunteer teams to provide free vehicle repairs, consultation and other services, which has won the project a wide recognition and support from all walks of life in the society.

The main operation modes of the project include:

Implement the management method of "unified brand, unified standard, unified facility, unified platform" so that public bicycles can be rented and returned throughout the city.

Through "Unattended, self-service operation, intelligent management", you can pick up or return the bicycles by swiping your card or scanning the code on your mobile phone.

Achieve "deposit sharing, one card with two uses" by implementing online no-detention bike rental and payment by security deposit of physical card, which is real-name and can be linked to the online platform.

All public bicycles shall be covered by insurance companies for personal accident insurance and third-party liability insurance for cyclists.

What has made the system an inspiration for many other bikeshare systems around the world is not only its sheer volume but also its close integration with public transport. Or to put it more accurately; that the bikeshare system is seen and planned as an essential part of the overall public transport system. Or put simply: Bikes as public transport.

Though all is not bikeshare. Hangzhou also has a network of physically separated cycle lanes crisscrossing the city, complete with dedicated traffic signals for bikes in many major intersections.

A key feature of Hangzhou and many other Chinese cities is a high population density. This fact, and a continued focus on high density land-use planning, is yet another measure that has been important for the competitiveness of the bike in Hangzhou.

During the current COVID-19 pandemic, Hangzhou issued the first local standard for the prevention and control of the pandemic in the bike sharing industry, *The Urban Public Bicycle Hygiene Prevention and Control Regulations during the Epidemic Period,* which stipulated the hardware, services, public health requirements of staff and renters of public bicycles during the epidemic prevention and control period. This document provides a scientific implementation guide for the urban public bicycle industry in responding to public health emergencies, improves the public bicycle emergency management service system, reduces the risk of epidemic infection, and improves public's confidence in choosing public bicycles for travel during the epidemic prevention and control period.

Figure 7-7 Cycle lanes in Hangzhou

18.3 Impact

Since the Hangzhou public bicycle transportation system was put into operation, the results obtained from various aspects have far exceeded the original intention of “solving the last mile of bus travel” and alleviating the “dilemma” of urban traffic. Some results have been achieved in terms of emission reduction, building low-carbon cities, advocating green travel, improving city quality, improving city image, and improving citizens’ physical fitness.

1. Impact data of Hangzhou public bicycle sharing project:

- It started trial operations in 2008 with 61 service points and 2.800 public bicycles and has developed to the current 4.514 service points and 126.600 public bicycles. The cumulative number of rentals has recently reached 1.098 billion rentals.
- The average trip length is 3-5 kilometers and the cumulative mileage is about 3.294 billion kilometers. Based on an average of 2 people carried by each car, it is equivalent to reducing the travel volume of 549 million cars. Or converted to carbon dioxide emissions, it can be argued that the bikeshare system has cut emissions by approximately 1,461,300 tons.
- The public bike sharing system has been integrated into the urban public transportation system and basically solves the problem of "the last mile travel by public transport". The distribution of service point construction facilities is as follows: about 6.39% around subway, about 7.18% around bus stations, and about 0.57% around important transportation hubs. The rental period is concentrated in the morning and evening peak travel period, accounting for about 45% of the daily rental usage.
- It facilitated public travel and reduced travel costs for Hangzhou citizens. The rental fee is capped at 5 yuan per day, and the rental free rate is over 98%.

2. Hangzhou public bicycle sharing project won domestic and foreign awards:
    - 2015 China Good Design Award
    - Guangzhou International City Innovation Award
    - 2017 Ashton Award for Sustainable Transport Project
    - The 2nd Tehran Golden Adobe Global Award in Urban Management
    - One of the "8 cities that provide the best public bicycle service in the world" (BBC)
    - The world's best 16 regional public bicycle systems ranked first (USA TODAY)

18.4 Three Key Take-aways:

1. Bikeshare has a huge potential as a tool to increase the catchment area and convenience of using public transport. As an important part of urban transportation, public bicycle has advantages that cannot be replaced by bus and taxi in short-distance travel: firstly, it is human-powered and has the environmental advantages of no emission and low noise, which can provide convenient travel for residents and tourists; secondly, it has the advantages of small size, convenience and flexibility, high accessibility and low investment, which can be used as an important transportation means to connect with subway and bus; thirdly, it has the advantages of strong adaptability to roads and flexible mobility by taking advantage of gaps and bypasses in case of traffic jams, improving the overall efficiency of urban transportation. The construction of public bicycle service system has become a powerful measure for Hangzhou to save energy and reduce emissions and improve the green ecological benefits and competitiveness of the city.
2. Bikeshare is public transport – and should be planned, operated and regulated as such. In China, the public bicycle system was launched in Hangzhou in 2008 with public funding. Subsequently, the

low-carbon, environmentally friendly, free and convenient public bicycle quickly set off a "green whirlwind" that spread from Hangzhou to the rest of the country. In essence, the public bicycle sharing program is a public service product led by the government, which puts social benefits first, protects people's livelihood needs, and provides a more intimate, high-quality and safe short-distance travel service than bicycle sharing companies in the market. Hangzhou public bicycle has been successfully integrated into Hangzhou's "four-in-one" urban public transportation system, becoming an important component of Hangzhou's well-run integrated public transportation system.

3. Cycling is not just about a convenient everyday life. Good cycling conditions are also valued by tourists. Bicycle riding is an important way for tourists to experience the city, while planning and building an efficient and reasonable bicycle tourism slow travel system has become an important task for many tourist cities. As a famous tourist city in China, Hangzhou has a large demand for tourist transportation, and most of the tourists travel are near the scenic spots. The bicycle as a green and convenient transportation means precisely meets the travel demand of tourists and becomes a new channel to graft tourists into tourism demonstration sites. At the same time, the development of cycling meets the diversified development needs of Hangzhou tourism and injects new elements and vitality into the tourism industry.

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Chapter 8: Green Buildings

19 Green Building Rating Tool in South Africa

Green Star South Africa (Green Star SA) is a green building rating tool launched by Green Building Council of South Africa (GBCSA) to provide comprehensive assessment and rating for the environmental design and performance of buildings in South Africa. Since the rise of green building, more and more buildings are incorporating green design elements, adopting greener and more efficient technologies; and existing buildings are gradually being reconfigured in a green direction. The green building movement will certainly contribute to slowing resource exhaustion and improving the ecological environment.

19.1 Background

South Africa is located in the southernmost part of the African continent, and is known as the “rainbow nation”. It is surrounded by the Indian Ocean and the Atlantic Ocean to the east, south and west, and bordered by Namibia, Botswana, Lesotho, Zimbabwe, Mozambique and Swaziland on land. It is the second largest economy in Africa with relatively stable economy and more developed finance, legislation, communication, energy and transportation industries compared with other African countries. It has complete hardware infrastructure and stock exchange markets; its gold and diamond outputs are the first in the world, and its technologies like deep-well mining are leading in the world.

Climate change is one of the most serious environmental challenges of our time, for which the construction industry is largely responsible. Globally, construction consumes 40%-50% of the world’s produced energy, about 30% of its resources, and 20% of the freshwater resources, and generates 50% of the world’s waste, majority of the water pollution and 40% of the air pollution, far more than those caused by any other industries. The construction industry is one of the four largest industries in South Africa. The annual CO_2 emission is around 800 million tons and is expected to exceed 1.2 billion tons by 2025, with about 23% of the emission caused by the operation of residential and non-residential buildings. In this context, the implementation of green building has a significantly positive effect on mitigating resource consumption and combating global warming. As rolling blackouts in 2008 brought about a focus on energy efficiency, building owners and contractors began to turn to greener building technologies, which led to the emergence of a green building market in South Africa. As green building is a new concept that has just been recently implemented, the green building market is still in its early stage in South Africa.

19.2 Project overview

The concept of green building was developed in response to the severe negative environmental impacts of construction, including its contribution to greenhouse gas emissions and the resulting environmental changes. The core of green building is to try to create buildings that are designed, constructed and operated friendly to the environment and its inhabitants. Established in 2007, GBCSA is a member of the World Green Building Council and a building certification body under the Green Star rating system, and it was established to promote and guide green building design. GBCSA defines green building as follows: “A green building is an energy-efficient, resource-efficient, and environmentally-friendly building that incorporates design,

construction and operation that significantly reduces or eliminates the negative impact of development on the environment and its inhabitants. Green buildings not only use resources efficiently and combat climate change, but also create a healthier and more productive environment for people to live and work in." Buildings built based on green principles can significantly reduce energy consumption, water use and solid and liquid waste output. By promoting green principles in construction, GBCSA can make a vital impact in mitigating resource consumption and global warming.

In November 2018, GBCSA launched the Green Star SA rating tool, a comprehensive assessment system for rating the environmental design and performance of buildings in South Africa. This tool is based on the Australian Green Star system, and is customized for use in the local South African context. Green Star SA recognizes and rewards initiatives that reduce environmental impact and aims to drive a shift in building construction and management from traditional models to new and more environmentally-friendly ones. The main goals of Green Star SA include establishing common standards for green buildings; promoting integrated, whole-building design; inspiring the recognition of green buildings; reducing the environmental impact of development and recognizing the leading role of environmental protection. By setting standards and benchmarks, Green Star SA enables GBCSA to objectively assess the green level of buildings.

As of 2016, GBCSA has certified 200 Green Star buildings; in September 2018, GBCSA reached the milestone of 400 certified buildings in its ten years of existence. Green Star certified projects are largely located in Gauteng, Western Cape, and KwaZulu-Natal Provinces. The location of green buildings also responds to the importance of these three provinces in South Africa: in terms of contribution to South Africa's GDP, Gauteng dominates with over 33%, followed by KwaZulu-Natal with over 15% and the Western Cape with over 14%.

19.3 Rating Process of Green Star

Green Star SA provides projects with the opportunity to attain the certification at two different stages of development, namely "Design" certification and "As Built" certification. "Design" certification is submitted when the design phase of a project is completed, indicating that the building can be marketed as a Green Star certified project. The "As Built" certification is applied when the project construction is finished, indicating that all strategies have been incorporated into the completed building. For the certification process, the project team would submit required documents to GBCSA, which then hires an independent evaluator to determine the green level of the building and assign an appropriate rating with the rating tool.

There are nine categories in the rating tool: management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions, and innovation. Under each category, points are awarded for meeting the Green Star rating criteria; after each category is evaluated, environmental weighting factors are assigned to each category to calculate the overall score. Green building certification is divided into several star levels based on the weighted score of the rating tool: 1-3 Star (10-44 points, unqualified of the formal certification requirements), 4 Star (45-59 points, Best Practices), 5 Star (60-74 points, South Africa Excellence) and 6 Star (≥ 75 points, World Leadership). Achieving 4 Star and above indicates that the building is certified as a green building. An analysis of 95 South African buildings certified between 2009-2015 revealed significant differences in the percentage of scores in nine categories. Three categories that are most likely to be met are water (84%), transportation (79%) and energy (77%), and two categories with the lowest success rate are ecology (37%) and innovation (19%).

The weighting differs per tool to reflect the distinct environmental concerns in the different sectors. There

are different rating tools for each phase of the building life cycle, i.e. design, construction, operation and renovation, and for different building types, including office, retail, health care, education, residential, industrial and public buildings.

The actual assessment also takes into account the use of design, materials and technology to reduce energy and resource consumption, and create a better environment for people and the nature. Green Star rating system lists all green measures incorporated into building design and construction to achieve green structures, including reducing heat loads, maximizing the use of natural light, promoting fresh air circulation, using energy-efficient air conditioning and lighting, using environmentally-friendly and non-toxic materials, reducing waste and using recycled materials, efficient water plumping installation and water collection, using renewable energy, and developing the sensitivity to environmental impacts.

19.4 Water-efficient Measures in Green Star SA

South Africa is a country with scarce and unevenly-distributed water resources. The Green Star SA transforms the building landscape by promoting less water use, and creates effective water conservation mechanisms. According to GBCSA, the “water” category of the rating system is designed to reduce potable water use through efficient design of building systems, rainwater harvesting and water reuse.

Green Star SA awards water source alternative systems for rainwater harvesting, gray water and black water. As rainwater is relatively clean, a simple filtration system is sufficient for the treatment of collected rainwater for non-potable uses. The rainwater system advocated by Sotiralis Consulting Company collects all rainfalls in a unified system, including rainwater sedimentation and the storage of the treated water. Gray water collection and filtration is more suitable for low rainfall areas due to the cost as well as maintenance issues. Gray water systems rarely provide the amount of water needed for office buildings, and projects that generate lots of gray water, such as gyms, prefer to use gray water as an alternative water sources. Black water systems can recover 99% of the water used in a building, but due to the involved capital costs, complexity, ongoing maintenance and the presence of pathogens, most clients find this type of system too risky, and therefore, there is more resistance to using black water systems as an alternative water source.

19.5 Building Material Selection under Green Building Rating

In the context of green building, construction materials should follow the following two selection principles: the first is to evaluate the building based on its impacts in all phases, including design, construction, operation and scrap; the second is to evaluate materials based on their energy efficiency, resource efficiency and environmental responsibility.

In terms of energy efficiency, Green Star SA identifies only the energy efficiency of materials prior to installation. The construction process and the extraction, manufacturing, transport and disposal of materials all require energy, which equates to a kind of hidden energy that affects the environment as much as the greenhouse gases released by combustion. The green building rating tool reduces or reuses materials with high quantity of hidden energy, such as cement, and provides incentives for sourcing and processing materials near the building so as to reduce gas emissions and internal energy consumption.

In terms of resource efficiency, the green building rating tool mitigates the environmental impacts and reduces resource consumption through limiting the quantity of materials used. Designers may replace

high-pollution materials, reuse existing materials, reuse buildings, recycle the construction materials, reduce construction waste and other measures to realize the reduction, reuse and recycle of materials, and consequently enhance the resource efficiency.

In terms of environmental responsibility, sustainability and content of harmful substances are factors of major concern. Although it might be difficult to reduce the use of certain materials in certain circumstances, it can still mitigate the negative impact to some extent if it is sustainable. In the Green Star SA, wood is the only recognized renewable resource. In addition to the impact on external environment caused by the development and production of materials, indoor environment and the health of residents are also involved in green buildings. In order to guarantee the health of residents, it is necessary to treat the harmful substances in the construction materials and in the indoor environment based on the green building standards.

19.6 Green Development of Different Enterprises

The greening of government departments is expected to accelerate the development of the green building industry in South Africa. For example, the new headquarters built by the Department of International Relations and Cooperation and the Department of Water Resources and Environmental Affairs, and the provincial legislature building in Petermaritzburg are all green buildings. There has been a clear trend towards sustainable building in government tenders, with green design and financial feasibility playing an important role in the tender evaluation process.

South Africa's banking sector has been at the forefront of greening, and sustainability will increasingly be at the forefront as a differentiating factor and new operating point for enterprises. Phase II of Riley Bank is one of the first two projects to register for a Green Star rating in South Africa, and it received a 4 Star certification in 2009.

Green buildings focus on the use of locally manufactured building materials, so suppliers must try to meet the product demand. In South Africa, large paint manufacturers have begun producing non-toxic and low-VOC paints that meet GBCSA standards; the cement and brick industries are also moving their products toward environmental-friendly standards. In addition, the property development and retail sectors are also turning to environmental-friendly practices under the Green Rating tool.

19.7 Cases

- Case 1: 2010 FIFA World Cup Stadium in South Africa

South Africa, the host of the 2010 FIFA World Cup, needed to upgrade the existing stadiums and build new ones to meet the standards required to host the event. The Department of Environmental Affairs and Tourism (DEAT) of South Africa conducted a review of the green levels of the stadiums in Cape Town and Durban. The assessment listed all greening measures in the stadium design related to water, energy, waste and materials, and rated them according to "good practice", "cutting-edge practice" and "best practice".

Cutting-edge practices include: hybrid turf combing synthetic and natural grass; water-cooled variable refrigerant cooling systems that reduce irrigation by 50%; parking lot CO_2 monitors that turn on fans only when necessary; and low-emitting surfaces. Best practices include: rainwater harvested from cisterns for irrigation; mesh fabric combining insulation panels (to reduce heat absorption) and natural ventilation;

purchase of “green energy” for the stadiums; and reuse of materials demolished from old stadiums. To further enhance the greening level, the responsible department also proposed measures such as the building management systems, sewerage treatment facilities, intelligent drip irrigation system, etc.

- Case 2: Building of World Wide Fund for Nature

Located in Johannesburg, the building of WWF has received a 6 Star green building certification and is the first renovated building in South Africa to receive the honor. The project reflects WWF’s approach to environmental protection and natural resource conservation, and to reduce the building’s dependence on water and electricity by implementing water-related interventions. Specifically, the building not only features a roof garden that uses rainwater to water plants, but has also installed an on-site waste-water treatment unit that reuses treated water within the building.

20 Landscaping for Urban Spaces and High Rises (LUSH) in Singapore

In Singapore, the LUSH programme has been designed to reconcile the seeming contradiction between continued urban development and the desire to have greener cities in which to live and work. Under the management of the Urban Redevelopment Authority (URA), the LUSH programme helps transform Singapore's cityscape into a greener, more aesthetically-pleasing environment.

20.1 Background

Implemented in close collaboration with private sector partners, the LUSH programme was introduced in 2009 as a consolidated urban and skyrise greening scheme comprising incentives and requirements. It capitalises on development as a means to inject more greenery into the city and the premise is simple – to partially replace the greenery that has been taken away as a building is developed or redeveloped.

Under the programme, developers can provide landscaped replacement areas on the ground, rooftops or mid-level sky terraces. Greenery can be in the form of landscaping, roof gardens, sky terraces or planter boxes. Members of the public or occupants of the buildings should have easy access to enjoy communal areas.

2014 saw an expansion of the geographical coverage and development types in the scheme under LUSH 2.0, to include non-landed residential, commercial, mixed-use and hotel developments. Since 2017, the project has moved into a further stage of development: LUSH 3.0.

20.2 Project Overview

The 2017 instalment of LUSH featured enhancements such as:

- Encouraging landscaping on walls and roofs of buildings. These features beautify the buildings, provide visual relief and cool the ambient temperature.
- Making greenery more relevant to current needs by incorporating sustainability-related uses such as urban farms and communal rooftop gardens. In response to feedback from the industry on making better use of rooftops, rooftop urban farms could now contribute towards the landscape replacement requirements in developments. Developers and building owners were also encouraged to use rooftop spaces for urban farming, solar panels, communal roof gardens and greenery in lieu of mechanical and electrical equipment. The relocated equipment space can be exempted from gross floor area computation.
- Guiding developers and building owners on the amount of greenery in their buildings by introducing a Green Plot ratio (GnPR) standard. GnPR is a measure of the density of greenery within a site. The standard would apply for developments providing replacement landscape areas, provide transparency for the industry and safeguard the quality of greenery provided by developments.

20.3 Project Highlights——Encouraging more innovative and better rooftop design

URA had extended the guidelines in LUSH 3.0 to allow more uses on rooftop space in commercial and hotel buildings. Previously, covered mechanical and electrical (M&E) equipment transferred away from the rooftop to one of the top three floors directly below the roof could be exempted from Gross Floor Area (GFA)

computation if the rooftops were used for activity-generating uses like leisure and recreation. Applicants can now apply for this GFA incentive if they propose urban farming, solar panels co-located with communal roof gardens and green roofs at rooftops. This will support sustainability objectives to improve food resilience, increase take-up of renewable energy, enhance community bonding and enhance Singapore's green coverage.

Funan, a recently renovated downtown mall, is one such development that embraced LUSH 3.0, with its incorporation of rooftop urban farms that are open for the public to enjoy.

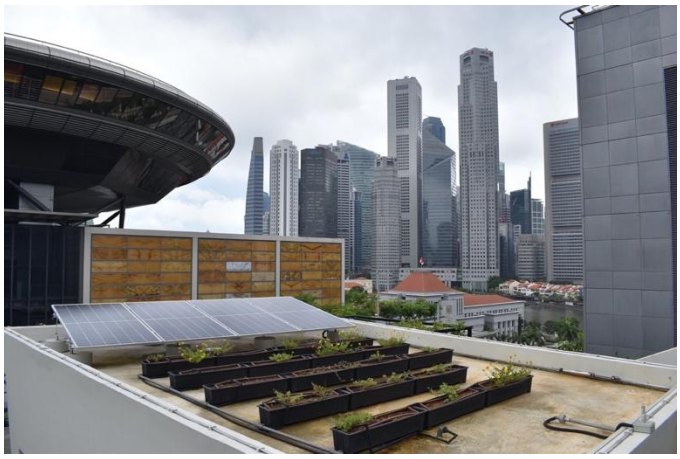

Figure 8-1 Funan (Credit: Urban Redevelopment Authority of Singapore)

Figure 8-2 Funan (Credit: Urban Redevelopment Authority of Singapore)

Figure 8-3 Funan (Credit: Urban Redevelopment Authority of Singapore)

20.4 Expected Impact (environment, economic, social etc.)

URA regularly engages industry stakeholders to solicit feedback, as well as to keep them updated on the latest urban redevelopment trends and ideas, so that URA can work hand-in-hand with the industry to continue to inject urban greenery. Industry has been highly supportive of the LUSH programme.

Since the LUSH programme was initiated, greenery has become an increasing norm in Singapore's built environment, actively injected into the design of sites which have undergone development.

To date, the programme has played a key role in introducing more than 250 hectares of greenery over the past decade, equivalent to about 400 football fields. LUSH has also contributed significantly to high density clusters like the key commercial and business area in Singapore, and other new growth nodes and regional centres.

The LUSH programme is part of overall efforts to achieve Singapore's vision of becoming a 'City in Nature' over the next decade. This is especially important as Singapore is a land-scarce country with many existing dense, built-up areas, and programmes such as LUSH allow people to experience the harmonious co-existence of greenery and the built environment in enhancing a city's liveability.

Apart from LUSH, Singapore has coordinated efforts to incorporate greenery wherever possible. Aside from parks, greenery has also been introduced along roads, pedestrian footpaths and integrated within utility buildings. These are examples of how greenery can be imbued within a densely built-up city, thus allowing people to appreciate the benefits of greenery and its importance within the urban environment.

20.5 Case Summary

Singapore has been attaching great importance to creating a green and livable environment for the people. It is also a key strategy to develop Singapore as a garden city. The Landscaping for Urban Spaces and High Rises (LUSH) Program introduced by the government of Singapore is a comprehensive urban greening scheme that could effectively expand the coverage of green space. In 2014 and 2017, the government launched LUSH 2.0 and LUSH 3.0 respectively with an expansion of the geographical coverage and development types in the scheme, pushing forward urban greening into a further stage.

21 Fuzhou Renewable Energy Building Application Pilot Demonstration City[8]

Fuzhou has an important location within China's 21st Century Maritime Silk Road, is a national new area, a pilot free trade zone, as well being a demonstration zone for independent innovation and ecological civilization. In this context, Fuzhou has actively integrated into the Belt and Road Initiative (BRI), accelerated the expansion of opening up and international cooperation and made considerable efforts to promote green and low-carbon development. Fuzhou was listed as a "National Demonstration City for Renewable Energy Building Applications" and a "National Key City for Energy Efficiency Improvement in Public Buildings" in 2009 and 2015 respectively. From 2018 to 2021, with the support of the C40 Cities Climate Leadership Group, the C40 China Buildings Programme was piloted in Fuzhou, focusing on the application of renewable energy in buildings. In this programme, Fuzhou adopted building energy efficiency policies and actions, accelerated capacity building and experience sharing, and vigorously promoted the application of renewable energy technologies in buildings. All these actions supported Fuzhou to contribute to the national goals of carbon peaking by 2030 and carbon neutrality by 2060.

21.1 Background

In 2019, Fuzhou had a resident population of 7.8 million, an urbanisation rate of 70.5% and a regional GDP of RMB 939.2 billion, achieving rapid economic growth for multiple years (see Figure 8-4). With rapid economic development and rising living standards, the total energy consumption of buildings in Fuzhou has reached 6.16 million tonnes of standard coal, accounting for 22% of the city's total energy consumption and generating a significant portion of carbon dioxide emissions. As such, targeted measures to reduce building energy consumption and emissions are required in Fuzhou. With a maritime subtropical monsoon climate, Fuzhou also has considerable demand for cooling in the summer and partial heating in the winter, as well as a demand for domestic hot water in civil buildings. According to the results of energy audits in recent years, the energy consumption of air-conditioning and heating, as well as domestic hot water in civil buildings, accounts for more than 60% of total building energy consumption in Fuzhou. The focus on reducing energy consumption in buildings has been primarily targeted on how to reduce energy consumption for air conditioning, heating and domestic hot water.

[8] This case study was prepared by China Buildings Programme of C40 Cites Climate Leadership Group and Hu Daming, Lu Guanli, Tian Yuan from C40 partner Fujian Academy of Building Research Co., Ltd..

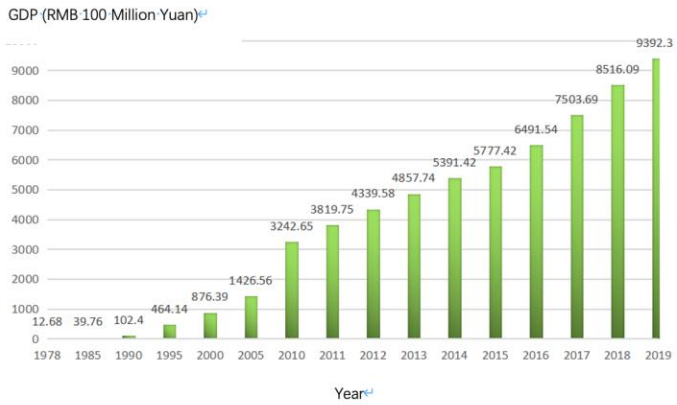

Figure 8-4 Gross National Product (GNP) of Fuzhou by Year [1]

The natural resource endowment of Fuzhou provides the city with strong conditions to support the effective deployment of renewable energy building applications. Firstly, the annual sunshine hours in Fuzhou range from 1900h to 2000h, with an annual guaranteed rate of 45% or more, and the total annual radiation is 4200MJ/m2 to 5200MJ/m2, which is conducive with the application of solar thermal and photovoltaic technologies. Secondly, Fuzhou is located in the lower reaches of the Min River (see Figure 8-5), with rich surface water resources of 130.6 billion m3, as well as suitable water temperature and excellent water quality, making the city suitable for the application of water-source heat pump technology. Finally, with Fuzhou's maritime subtropical monsoon climate, the city is relatively warm and humid throughout the year with short winters and long summers. It has an average annual temperature of 16℃~20℃, with an average temperature of 6℃~10℃ even in the coldest months, January to February; and an average temperature of 24℃~29℃ in the hottest months, July to August, making it suitable for the application of air-source heat pump hot water technology.[2] With these favourable renewable energy application conditions, Fuzhou has the potential to significantly reduce building energy consumption and greenhouse gas emissions through the application of water-source heat pump technology, solar thermal and air-source heat pump hot water technology, solar photovoltaic technology and other renewable energy sources in buildings.

Figure 8-5 Min River (Fuzhou section)

21.2 Project Overview

In order to explore the potential of renewable energy technologies in buildings in Fuzhou, the city took the opportunities presented through being selected as a "National Demonstration City for Renewable Energy Building Applications" and a pilot city for the C40 China Buildings Programme. As part of the C40 China Buildings Programme the city worked to develop renewable energy policies that combine mandatory and incentive measures, improve technical standards for renewable energy, and accelerate the promotion and application of various renewable energy technologies. As of December 2020, Fuzhou has promoted the implementation of 65 renewable energy building application projects (see Table 8-1), including flagship projects such as an air-source heat pump hot water project at the Union Hospital, a solar thermal project at Fuzhou University, a solar photovoltaic project at the Fujian Academy of Building Research, and a water-source heat pumps project in the Eastern Office District of Fuzhou, covering a total building application area of 4.79 million square metres and encompassing different types of renewable energy building application technologies (see Figure 8-6 and Figure 8-7). Through the application of these renewable energy demonstration projects, Fuzhou has been able to reduce carbon dioxide emissions by 30,700 tonnes per year (see Table 8-1) highlighting the emissions mitigation potential of such technologies.[3][4].

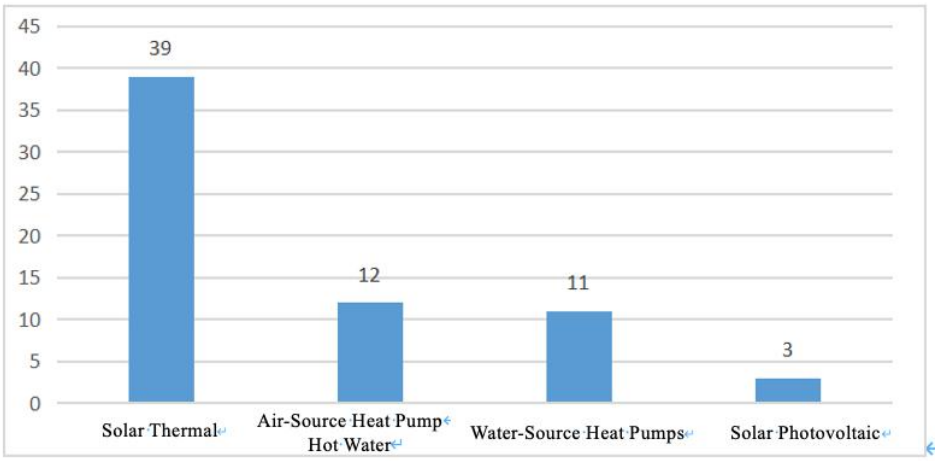

Figure 8-6 Number of demonstration projects of renewable energy building applications

(a) Air-Source Heat Pump Hot Water Project at the Union Hospital

(b) Solar Thermal Project at Fuzhou University

(c) Solar Photovoltaic Project at the Fujian Academy of Building Research

(d) Water-Source Heat Pumps Project in the Eastern Office District of Fuzhou

Figure 8-7 Projects of typical technologies

Table 8-1 Carbon emission reduction calculation for demonstration projects of renewable energy building applications in Fuzhou

No.	Type	Number	Area (10,000 m^2)	Carbon emission reduction (tCO_2/a)
1	Air-Source Heat Pump Hot Water	12	67	7476
2	Solar Thermal	39	181	10144
3	Solar Photovoltaic	3	7	1295
4	Water-Source Heat Pumps	11	224	11785
Total		65	479	30700

21.3 Green Development experience

21.3.1 Formulation of Renewable Energy Application Policies

In recent years Fuzhou has formulated a set of comprehensive policies relating to the application of renewable energy for buildings, helping to promote technologies such as air-source heat pump hot water systems and solar water heating systems through a combination of mandatory and incentive policy measures. A development plan for renewable energy building applications was first formulated in 2009, focused on developing targets and priorities for these applications and acting as a step-by-step guide for their roll-out and implementation.

21.3.1.1 Formulating incentive policies

In December 2018, in order to promote the application of renewable energy technologies such as solar thermal technology, solar photovoltaic technology, air-source heat pump technology and water-source heat pump technology in energy-saving renovation projects, Fuzhou organised a team of experts to conduct an economic analysis of the application of these technologies, began the revision of the *Interim Measures for*

the Management of Special Subsidy Funds for Energy-saving Renovation Demonstration Projects in Existing Public Buildings in Fuzhou, and formulated incentive policies to raise the subsidy standard from RMB20/m^2 to RMB40/m^2 for school buildings that had adopted renewable energy technologies.

21.3.1.2 Formulating mandatory policies

In November 2020, Fuzhou released the mandatory policy document *Notice on Further Promoting the Application of High-Efficiency Air-Source Heat Pump Technology in Renovation Projects of New Buildings and Existing Buildings* after policy research, expert demonstrations and a thorough suitability analysis of these renewable energy technologies. The policy clearly requires that: 1) public buildings with centralized hot water demand (such as hospital wards, hotels, dormitories, etc.) should select an appropriate renewable energy technology according to technical and economic conditions; 2) new residential buildings should be designed with solar hot water systems or reserved for sub-family installations of air-source heat pump hot water systems that meet relevant requirements; 3) project design, drawing review, construction supervision and acceptance, and other management requirements are met. As such, this policy is already playing a significant role in scaling the application of efficient solar hot water and air-source heat pump technology and the promotion of renewable energy for buildings in Fuzhou.

Figure 8-8 Expert peer review on the application of renewable energy technologies in buildings

21.3.2 Capacity Building of Supporting Techniques

21.3.2.1 Establishing an expert committee for renewable energy building application

To support this work Fuzhou set up an expert committee on renewable energy building applications, including a team of experts across the fields of architecture, structural design, equipment installation and operation, renewable energy design, as well as construction and engineering costs experts. This committee was therefore convened to provide strong technical support and review capacity, ensuring that implementation, supervision and post-operation evaluations of demonstration projects was well executed.

21.3.2.2 Improving supporting standards for renewable energy technologies

Paying attention to the geography, climate and natural resources of Fuzhou, the city organised specialist research on the applicability of renewable energy sources such as solar thermal technology and shallow water-source heat pump technology. Fuzhou has also worked to gradually improve the technical standards and specifications for renewable energy building applications. A range of relevant local standards and codes have now been officially promulgated and implemented, such as the *Regulations for the Application of Integrated Technology of Solar Hot Water and Air-Source Heat Pump Systems in Civil Buildings*, the *Technical Regulations for the Application of Ground-Source*[9] *Heat Pump Systems in Fujian Province*, the *Regulations for the Application of Photovoltaic Systems in Buildings* and the *Energy-Saving Design Standards for Residential Buildings in Fujian Province*. In addition, in order to summarise the types of renewable energy technologies applicable in Fuzhou, the city has organised the compilation of the *Guidelines on Operation and Management of Renewable Energy Application Projects in Fuzhou* and the *Technical Guidelines on Acceptance and Assessment of Renewable Energy Building Application Projects in Fuzhou* to guide the scientific design of renewable energy application systems for demonstration projects. Fuzhou has also developed demonstration project monitoring software to provide technical support for the promotion of renewable energy applications.

Figure 8-9 Compilation of standards related to renewable energy building applications

21.3.3 Dissemination and Communication of Demonstration Projects

21.3.3.1 Promoting technology uptake

In order to promote the application of renewable energy technologies in Fuzhou and to enable designers of various professions, construction drawing examiners and other relevant personnel to grasp the new standards, the city organised and carried out dissemination meetings on the *Technical Regulations for the*

[9] In China, water-source heat pump technology is included in the general ground-source heat pump technology category.

Application of Solar Photovoltaic Systems in Buildings, *Energy-saving Design Standards for Residential Buildings in Fujian Province* and other standards. Furthermore, the training sessions were held for technical personnel in the fields of architectural design, construction drawing review, technical consulting and other relevant units and construction administrative departments, helping to improve their technical and management capacities.

Figure 8-10 Standards dissemination meeting

21.3.3.2 Technology sharing and exchanges

The Fuzhou city government regularly organises various forms of technical exchanges on the application of renewable energy in buildings for administrators and technical staff. For instance, officials in charge of the Fuzhou Urban and Rural Construction Bureau and the Fuzhou C40 project team have participated in several C40 China Regional Forums and presentations to promote technical exchanges between Fuzhou and other C40 cities. At the same time, these partners have actively carried out research and technical exchanges on renewable energy building applications and summarised models for promoting the applications. In addition, by hosting such events as the 10th Green Building Technology Forum for Tropical and Subtropical (Hot Summer and Warm Winter) Regions, Fuzhou has promoted joint discussions on issues relating to green building development, renewable energy building applications and feasible technical routes. Through these technical exchanges and discussions at home and abroad, a good foundation has been laid for a key concept termed “going out and bringing in” - relating to bringing in relevant policies and technology applications for renewable energy and for buildings in Fuzhou.

(a) C40 China Regional Forum

(b) Special Report on C40 Projects in Fuzhou

(c) Solar Thermal Project On-Site Survey

(d) The 10th Green Building Technology Forum for Tropical and Subtropical Regions

Figure 8-11 Technology sharing and exchanges

21.3.3.3 Promotion of demonstration projects

In order to enhance the promotion and publicity of this prject, Fuzhou organised experts to conduct a comparative study of renewable energy projects implemented in recent years based on their effectiveness. As a result they selected eight high-quality projects such as Minjiang College, Fujian Engineering College and Fuzhou University to become “Fuzhou Demonstration Projects of the C40 China Buildings Programme”. The Projects were promoted and awarded at the 10th Green Building Technology Forum for Tropical and Subtropical (Hot Summer and Warm Winter) Regions.

Figure 8-12 “C40 China Buildings Programme – Fuzhou Demonstration Projects” Awarding Ceremony and Certificate

21.4 Case Summary

In recent years, Fuzhou has taken multiple measures to achieve better results in the promotion, application and demonstration of renewable energy in buildings, with the following experiences: firstly, Fuzhou insists on ensuring technology suitability, carries out research on the application of renewable energy technologies in combination with local natural resource conditions and develops sophisticated technical standards for renewable energy building applications; secondly, when ensuring technical feasibility, the city develops a combination of mandatory and incentive policy measures; finally, the city has actively carried out renewable energy technology exchanges, publicity and promotion through multiple channels and worked to stimulate market momentum by guiding and supporting local stakeholders to apply appropriate renewable energy solutions in buildings . Through combining efforts and paying attention to technology as well as policy and market conditions, the application of renewable energy in Fuzhou is set to develop in a sustainable, effective and healthy manner.

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[2] Fujian Academy of Building Research: Report on Renewable Energy Utilization Technology in Buildings, the Third Sub-topic of Fujian Science and Technology Major Special Project "Research and Application Demonstration of Key Technologies for Building Energy Efficiency" (2008HZ0003-1).

[3] Fuzhou Urban and Rural Construction Bureau: Acceptance and Evaluation Report of Demonstration City of Renewable Energy Building Application.

[4] Wang Shanshan et al. Assessment of Energy Savings and Carbon Emission Reduction in Fuzhou Pilot Accelerated Renewable Energy Building Application. Construction Science and Technology.

Conclusion

The green and sustainable development of cities is an unavoidable issue in the way to achieve sustainable development worldwide. The city is of vital importance to the realization of sustainable development. The development of cities needs to coordinate economic growth, environmental protection and the well-being of the people. To this end, effective communication and cooperation among cities are necessary. For one thing, China and BRI participating countries are faced with a series of environmental challenges brought by rapid urbanization. For another, cities could work together to promote transformation through replacing traditional development models with sustainable development modes, providing intelligence and solutions to addressing biodiversity degradation, natural resource shortage, waste management and pollution.

Governments and cities need to engage in extensive cooperation to promote experience sharing and coordination among BRI participating countries in the development of green cities. We need to enhance policy dialogue on BRI green city development, and make full use of BRIGC and BRI Environmental Big Data Platform to facilitate policy exchange, experience sharing and mutual learning of best practices in green city development. We need to strengthen the alignment of standards and technical specifications on green cities among BRI participating countries, especially in key areas such as green energy, green buildings and green transportation, to build livable cities with the harmonious coexistence of human and nature. We also need to enhance communication and cooperation among governments, research institutions and businesses in BRI participating countries to identify major issues and priority areas for the green transition of cities, carry out pilot programs for the development of climate-resilient cities, and produce replicable experience. Let’s work together to improve the environmental quality and promote the development of BRI participating countries and take concerted actions for the early realization of 2030 SDGs.