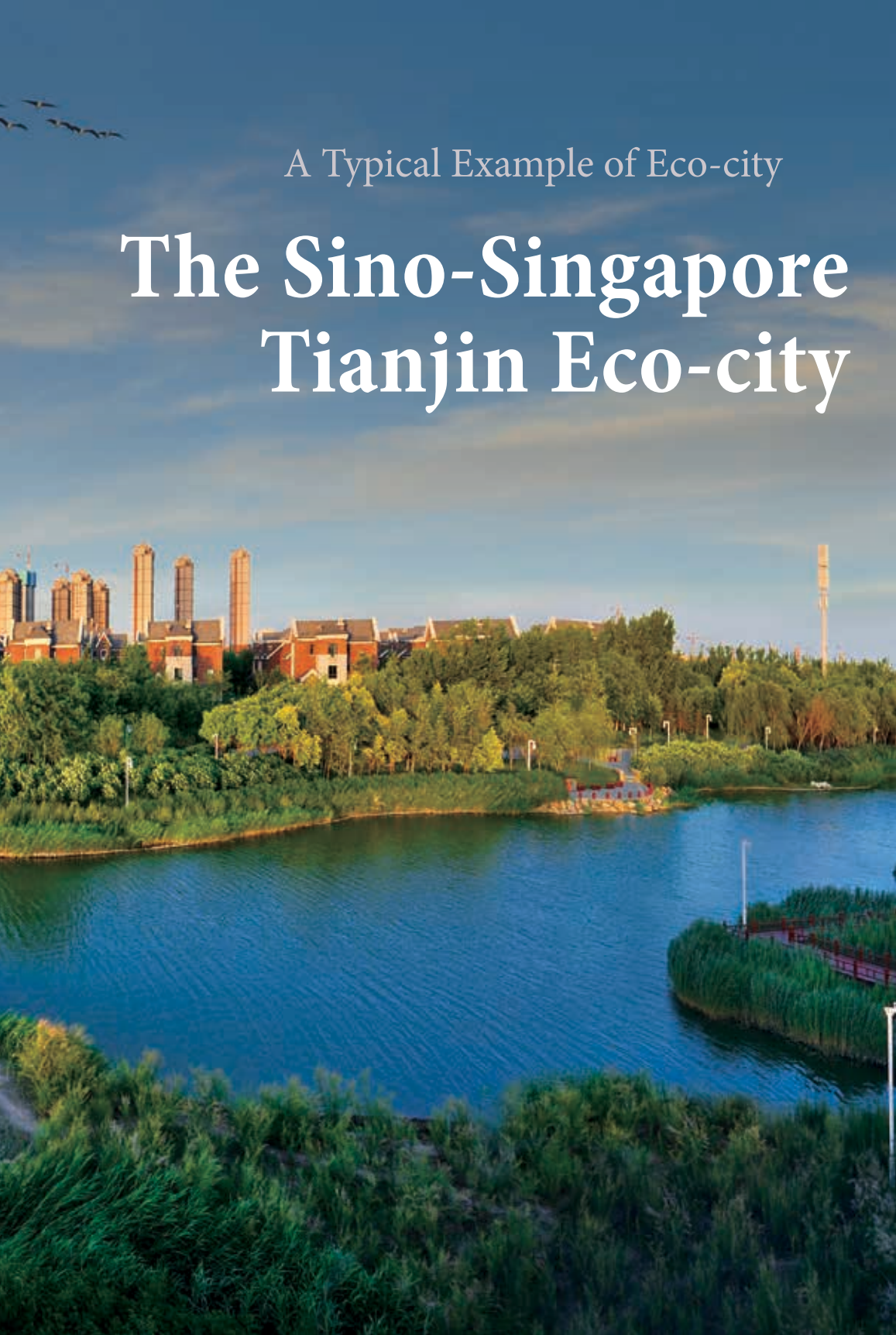
A Typical Example of Eco-city

The Sino-Singapore Tianjin Eco-city



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中国生态城市研究院
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中新天津生态城
CHINA-SINGAPORE TIANJIN ECO-CITY

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The Tianjin Eco-city Administrative Committee (ECAC) was set up by the Tianjin Municipal Government to oversee the planning and development of the project. The Eco-city site is located 40 km from Tianjin city Centre and 150 km from Beijing city centre. It has a land area of 30 km^2 and is planned for a population of 350,000 residents

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Part 1

Background and Orientation

This section describes the Sino-Singapore Tianjin Eco-City's (TEC) origin and development orientation, in particular, the history and future of the eco-city.

In 2007, the idea of such an eco-city was formed. This was a strategic plan of China and Singapore to tackle the major challenges faced in terms of climate change, building a harmonious society, and sustainable development. It was a major decision by the two countries to further develop a mutually beneficial cooperation and to deepen the partnership based on the earlier success of the Suzhou Industrial Park. The project was in line with the trends of the times, and would meet the current needs of China. China responded to Singapore's project proposal and quickly started the site selection and business negotiation processes. Six months later, Tianjin Binhai New Area was officially chosen as the site for the eco-city project.

The leaders of the two countries have great expectations for the project. They emphasised that the eco-city was a flagship project for the governments of China and Singapore, and was of great significance in terms of the economy, the environment and as a model. The eco-city should be constructed with resource conservation, environmental friendliness, social harmony and economic prosperity to create a template for the sustainable development of other cities in China. The eco-city should strive to ensure that its people live in harmony with other people, economic activities and the environment, and that the model must be practicable, replicable and scalable. The project was more than just the building of an eco-city, but should also explore a new path of sustainable urban development and accumulate relevant experience as a reference for other cities. On this basis, China made it clear that the project should be situated in areas with a poor natural environment and lack of water resources, to highlight the significance of the eco-city as a model for urban development with limited resources.

The eco-city can be seen as a pioneering, exploratory and experimental city where new concepts, methods and technologies on sustainable development were widely adopted. It was constructed as a world-leading eco-city. It served as a model and benchmark for all-round urban development, encompassing different aspects such

as the economy, society, environment, planning, construction and management. It is a city that features green, low-carbon, circular and sustainable development, and is the first large-scale urban development through international cooperation. It is a city built on a saline-alkali wasteland, meaning that it started with nothing, making it a perfect urban development model.

Chapter 1

Choosing Tianjin

Summary

This chapter explains the background and processes of choosing Tianjin as the location for the eco-city project and the basic conditions for site selection.

The key considerations behind the proposal of the eco-city project were manifold. First, the eco-city would demonstrate the determination of both China and Singapore to tackle the serious challenge posed by climate change. Second, in view of China's rapid, large-scale urbanisation, there was a need to explore new ways of developing cities in a sustainable, coordinated and healthy manner. Third, considering the remarkable success of the China-Singapore Suzhou Industrial Park, both countries sought to explore further avenues of cooperation and partnership.

Tianjin was chosen for the eco-city project for several reasons. The city met the overall requirements and guiding principles of both countries. It reflected the value of building an eco-city with limited resources and met Singapore's preference in terms of location – lying within the jurisdiction of the two cities that form the Beijing-Tianjin corridor. Furthermore, Singapore had prior experience in investment and development projects in Tianjin. Importantly, Tianjin was also well-prepared and proactive in securing the project. Naturally, the leaders and leading ministries of both China and Singapore supported this project, lending impetus to the formation of the eco-city in Tianjin. Close interaction and smooth communication between China and Singapore also acted as a catalyst during the project's formative stages.

One-third of the site selected for the eco-city consisted of abandoned salt farms, one-third was polluted water bodies and one-third comprised abandoned alkali fields. The area basically did not cover any arable land. It lacked water resources, had a fragile ecosystem and its environment was deteriorating. However, the surrounding transportation system and energy infrastructure were favourable, meeting the selection requirements and principles of both China and Singapore.

The eco-city project proposal came at the right moment, in line with the international community's initiatives to deal with climate change and exploration of sustainable urban development. The proposal was also especially timely in the context of China's search for a different development model amidst increasing urbanisation. It only took half a year to complete the complicated preliminary work, starting from the project proposal to final site selection. This was a remarkable record, possible only through strategic planning and intensive coordination.

1. Background

Demonstrating the determination of China and Singapore in tackling climate change: The international community's response to climate change began with the adoption of the *United Nations Framework Convention on Climate Change* on 15 December 2007. The *Kyoto Protocol*, adopted in December 1997, specified the different types of greenhouse-gas emission reduction, timetables and quotas for major developed countries. However, it was difficult for developed and developing countries to reach a true consensus on the setting of emission reduction targets, and the completion of emission reduction tasks set out in the *Kyoto Protocol* was fraught with difficulties. At the UN Climate Change Conference in late 2007, the *Bali Road Map* was passed with difficulty. As the largest developed country and the largest developing country respectively, the United States and China have attracted much attention from the international community on this issue of climate change. On 30 May 2007, the State Council issued the *National Program on Climate Change*, which listed the specific targets, basic principles, key areas and policy measures for China to tackle climate change by 2010. The initiation of the eco-city in the same year was a major initiative by China to demonstrate to the international community its determination and positive attitude in tackling climate change.

Exploring a model for sustainable urban development: The period around 2007 was an important stage in the accelerated development of China's urbanisation and industrialisation. Due to China's level of economic development and large population, the resources per capita were low. With the further development of China's economy, energy consumption and carbon dioxide emissions were bound to c ontinue increasing. To date, no country has achieved a high GDP per capita while keeping energy consumption per capita low. Given the challenges of resource constraints and environmental pollution, there was a need to explore a different model for sustainable urban development for Chinese cities.

Further developing the Sino-Singapore partnership: China and Singapore are geographically close, culturally similar, and have a long history of friendly ties. The two countries established diplomatic relations on 3 October 1990. Since then, the leaders of both countries have maintained frequent high-level exchanges. Economic and trade relations between the two countries have also experienced sustained and rapid development. China has a large market, enjoys rich labour resources and possesses a robust industrial base, while Singapore's competitive edge lies in areas such as capital, information, technology and management. Thus, the economic structures of both countries are highly complementary. From February 1994, in order to learn from Singapore's experience in social governance and economic development, China began working with Singapore to develop the Suzhou Industrial Park. By leveraging Singapore's planning principles and experience in management, the Suzhou Industrial Park was able to maintain rapid economic and social development. The park quickly became an internationally competitive and influential development zone. The success of Suzhou Industrial Park not only paved the way for future joint initiatives between China and Singapore, but also provided a successful model for the rapid implementation of the eco-city project.

The background and significance of building an eco-city were reflected in multiple agreements between China and Singapore. As the *Framework Agreement* states: "The development of the Eco-city will demonstrate the determination of both countries in tackling global climate change, strengthening environmental protection, conserving resources and energy, and building a harmonious society, thus serving as a model for sustainable development for other cities in the PRC." In June 2007, Singapore submitted a concept plan for the eco-city: "Singapore has experience in optimising land use, water recycling and construction of an eco-city, as well as advanced technologies and an efficient management system. Based on the success of the Suzhou Industrial Park, both countries will continue to work together to construct a new eco-city. This partnership will help us acquire the necessary experience and technology, as well as promote sustainable models for urbanisation."

It is worth mentioning that Singapore has always paid close attention to international trends and China's development needs. Singapore is adept at viewing issues strategically and subsequently proposing major joint initiatives of mutual benefit. Many of these proposals have been implemented successfully, as is the case for the Chongqing Connectivity Initiative in 2015. Singapore's concept plan states: "Taking a global perspective, rapid economic development not only puts pressure on the environment through energy consumption, water shortage, greenhouse gas emissions and pollution, but also creates social challenges. This poses serious challenges to a country's social harmony and sustainable development. Recognising China's needs in these areas, Singapore is proposing a cooperation project with China to build a model city for sustainable development. This will be in line with the objectives of environmental protection and building a harmonious society mentioned in China's 11th Five-Year Plan. This covers a broader agenda than just an eco-city project. The joint initiative has two main goals: the first is to share current knowledge and experience in sustainable urban development; and the second is to jointly develop new technologies to achieve this goal. The success of this project will prove to the world that Singapore and China are committed to combining rapid economic growth with sustainable development and social harmony. It will balance the demands of society, economy and environment, and lay a solid foundation for the prosperity of both current and future generations; it will become a mutually beneficial flagship project between Singapore and China. We will implement this project concurrently with the Suzhou Industrial Park project, which still remains an important pillar of our partnership, as well as the Sino-Singapore free trade agreement to further develop the Sino-Singapore partnership."

2. From proposal to signing of agreement

Project proposal: On 25 April 2007, then-Chinese Premier Wen Jiabao met with Singapore's then-Senior Minister Goh Chok Tong, who was on a work visit to China, at Zhongnanhai. Mr Goh said: "A lot of Chinese cities hope to work with Singapore on projects similar to the Suzhou Industrial Park, but this is an old model. I suggest developing a new mutually beneficial model and piloting it in a small city or in an urban area of a major city in China. Leveraging Singapore's beneficial experience in urban development, we can cooperate on public housing, modern sanitation, water treatment and utilisation projects to transform the city or urban environment into a model of sustainable economic development. If Premier Wen supports this proposal, we can discuss it in detail during the Joint Council for Bilateral Cooperation." Mr Wen noted: "I agree with Senior Minister Goh's views. Building a resource-conserving and environmentally-friendly society is China's major concern. Singapore has a lot of experience in this area and we can learn from each other. Both sides can work on this cooperation at Suzhou Industrial Park or in Suzhou, or we can choose another city as well. This issue can be discussed at the meeting of the Joint Council for Bilateral Cooperation."

Construction principles: In July 2007, then-Vice Premier Wu Yi and Singapore's Deputy Prime Minister Wong Kan Seng co-chaired the fourth meeting of the Sino-Singapore Joint Council for Bilateral Cooperation. Mr Wu pointed out that the cooperation between China and Singapore to build a new eco-city should pay attention to four aspects, and the cooperation should possess a powerful demonstration effect. First, the project should emphasise resource conservation, recycling and an environmentally-friendly approach, including not occupying arable land. Second, it must comply with the requirements of relevant Chinese laws, regulations and national policies. Land acquisition must be consistent with relevant statutory rules, and the implementation and management of the plan must be consistent with China's legal procedures. Third, there was a need to enhance the capacity for independent innovation and develop applicable technologies suitable in the Chinese context and protected by independent intellectual property rights. Fourth, it was essential to maintain a separation between the government and enterprises, clearly define the division of responsibilities between local governments and Sino-Singapore commercial joint entities, and strive to resolve issues of new municipal public facilities in the eco-city through market mechanisms. Site selection for the new eco-city was heavily influenced by the challenges arising from China's large population, land scarcity and limited resources. Furthermore, in view of Singapore's strengths, coupled with the need for the eco-city to act as a model for other cities, two key principles came to guide the process of site selection. First, the choice of location had to reflect its significance as a demonstrative model for the building of a new eco-city with limited resources, especially on non-arable land and areas where water resources were scarce. Second, the eco-city had to be within the proximity of central cities. This would minimise the cost of infrastructure construction by leveraging the well-developed transport and service systems in major cities. China proposed four possible cities in the eastern and western regions, namely Urumqi, Baotou, Tianjin and Tangshan. The finalised location was then decided through discussions between the two sides.

Site selection discussions: In order to be selected as the site for the eco-city, Tianjin city underwent meticulous preparation and proactive coordination with the relevant parties. On 25 July 2007, Tianjin city set up an eco-city site selection team comprising 13 government agencies with the Party Secretary of Tianjin Municipal as the team leader. Efforts leading up to the site-selection were extensive, consisting of the then- Party Secretary of Tianjin, Zhang Gaoli and then-Mayor of Tianjin, Dai Xianglong communicating with, and reporting to, the Ministry of Construction and Ministry of Land and Resources repeatedly. Additionally, they met with several leading figures of Singapore, such as Singapore's then-Minister Mentor Lee Kuan Yew, then-Deputy Prime Minister and Minister for Home Affairs Wong Kan Seng, then-Minister for National Development Mah Bow Tan, Senior Minister of State (National Development) Grace Fu, Singapore's Ambassador to China Chin Siat Yoon, Deputy Secretary (Ministry of National Development) Chionh Chye Khye, and Chairman of Keppel Corporation Lim Chee Onn. They also accompanied Singapore's delegation to survey the three sites proposed by Tianjin city multiple times.

On 3 August, the Ministry of Construction convened the first meeting of Chinese Preparatory Working Group for the Sino-Singapore Eco-city Cooperation and listened to the reports from the city governments of Tianjin, Urumqi, Tangshan and Baotou regarding the site selection for the eco-city. In early September, Tianjin's Binhai New Area and Tangshan were selected as candidate cities after several field visits and discussions between China and Singapore.

On 17 October, the Ministry of Construction held a meeting to study the evaluation indicators (nine major items and 46 minor items) for the sites proposed for the Sino-Singapore eco-city and put forward suggestions for improvement.

On 6 November, the Ministry of Construction received reports from Tianjin and Tangshan on the Sino-Singapore eco-city project. On 7 November, the Sino-Singapore Joint Working Committee (JWC) held a meeting in Beijing to discuss the location of the eco-city. On 10 November, the Ministry of Construction held a meeting to discuss the location of the Sino-Singapore eco-city, where it emphasised that the construction of the eco-city should set standards with global influence and significance, acquire internationally recognised achievements, and fulfil the requirements of sustainable development. It evaluated Tianjin and Tangshan based on six standards: compliance with economic benefits and ecological standards, regional and specific layout, preliminary site selection discussions, short-term feasibility and basic conditions, independent innovation and technological advantages, among other promised conditions. This provided a comprehensive evaluation of the site selection for the Sino-Singapore eco-city project.

On 12 November, the Ministry of Construction held a special meeting to discuss the reports on the Sino-Singapore eco-city project that were submitted to the State Council, and agreed in principle to the *Request for Submission of the Draft Agreement and Site Selection Plan on the Sino-Singapore Eco-city Project, Opinions on the Comprehensive Evaluations of the Sino-Singapore Eco-city Project,*

Supplementary Agreement to the Agreement Signed between the Government of the People's Republic of China and the Government of the Republic of Singapore for the Construction of an Eco-city in the People's Republic of China.

On 14 November, the Ministry of Construction forwarded the opinions of the various Chinese ministries and Singapore to Tianjin, officially selecting the Tianjin Binhai New Area as the site of the project. It was also requested that Tianjin city fulfil 13 indicative requirements of the eco-city project. On 15 November, Tianjin city submitted the *Sino-Singapore Eco-city Implementation Scheme to the Ministry of Construction*.

On 18 November 2007, then-Premier Wen Jiabao of the State Council and Singapore's Prime Minister Lee Hsien Loong signed the *Framework Agreement*, and then-Minister of the Ministry of Construction of China Wang Guangtao and Singapore's then-Minister for National Development Mah Bow Tan signed a supplementary agreement for the *Framework Agreement*, which signalled that Tianjin Binhai New Area was chosen as the site for the eco-city.

Business negotiations: While surveying and determining the site for the Sino-Singapore eco-city, a series of discussions was carried out concurrently, including two important and in-depth business negotiations.

On 8 October 2007, Singapore's then-Senior Minister of State for National Development Grace Fu led a 12-member Singapore delegation for the Sino-Singapore eco-city project to Tianjin. During the visit, then-Mayor Dai Xianglong met with Ms Fu. The two sides exchanged views pertaining to the site selection plan and the 24 issues spanning eight areas raised by Singapore, including the name and vision statement, overall development strategy, social harmony, economic activities within the eco-city, creating suitable conditions for growth, infrastructure, energy and environment, formation of a Sino-Singapore consortium, etc. Through these discussions, the two sides deepened their understanding of the eco-city project and reached a basic consensus on significant matters such as developmental goals and strategies of the eco-city, infrastructure construction plans, the current state of environmental pollution and remedial measures, related supporting policies and the appropriate model of cooperation.

From 25 to 29 October 2007, Singapore's then-Minister for National Development Mah Bow Tan, Deputy Secretary Chionh Chye Khye and other officials visited Tianjin city, and discussed in detail issues such as the various forms of cooperation, land costs, taxes, pollution control, municipal infrastructure and the construction of public welfare service facilities. After several rounds of talks, both sides reached an agreement on the management system, developmental model, land transfer pattern, land price, infrastructure construction, public facilities construction, environmental governance, supporting policies, construction schedule and other key issues, securing a foundation for the signing of a future commercial agreement between both parties and accelerating the pace of development and construction work.

3. Site Overview

Tianjin Eco-City is located in Tianjin Binhai New Area, a pivotal strategic area of China's national development situated between Tanggu and Hangu, near the Tianjin Economic and Technological Development Zone and Tianjin Port. It is west of the Bohai Sea, east of the Jiyun River, north of the Yongding River and south of the Jinhan highway. It occupies a total area of 30 square kilometres (Figure 1-1) and is 150 km away from Beijing and 45 km from Tianjin city centre. Multiple highways and high-speed railways pass through the surrounding areas, including the Beijing-Tianjin-Tangshan Highway, Tianjin-Binhai Highway, Jingjintang Expressway, Jingjin Highway, Jinbin Expressway, Yanhai Expressway and Tangjin Expressway (Figure 1-2). In other words, it has clear advantages in terms of accessibility and location.

Tianjin Eco-City is located northeast of the North China Plain, a typical marine plain. Its main landforms are silt-heavy beaches, coastal plains, uneven and flat grounds and flood land. The terrain is generally five metres above sea level, with a majority of it under three meters above sea level (Figure 1-3). The land originally comprised mostly salt pans with a high level of soil salinity (Figure 1-4). The regional water bodies are the Jiyun River, as well as Hangu sewage reservoir, both of which were affected by high levels of pollution (Figure 1-5). The area suffered from a scarcity of water resources and the ecological environment had deteriorated severely (Figure 1-6). The annual average temperature of the area was 11.9C. Annual average precipitation was 572.7 mm and annual average relative humidity was 66%. Annual average sunshine stood at 3,100.2 hours.

This area was home to what was considered the first large-scale salt pan in feudal China, with the legend of the "Salt Mother" becoming the cradle of China's sea-salt culture. The Jiyun River, which wound through the city, was an ancient canal used during the period of the Three Kingdoms. The original name of the Jiyun River ("运粮河", meaning "transporting grain") has appeared in ancient records since the Liao dynasty. During the Yuan and Ming dynasties, large amounts of building materials were transported directly from Northeast China and the surrounding seas to Jizhou through the Jiyun River. During the Yuan dynasty, 600,000 stones of military food supplies were transported to

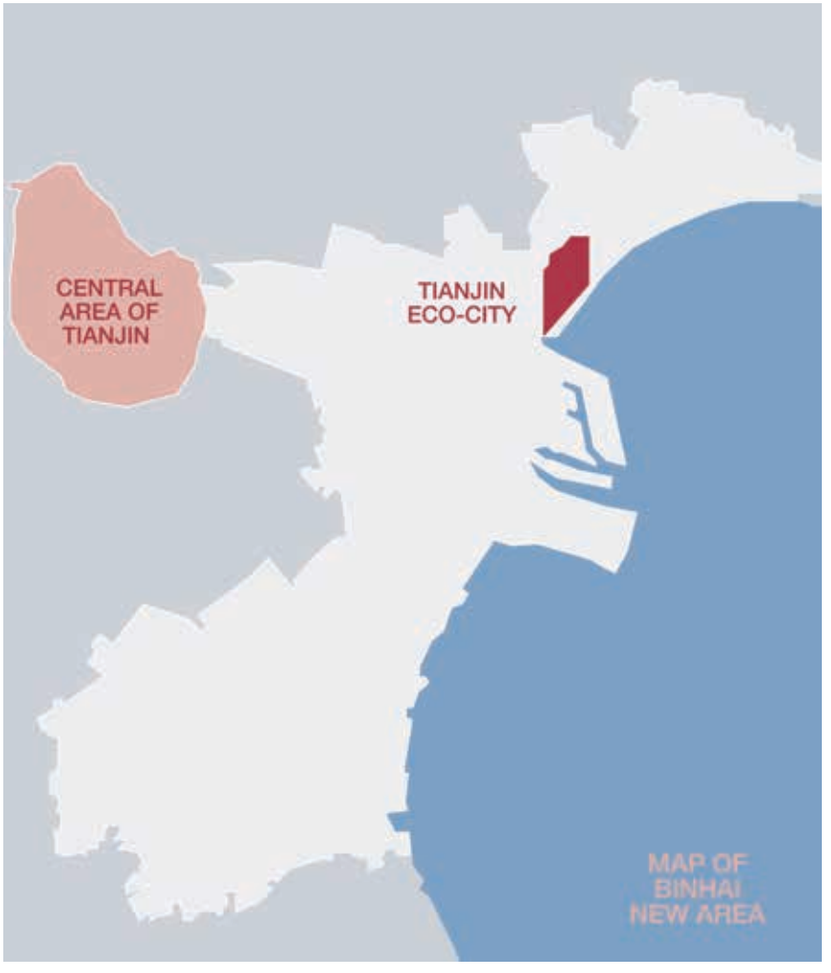


Figure 1-1: Location of the eco-city

Figure 1-2: Eco-city's Regional Transportation Analysis

the border every year. During the early Qing dynasty, Du Lide, an illustrious prime minister living in Liangcheng city near the Jiyun River, acquired fertile land downstream along the Jiyun River on behalf of the Ministry of Works to produce reed, salt, whitebait and other special tribute goods for the imperial court—they were all deemed excellent by the court. In the 1950s, the army built the Bayi salt pan, which covers an area of 10 km^2.

Figure 1-3: Original Landscape of the Eco-city

Conclusion: The proposal to build an eco-city is the embodiment of Singapore's emphasis on strategic planning. With successful strategic planning, it is possible to defy expectations and yield twice the results with half the input. Indeed, it only took a little over half a year for the eco-city project to move from the drawing board during the proposal phase to the official signing of the agreement, a record for such a big project. This was thanks to the top-down push and intensive work of both countries. Eventually, Tianjin emerged as the top choice to host the eco-city. Besides external factors such as good timing, geographical advantages and social conditions, Tianjin city also worked diligently to secure the project, a fact that should be applauded. Therefore, it should not lose sight of its initial aspirations, and strive to build up the project so as to propel Tianjin city onto the international stage and take the lead in becoming China's "green namecard."

Figure 1-4: Alkali Soils

Figure 1-5: Polluted Waters

Figure 1-6: Cracked Earth

Chapter 2

Development Direction

Summary

This chapter describes the discussions between China and Singapore during the early stages of construction, confirmation processes and the subsequent expansion direction of the eco-city's development.

China and Singapore engaged in in-depth study and discussions on the eco-city's development direction. Based on its experience in urban construction, Singapore proposed that the eco-city should realise "three harmonies and three abilities", i.e., "people living in harmony with other people; people living in harmony with economic activities; and people living in harmony with the environment; while ensuring that the eco-city is practicable, replicable and scalable". China, on the other hand, defined the orientation as: resource conservation, being environmentally-friendly and social harmony. Both sides agreed that the essence of the eco-city is "sustainable development", and China and Singapore made it clear in the *Framework Agreement* that the eco-city should serve as a model of sustainable development for other cities.

Through this process, China and Singapore were able to establish a common understanding and consistent mode of expressing the direction of development. Clarity in terms of the development direction and plan for implementation was achieved in the *Framework Agreement, Supplementary Agreement, Supplementary Agreement II, Commercial Agreement, and Joint Venture Contract*.

In 2013, the State Council approved the eco-city as a "National Green Development Demonstration Zone", and emphasised that the eco-city should be constructed as "a demonstration zone for the establishment of an ecological civilisation, an innovation zone for green systems and mechanisms, and a source of green concepts and cultures." These further deepened and expanded the eco-city's development mission.

The eco-city was first conceptualised in a project proposal by the governments of China and Singapore, and was gradually refined through interactions between both countries during site selection and business negotiations. Subsequently, the direction of the eco-city was defined in agreements between both countries and the master plan, and further elaborated on during the construction phase.

1. Preliminary Discussions

During the initial stages of construction, China and Singapore engaged in frequent discussions that varied in levels of intensity, encompassing issues such as the eco-city's development direction, vision, mission and name. Of these discussions, the opinions expressed during the two meetings by both countries' leaders and the three discussions between Singapore's Ministry of National Development (MND) and Tianjin proved essential in guiding the project.

The spirit of discussions on the development direction between the leaders of China and Singapore. When the then-Senior Minister of Singapore Goh Chok Tong proposed the eco-city project to the then-Premier of the State Council Wen Jiabao, he mentioned three aspects. First, the eco-city should strive toward the development of a new model of mutually beneficial cooperation between the two countries. Second, Singapore's experience in urban development and construction should be leveraged to build an environmentally-friendly city in China and achieve sustainable development. Finally, Singapore's past experience in housing, sanitation and water treatment could also be used as a reference for the eco-city. Mr Wen responded and agreed with Mr Goh's proposal, raising the point that fostering a resource-conserving and environmentally-friendly society was a major concern for China.

On 6 September, 2007, Mr Wen and Mr Goh met again. The latter declared that the eco-city project possessed immense significance and would have to meet the two conditions proposed by China, i.e., it must not occupy any arable land and that the site must be located in an area lacking water resources. Singapore believed that in order to make this project a success, a few other elements were required. First and foremost, the project had to achieve sustainable development. Apart from this, it should have a positive effect on business and commerce and should be easily replicated in other locations. The project's location should be close to the city centre to attract people and foreign investments. Preparation of the land slated to be used for the eco-city was intended to be brief, with preliminary construction estimated to take two to five years, and

basic completion was expected within 10 years. Mr Wen said that the construction of the eco-city was a new highlight of Sino-Singapore cooperation. The cooperation between the two countries in Suzhou Industrial Park was comprehensive and included not just industrial cooperation, but also cooperation in terms of management and human resources. In the same vein, it was expected that the eco-city would feature similarly all-encompassing cooperation. Therefore, in principle, China agreed with Mr Goh. The ecological environment is a worldwide concern, so the project is of great significance economically, environmentally and as a demonstration model. The scope of cooperation should include a circular economy, environmental protection, ecological construction, renewable energy utilisation, use of reclaimed water, etc.

Discussions on the development direction between Tianjin city and MND. On 6 June, 2007, Singapore proposed an overall discussion plan for the eco-city project: "Our goal is to build a prosperous and harmonious green city with residences, office buildings, educational and research institutions, businesses, parks and recreational areas. In this green city, people will live in harmony, enjoy high-quality living, perform efficient economic activities and minimise the consumption of natural resources to protect the environment. This project must be practicable, replicable and scalable. Being practicable means that the technologies adopted must be affordable and commercially viable, with no exception for cutting-edge technologies. Being replicable and scalable means that the project's technologies can be adopted in other cities in China and even in other countries. We would not want to construct an artificial experimental city that looks good but cannot be replicated, or is expensive to build. In short, the concept of this city should be centred on 'three harmonies' and 'three abilities'. The 'three harmonies' refer to people living in harmony with other people (including both current and future generations); people living in harmony with economic activities; and people living in harmony with the environment. The 'three abilities' refers to being practicable, replicable and scalable." The letter made a special mention of the project's name: "The project must be given a suitable new name that reflects the significance afforded to it by the top leaders of both countries and embodies its broad objectives." China carefully studied Singapore's concept proposal and raised the site selection principles and requirements for the eco-city project (see Chapter 1).

On 8 October, 2007, a Singapore delegation visited Tianjin with the Keppel Group's Eco-city Project Questionnaire, which included 24 items in eight areas, many of which involved the eco-city's orientation.

Of these, the first item was "Name and Vision Statement": "The vision of the eco-city is to be 'a city featuring economic prosperity, social harmony, being environmentally-friendly and resource conservation' – a model of sustainable development. The suggested Chinese translations for the key terms were: 'economic prosperity, social harmony, being environmentally-friendly, resource conservation, and a model of sustainable development'. An innovative name had to be chosen to clearly reflect the goal of the eco-city. Both "eco-city" and "green city" are terms that are too commonly used, and an alternative is Sino-Singapore Xinhe City." During the talks, Tianjin city said: "We agree with Singapore's vision statement for the eco-city and the Chinese translations of the key terms. We suggest that both sides set up a joint team to perform an in-depth and meticulous preliminary study of the purpose, guiding ideology and principles for planning and construction, development goals, and KPIs Framework for the eco-city, so as to create favourable conditions to begin the construction of the eco-city as soon as possible. Regarding the name of the eco-city, we agree to use 'Sino-Singapore Xinhe City' as one of the main alternatives. In our opinion, its name should reflect the following areas: first, the cultural background of China and Singapore; second, the essence of 'three harmonies'; third, it should reflect modernity; and fourth, it should be easy to remember and sound good. Both parties can study and discuss this further based on the above aspects.

The second item was "Harmony between the People and Society": "The concept of the eco-city focuses on three harmonies, i.e., people living in harmony with other people (current and future generations); people living in harmony with economic activities; and people living in harmony with the environment. The purpose of the eco-city is not just to present a tangible, environmental and ecological solution, but it should also build a solid social structure that promotes and drives social harmony. This social structure refers to a set of values and concepts that governs the activities, behaviours, and connections between people and organisations, which will stimulate the development of a harmonious society with a green and high-quality living environment in an economically developed city. Building a tough social structure involves the implementation of strong social systems, including public policies, market mechanisms, social education and awareness, public housing, and support from the governments and people at all levels." Tianjin city responded: "The construction of the eco-city will fully reflect the "Scientific Outlook on Development" proposed by the Chinese government and the development concept of a harmonious society. Currently, the city has attached great importance to social construction in the

development process, establishing a housing security system consisting of indemnificatory housing, commercial housing, etc., as well as a compulsory education system. The construction of the eco-city should focus on the study and resolution of the issues in the following four areas: first, administrative organisation structure; second, legal framework, including law enforcement system; third, social organisation structure; and fourth, livelihood system, including public rental housing, civil organisations, etc. We can learn from Singapore's advanced and mature development concepts and models to promote greater harmony in society.

In early November 2007, Singapore put forward the Key Points of the Eco-city Project and proposed "a high-quality environment featuring economic prosperity, being environmentally-friendly and social harmony that integrates lifestyle, work and entertainment as one" as the eco-city's slogan. Singapore believes that the eco-city should be a garden city with resource conservation and clearly proposed a series of KPIs including transportation, resource utilisation and waste recycling. Singapore emphasised that the eco-city should create an open and inclusive neighbourhood: a neighbourhood that is safe and healthy, that caters to different economic and social groups, with very strong cohesiveness and a sense of belonging, and where everyone is involved in planning and management to constantly strengthen the sense of ownership of every member of the neighbourhood. These ideas were incorporated into the KPIs Framework and master plan of the eco-city that were jointly developed by China and Singapore, and implemented in subsequent development and construction processes.

2. Singapore's Experience in Liveability Framework

Singapore proposed the idea of building and developing an eco-city based on its basic experience in urban development (Figure 2-1). In the process of building liveable cities, Singapore has always focused on three key objectives – a competitive economy, a sustainable environment, and high quality of life – and strived for balance and coordination among them. Singapore uses two key approaches – "integrated master planning and development" and "dynamic urban governance" – to monitor the liveable city outcomes on a continuous and long-term basis, and to inject a certain flexibility to maintain the city's liveability and prosperity.

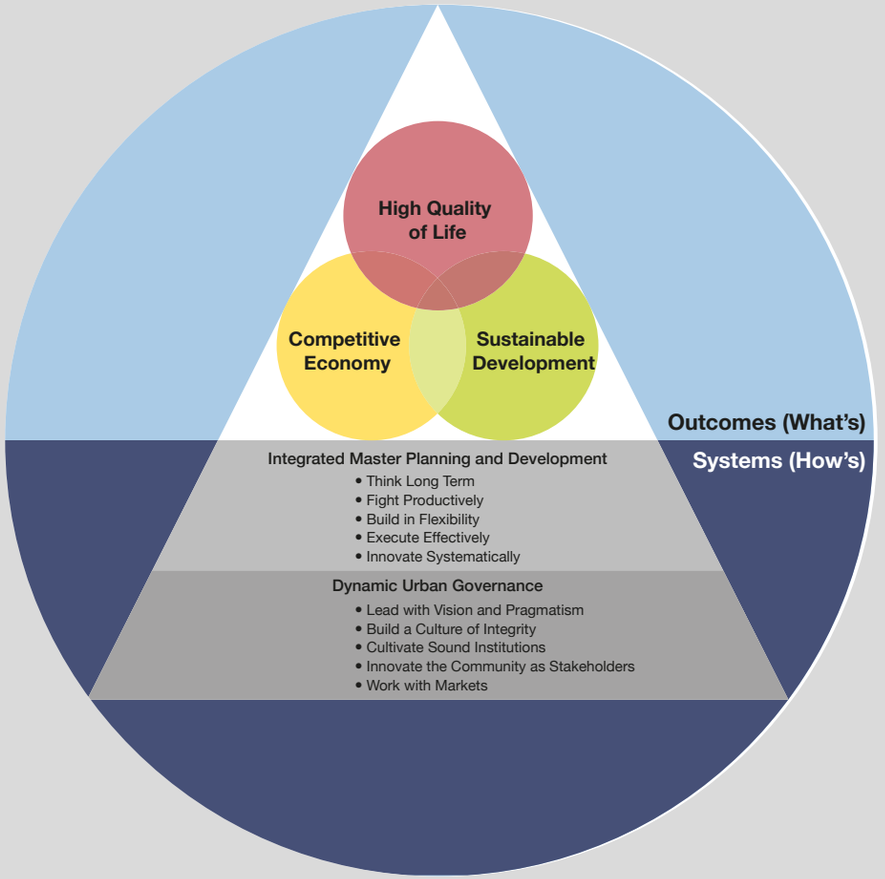


Figure 2-1: Singapore's Liveability Framework

Liveable City Outcomes

In 1992, the United Nations Conference on Environment and Development (UNCED) posited that the social, environmental and economic needs of a country must be met in balance with one another. The real challenge is to find the best trade-offs at every stage of development.

Outcome 1: A competitive economy that attracts investment and provides jobs;

Outcome 2: A sustainable environment, because the city has to survive with limited natural resources, especially in terms of land and water; and

Outcome 3: High quality of life, including the social and psychological well-being of the population.

A competitive economy provides security for the basic livelihood of the residents. In Singapore, harmony between the people and the economy is reflected in the mutual promotion of urban planning and construction and economic development. Singapore's land, infrastructure, public utilities, transportation and other urban systems supported its economic development. Singapore has to survive with limited natural resources, so the country's economic development will never come at the expense of the environment. Since the early stages of development, the country has included in its long-term strategic blueprint the aim of creating a sustainable environment and plan for clean air, clean water and green cover. With economic security and an excellent environment, Singapore must also protect the interests of the people by creating high quality of life that is centred on the people and focused on the provision of high-quality housing, security, health facilities and public healthcare systems, while taking into account different aspects such as accessibility, sense of security, culture and sense of community. Singapore is committed to balanced development involving three areas: economy, environment and people, as well as the efficient use of its limited resources. It has been practically proven that the economy, environment and high-quality life do not contradict, but complement, one another.

Integrated Master Planning and Development

Integrated master planning and development enables the government to create and operate an urban system that balances long- and short-term goals and priorities in order to adapt to the changing political, economic, and social environment. What makes Singapore's planning system unique is precisely the fact that it emphasises scientific, comprehensive and pragmatic implementation. Singapore's integrated master planning is based on five implicit principles: to think long-term, fight productively, build in some flexibility, execute effectively, and innovate systematically.

"Think long-term" means that government agencies should be able to think proactively to predict possible challenges in the future and take preventive measures as soon as possible. Singapore's Concept Plans determine a land use plan for up to 50 years to ensure a rational and compliant use of its limited land resources.

"Fight productively" means that, with the support of political leaders, government departments are strongly encouraged to proactively explore their respective concerns through an inter-agency structure and find a balance through effective discussions. To execute planning policies, Singapore has also set up a number of executing agencies. The effective execution of planning policies also relies on inter-institutional cooperation. Both political leaders and ordinary civil servants are dedicated to the development of Singapore with a sense of crisis and mission.

"Build in some flexibility" means that as the future is ultimately unpredictable, the master plan cannot remain unchanged, but should be periodically reviewed and revised. Some flexibility is afforded in the execution of the master plan, such as reserving spare land and setting an order of priority in the project development schedule to ensure that there is room for adjustment.

"Innovate systematically" means that when urban development encounters bottlenecks, Singapore must have the courage to break from convention and innovate systematically. Due to the relative scarcity of land resources, Singapore is facing serious environmental constraints. Under such circumstances, Singapore has boldly planned projects such as Pulau Semakau Landfill, taking into account the needs of urban development, land and the environment, and successfully resolving many urban problems.

Dynamic Urban Governance

An emphasis on dynamic urban governance helps the government make the best decisions and choices in an unpredictable, complex and ever-changing environment while helping the society develop an ability to cope with different challenges. Dynamic urban governance involves five principles: to "lead with vision and pragmatism", "build a culture of integrity", "cultivate sound institutions", "involve the community as stakeholders", and "work with markets".

"Lead with vision and pragmatism" requires leaders to think for the long term, not to fear difficulties, and to systematically promote policies and programmes that will bring long-term benefits to the people.

"Build a culture of integrity" depends largely on Singapore's emphasis on accountability and transparency to enable its leaders to build credibility, legitimacy and impetus.

"Cultivate sound institutions" requires formal and institutionalised process designs that enable effective execution of the plan, as well as very formal governance norms that respect professional guidance in the various fields. Professionalism is an important feature of the Singapore government and many officials in the country are technical experts.

"Involve the community as stakeholders" turns the people into stakeholders. The public represents key social interests and the people's participation can effectively improve the correctness of decision-making and ensure that the development outcomes are more in line with the long-term interests of the public.

"Work with markets" enables the private sector to play its role and provide certain public services under the regulation and control of the government, which is one of the key principles of improving efficiency. The principle of working with markets is the use of market forces to enhance efficiency while exercising financial prudence to ensure financial sustainability and feasibility.

It can be seen that Singapore's liveability framework shares the same "three harmonies and three abilities" principle of the eco-city. The three outcomes above echo the "three harmonies", i.e., people living in harmony with other people, people living in harmony with economic activities and people living in harmony with the environment. The "three abilities", i.e., practicable, replicable and scalable, emphasises on pragmatism and the building of a model eco-city.

3. Development Direction Determination

China and Singapore made clear the development direction of the eco-city through a series of agreements and documents. To a certain extent, this ensured the high positioning, sustainability and practicability of the development direction.

The *Framework Agreement* between China and Singapore states: Tianjin Eco-City (TEC) should be built as an eco-city featuring "resource conservation, being environmentally-friendly and social harmony" and "a model of sustainable development for other cities in China". It should strive to achieve "three harmonies and three abilities", i.e., people living in harmony with other people, people living in harmony with economic activities and people living in harmony with the environment, and should be practicable, replicable and scalable.

The *Supplementary Agreement* between China and Singapore further refines the construction objectives of the eco-city, which include seven aspects: to (a) build a vibrant local economy with good environmental conditions, which offers opportunities for enterprises and innovation and provides job opportunities for the residents, (b) foster the formation of socially harmonious and inclusive communities, with residents who have a strong sense of ownership and belonging, (c) build an attractive, high-quality living environment, (d) adopt good environmental technologies and practices so as to facilitate sustainable development, (e) make better use of resources to reduce waste, (f) improve the overall living conditions of residents, and (g) serve as a reference for other cities in China in the management, technological and policy aspects of the development and protection of their ecological environment.

The KPIs Framework for the eco-city quantifies the development direction in four aspects: the health of the ecological environment, social harmony and progress, economic prosperity and efficiency, and regional coordination and integration. The first three include 22 controlling indicators, which correspond to the missions of "people living in harmony with the environment, people living in harmony with other people, and people living in harmony with economic activities", and "achieving resource conservation, being environmentally-friendly, and social harmony". In terms of regional coordination and integration, four guiding indicators were set up to echo the coordinated development of the region.

The Master Plan for the eco-city described strategic positioning of the region as: a comprehensive platform that applied and promoted technological innovation aimed at enhancing environmental protection, emissions reduction, green-building and the development of a circular economy, among others. Besides this, the strategic positioning in the region also comprised a national eco-environmental training and promotion centre, and a modern high-tech eco-industrial base. Furthermore, it also involved the aim of becoming a "resource-conserving and environmentally-friendly" model liveable city, acting also to display and demonstrate participation in the construction of the international ecological environment.

4. Expansion and Deepening of Development Direction

During the developmental process of the eco-city, especially in practical work (during the construction), it was found that the *Framework Agreement and Commercial Agreement* between China and Singapore served as the fundamental documents for the building of the eco-city, and there was a lack of official approval documents from the Chinese government. Tianjin city decided to apply for a national administrative approval document from the country. In 2012, Tianjin city and the National Development and Reform Commission submitted a request to the State Council for the construction of the eco-city as a national green development demonstration zone in China.

In March 2013, the State Council approved the construction of the eco-city as a national green development demonstration zone. The State Council requested that the eco-city follows the principles of giving priority to the ecological environment, being innovation-driven and being market oriented to promote green development, developing a circular economy and low-carbon development, and to serve as an example for China's exploration of intensive, intelligent, green and low-carbon new-generation urbanisation models.

In October 2014, the General Office of the State Council approved the implementation plan for the construction of the eco-city as a national green development demonstration zone. It requested that the eco-city highlight the construction of ecological civilisation (sustainable development), adhere to the focus of giving priority to the ecological environment, reform and innovation, being market-driven and coordinated development, and strive to optimise the urban space layout, promote green and low-carbon development, drive resource conservation and efficient recycling, and proactively cultivate a green culture. This will ensure that the eco-city is built as a liveable city with high productivity, affluence and a sound ecosystem, and set an example for new-generation urbanisation models with Chinese characteristics. The *Implementation Plan* specified the development goal of the eco-city as: by 2020, create a national development demonstration zone with KPIs of leading domestic standards, set an example for green development nationwide, and create a window for China to showcase its green development outcomes to the international community and a platform for international exchanges. The eco-city should to fulfil the main tasks in six areas including further optimisation of space layout, ensuring green and smart urban construction, resource conservation, environmental protection, green industry development, and innovation in green development systems and mechanisms, to realise the "three strategic orientations", i.e., being a demonstration zone for ecological civilisation (sustainable development) construction, an innovation zone for green development systems and mechanisms, and a source of green ideology and culture.

The construction of a national green development demonstration zone in China strengthened the role of the eco-city in highlighting urban green development and clarified the position of the eco-city in exploring new-generation urbanisation models with Chinese characteristics and serving as an example. In particular, the "three strategic orientations" are not only an extension of the mission of "three harmonies and three abilities", but also the expansion and deepening of the purpose of the eco-city. It brought the eco-city to new heights as an ecological civilisation demonstration zone and emphasised the innovation and leadership of the green development systems. The term "source of strategies" specified the innovative and practical requirements of the eco-city in green ideology and culture, endowing it with the mission of being a source, originator and driver.

Conclusion: The development direction of the eco-city is the result of repeated study and in-depth deliberation by both China and Singapore. A precise project orientation and appropriate project name, determined through accurate insights on external opportunities, in-depth exploration of regional advantages, enhancement of strengths and avoidance of weaknesses, highlighting features, and differential development, helps to create significant comparative advantages among intense competition to consolidate strengths, so as to fulfil the mission.

Part 2

Layout and Arrangement

This section is a follow-up to Part 1 Background and Orientation and describes the series of institutional arrangements made by China and Singapore for the eco-city after in-depth discussions on site selection and business negotiations. The section mainly includes:

The establishment of two high-level coordination mechanisms by China and Singapore, namely, Tianjin Eco-city Joint Steering Committee at the vice premier level and Tianjin Eco-city Joint Working Committee at the ministerial level.

Tianjin city's setup of the ECAC which featured streamlined, efficient, highly authorised and quasi-governmental operations.

Tianjin city's issuance of the Provisions on the Administration of the Tianjin Eco-City to form a legal basis for the development and construction of the eco-city.

Under the principles of separating government functions from enterprise management and market-oriented operation, the two sides established two market-oriented and joint-stock enterprises, namely, TECID and the SSTECID. This created development entities that operated independently, were responsible for their respective own profits and losses, and shared clear boundaries and capital relationships with government functions. This development model made the ECAC one of the few local administrative agencies in China that had no direct local debt.

China and Singapore jointly developed the standards for the eco-city and determined that construction standards must be of leading international levels. These standards provided guidance for the preparation of the master plan as well as subsequent development and construction.

The two sides jointly prepared the master plan to implement the requirements of the KPIs framework, and formulated corresponding systems to ensure consistent implementation.

This series of institutional arrangements laid a solid foundation for the development and construction of the eco-city. It formed the most basic, practical and valuable experience, which could be used in the preliminary planning and arrangements of a new city.

It should be noted that the eco-city was initiated through agreements between the two countries. China did not issue the master and implementation plans at the national level, and it was too late to formulate a package of supporting policies for green urban development. Five years later, the State Council approved the construction of eco-city as a national green development demonstration zone, which further improved the eco-city's top-level design.

Chapter 3

Administrative System

Summary

This chapter describes the original intention and process of establishing an administrative system for the eco-city and the operation of this system.

Singapore took the establishment of an administrative system for the eco-city seriously, and proposed the idea of creating a high-level Sino-Singapore joint deliberation mechanism together with a stable local administrative organisation and a high level of autonomy to ensure that the eco-city project would proceed smoothly, as well as policy continuity and commercial viability.

Using the Sino-Singapore steering mechanism of the Suzhou Industrial Park as a reference, China set up a Sino-Singapore Joint Steering Council for the eco-city and quickly formed a simple, efficient and highly authorised Eco-City Administrative Committee (ECAC) that is at the same level as a state department and operates in the form of a quasi-government.

China and Singapore institutionalised the Sino-Singapore Tianjin Eco-City Joint Steering Council through agreements. Tianjin city introduced the *The Regulations for Administration of the Sino-Singapore Tianjin Eco-City* to the govern vision, power and development model of the ECAC.

The establishment of an administrative system regulated through agreements agreed upon by China and Singapore ensured the stability and sustainability of the eco-city's implementation. Past experience has shown that a good administrative system is the cornerstone for the smooth progress and success of the eco-city.

1. Discussions between China and Singapore on an Administrative System for the Eco-city

The Sino-Singapore Joint Council for Bilateral Cooperation (JCBC) and the Sino-Singapore Suzhou Industrial Park Joint Steering Council laid a good foundation for the eco-city project.

In June 2007, a letter from Singapore specifically mentioned that attention from the highest levels of both sides is essential for this multi-faceted bilateral project to succeed, and a suitable intergovernmental framework should be set up to realise this goal. Singapore suggested the setting up of an independent joint steering council for the project, which would be co-chaired by the Vice Premier of China and Deputy Prime Minister of Singapore, who were also the co-chairs of the JCBC. JCBC is the most comprehensive and highest-level framework organisation for bilateral cooperation, hence the joint steering council for the eco-city should be guided by the JCBC. Hence, the distribution of responsibility among the following organisations is as follows: (1) JCBC: responsible for formulating the strategic goals and determining important and new cooperation projects that merit the attention of high-level leaders of both countries; (2) Joint Steering Council: responsible for determining the project's direction and scope and for drafting and implementing the relevant policies; (3) Joint Working Committee: responsible for resolving issues during the operation of the project.

On 7 July 2007, then-Vice Premier of the State Council of China Wu Yi said, during a meeting with then-Deputy Prime Minister of Singapore Wong Kan Seng, that the eco-city is a large-scale and comprehensive project that requires detailed planning and in-depth study from both sides. China had designated the Ministry of Construction (MOC) as its leading unit and suggested that the leading ministries of both sides first set up a joint working committee to discuss the relevant proposals within this framework based on the principles of "seeking truth from facts" and mutual benefit. The Chinese wished that further progress on the project could be made before then-Premier of the State Council of China Wen Jiabao's visit to Singapore in November that year. Hence, in August, the MOC and relevant ministries established the China Preparatory Working Group.

On 8 October 2007, then-Senior Minister of State (National Development) of Singapore Grace Fu led a delegation to Tianjin and met with then-Mayor of Tianjin Dai Xianglong. Singapore raised 24 issues in eight areas, of which, Item 15 was "Will the (Tianjin) Municipal Government set up a special administrative committee for the eco-city to ensure that there is only one point of contact for policies, regulations, government services, and other matters relating to the eco-city? Such an administrative committee should have in place, and should be able to accept and implement, policies and standards suggested by Sino-Singapore joint ventures." The Tianjin government responded: "We agree entirely with Singapore's proposal for setting up a special administrative committee to provide efficient administrative services for the eco-city. The specific name can be studied further."

In early November 2007, the MOC submitted the document titled *Request for the Submission of a List of Chinese Representatives and Their Functions in the Tianjin Eco-City Joint Steering Committee and Joint Working Committee* to the State Council of China.

On 15 November 2007, Tianjin city submitted the "Sino-Singapore Tianjin Eco-City Work Implementation Plan" to the MOC. The Plan proposed that both countries establish a cooperation mechanism to "standardise planning, collaborative development, government services and the processes to set up a company". Such mechanisms will help to promote the construction of the eco-city, and should be established at three levels: the first level is a joint steering committee between the Chinese and Singaporean governments to coordinate all important matters relating to the development and construction of the eco-city; the second level is the Sino-Singapore Joint Working Committee formed by the MOC, Tianjin Municipal People's Government (TMPG), and MND to study and resolve matters and issues relating to the development and construction of the eco-city, and to report any major issues to the joint steering committee; the third level is a work implementation organisation, the "Tianjin Eco-City Administrative Committee" established by the TMPG, which is led by one municipal leader, which will serve as a deployment organisation of the TMPG to administer this jurisdiction.

On 21 November 2007, then-Minister of Construction of China Wang Guangtao, met with then-Minister of MND Mah Bow Tan to discuss the working system of the joint working committee. The system was divided into three levels: the Tianjin Eco-City Joint Steering Committee (JSC), Tianjin Eco-City Joint Working Committee (JWC), and offices responsible for specific tasks. Mr Wang suggested that the TMPG should propose a plan for the preparation and establishment of the administrative committee and be responsible for the creation of the committee. The relevant laws and regulations should be drafted mainly by China, reviewed by the JWC, and approved for implementation by the TMPG. The first meeting of the JWC was held at the end of November that year.

2. Institutionalising the Administrative System

The *Framework Agreement* and *Supplementary Agreement* signed between China and Singapore, and the *Supplementary Agreement II, Commercial Agreement,* and *The Regulations for Administration of the Sino-Singapore Tianjin Eco-City* signed by the local government legalised and contractualised the Sino-Singapore steering mechanism and local implementation organisations for the eco-city (Figure 3-1).

Tianjin Eco-City Joint Steering Committee (JSC): Article 4 of the *Framework Agreement* stated that both sides should support and strengthen the guidance on the construction of the eco-city. The JSC should be established under the JCBC with both sides separately appointing a Vice Premier/Deputy Prime Minister to take charge, and representatives of the relevant ministries government agencies of both sides and TMPG as part of the committee. The JSC is responsible for coordinating all important matters relating to the development and construction of the eco-city.

Tianjin Eco-City Joint Working Committee (JWC): Article 5 of the *Framework Agreement* stated that both sides will establish a joint working committee with each side appointing one minister to take charge. The committee shall report to the JSC and study and resolve matters and issues relating to the development and construction of the eco-city. Article 6 of the *Supplementary Agreement* stated that a regular meeting and discussion mechanism of the joint working committee should be established. Responsibilities of the joint working committee are as follows: to negotiate important issues such as development goals and requirements, specific KPIs, mode of cooperation and other important matters pertaining to the eco-city, and report to the JSC; to supervise the performance of relevant agreements and implementation of the eco-city project work plan approved by the JSC; to resolve problems, disputes and difficulties arising from the performance of relevant agreements and the work plan; to study the scope of policies and implementation procedures of the eco-city, possibly using Singapore's experience as a reference; to submit to the JSC the agenda, work plans, opinions and suggestions that need to be deliberated on; and to complete

all necessary consulting, studies and reports required by the JSC. The JWC should give priority to the development of the planning, construction and operation management standard systems of the TEC and establishment of long-term evaluation and control KPIs framework to ensure scientific development of the eco-city.

Tianjin Eco-City Administrative Committee (ECAC): Article 1 of the *Supplementary Agreement* II signed by the MOC, MND, and TMPG stated that the TMPG should formulate The Regulations for Administration of the Sino-Singapore Tianjin Eco-City according to the constitution, laws and regulations. Article 2 stated that the TMPG should set up the ECAC and grant it full authority to exercise the relevant functions on behalf of the TMPG. Article 3 stated that the TMPG and relevant departments should create supportive policies for the construction and development of the eco-city, and the ECAC should be responsible for implementing there. Article 4 stated that the ECAC should sign commercial agreements on the development of the eco-city with joint ventures established by the Chinese and Singaporean consortiums. The Supplementary Agreement laid the foundation for the formulation of subsequent administrative regulations for the eco-city and authorises the ECAC to sign commercial agreements on behalf of the TMPG.

On 1 July 2008, the ECAC signed the Commercial Agreement with the proposed joint venture (signed by the Chinese and Singaporean investment consortiums), of which, Article 3.13(4) specified that the ECAC should provide one-stop services for the eco-city's development.

On 1 August 2008, *The Regulations for Administration of the Sino-Singapore Tianjin Eco-City* were passed and came into force by decree of the TMPG. The *Regulations* specified that the ECAC implements unified administration of the TEC on behalf of the TMPG. The *Regulations* also listed the duties and powers of the ECAC in terms of planning, economic development, administration and public management etc.

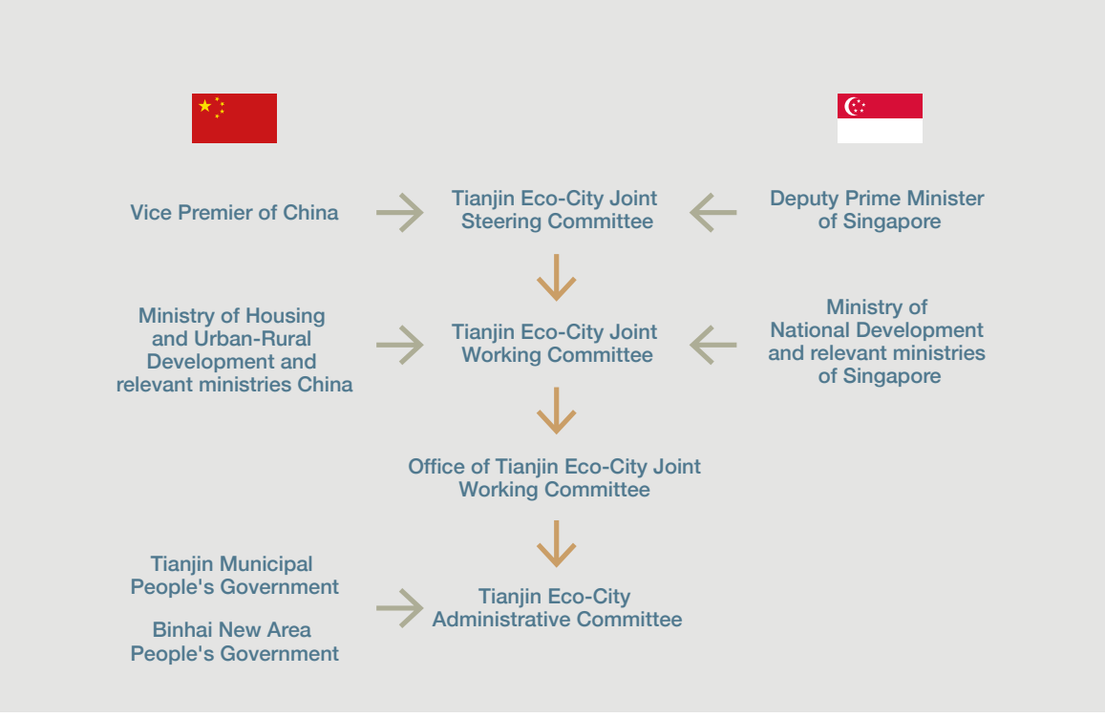


Figure 3-1: Schematic Diagram of Sino-Singapore Governmental Cooperation Mechanism

3. Establishment and Operation of Sino-Singapore Joint Steering Mechanism

In accordance with the spirit of agreements between both sides, China and Singapore established the JSC at Vice Premier/Deputy Prime Minister level and the JWC at ministerial level. For China, the leading ministry was the Ministry of Construction and member organisations included the General Office of the State Council, Ministry of Foreign Affairs, National Development and Reform Commission, Ministry of Commerce, Ministry of Science and Technology, Ministry of Finance, Ministry of Land and Resources, Ministry of Environmental Protection, State Taxation Administration, People's Bank of China, State Administration of Foreign Exchange, and Tianjin Municipality; for Singapore, the leading ministry was the MND and member organisations included the Prime Minister's Office, Ministry of Trade and Industry, Ministry of the Environment and Water Resources, and Ministry of Foreign Affairs. By December 2017, China and Singapore had held nine JSC meetings and seven JWC meetings, in which they listened to reports on the progress of construction and

development of the eco-city, studied significant matters, provided guidance for subsequent developments and implemented the relevant supportive policies and measures. The MND specially set up an Eco-City Project Office (ECPO) which was responsible for coordinating and driving matters pertaining to the construction of the TEC and assigned staff to work at the eco-city. China and Singapore also set up a Planning Group, Economy Group, Environment Group, Water Affairs Group, Public House Group, and Neighbourhood Group and other special work groups to engage in work exchanges in a prompt and efficient manner.

Table 3-1 Tianjin Eco-City Joint Steering Committee Meeting Schedule

Session	Date	Place	Chaired by	Main agenda
1st	3 September 2008	Tianjin	Wang Qishan Wong Kan Seng	To achieve sustainability in terms of resource utilisation, eco-environment, and development pattern, etc.
2nd	24 August 2009	Singapore	Wang Qishan Wong Kan Seng	To stay confident and jointly make the TEC another highlight following Suzhou Industrial Park
3rd	23 July 2010	Beijing	Wang Qishan Wong Kan Seng	To resolve the issues of water pollution control and saline-alkali soil improvement, etc., and jointly explore the future path of urban development
4th	27 July 2011	Singapore	Wang Qishan Teo Chee Hean	To strengthen technological innovation and system and mechanism reform, reduce costs, and become a demonstration project that is replicable, scalable and sustainable
5th	6 July 2012	Suzhou	Wang Qishan Teo Chee Hean	To support the TEC in the creation of a Green Development Demonstration Zone, strive to create a new path of coordinated development of ecology, economy and society, and set an example for sustainable urban development
6th	22 October 2013	Singapore	Zhang Gaoli Teo Chee Hean	The TEC 5-Year Development Outlook Report was passed, which strive to make the TEC a resource-conserving and environment-friendly green town, to provide replicable and scalable experience for China's promotion of new generation urbanisation and sustainable development
7th	27 October 2014	Suzhou	Zhang Gaoli Teo Chee Hean	Guided by the construction of National Green Development Demonstration Zone, to focus on industry development and improve the overall environment by paying attention to reform and innovation, and brining the development to new heights
8th	15 October 2015	Singapore	Zhang Gaoli Teo Chee Hean	Seize the strategic opportunity of Coordinated Development of Beijing-Tianjin-Hebei, insist on green development and innovation promotion, work to enhance regional attractiveness, competitiveness, and vitality, and accelerate the building of a National Green Development Demonstration Zone
9th	27 February 2017	Beijing	Zhang Gaoli Teo Chee Hean	Jointly planned for the celebration of the 10th anniversary of the TEC, proactively promote implementation of bilateral Sino-Singapore projects, and focus efforts on building an innovative cooperation platform with a high starting point and of high standards

Table 3-2 Tianjin Eco-City Joint Working Committee Meetings

Session	Date	Place	Chaired by	Main agenda
1st	31 January 2008	Tianjin	Wang Guangtao Mah Bow Tan	TEC KPIs Framework was reviewed and approved in principle.
2nd	8 April 2008	Singapore	Qiu Baoxing Mah Bow Tan	Tianjin Eco-City Master Plan was reviewed and approved in principle.
3rd	1 July 2008	Tianjin	Qiu Baoxing Grace Fu	The Detailed Preliminary Planning Scheme for Tianjin Eco-City Start-Up Area was reviewed.
4th	3 June 2009	Tianjin	Qiu Baoxing Mah Bow Tan	The Report on the Work of the Tianjin Eco-City was heard, and the Urban Design Scheme was reviewed.
5th	5 May 2010	Tianjin	Qiu Baoxing Mah Bow Tan	The Report on the Work of the Tianjin Eco-City was heard, and the KPIs Framework Breakdown Scheme was reviewed.
6th	2 April 2014	Beijing	Jiang Weixin Khaw Boon Wan	The Report on the Work of the Tianjin Eco-City was heard and the Tianjin Eco-City Vision Report was reviewed.
7th	28 April 2016	Tianjin	Chen Zhenggao Lawrence Wong	The Report on the Work of the Tianjin Eco-City was heard, and arrangements for future work were made.

Figure 3-2: The 3rd Meeting of JSC

Figure 3-3: The 7th Meeting of JSC

Figure 3-4: The 9th Meeting of JSC

Figure 3-5: The 2nd Meeting of JWC

Figure 3-6: The 3rd Meeting of JWC

Figure 3-7: The 7th Meeting of JWC

4. Establishment and Operation of the Local Administrative System

On 8 January 2008, Tianjin Municipal Committee of the CPC decided to establish the CPC Leading Group of Eco-City Administrative Committee. On 9 January, Tianjin Municipal Committee of the CPC and TMPG set up the Eco-City Administrative Committee (ECAC). In June 2008, Tianjin Planning Bureau approved "Sino-Singapore Tianjin Eco-City" as the project name, and the site name “Tianjin Eco-City”.

In January 2008, organisations within the ECAC included the General Office, Construction Bureau, Commerce Bureau and Environment Bureau. In March 2008, the Legislative Affairs Bureau and Finance Bureau were added, and the Eco-City Police Office was approved as a deployment organisation of the Tianjin Public Security Bureau, which was subject to the leadership of the ECAC. In September 2008, two fully government-funded institutions: Construction Management Centre and Urban Management and Law Enforcement Detachment were established.

In April 2009, the Tianjin Administration for Industry and Commerce Eco-City Branch was established and shared an office with the Commerce Bureau of the ECAC. In July 2009, the Construction Bureau added the plate of Land and Resources Bureau.

In December 2010, Tianjin Binhai New Area Committee of the CPC and Tianjin Binhai New Area People’s Government jointly issued the *Tianjin Eco-City Administrative Organisation Setup Plan*, specifying that the ECAC would be directly under the Tianjin Binhai New Area.

In July 2011, the Social Affairs Bureau, Human Resources and Social Security Bureau, and Economy Bureau were set up. In September 2011, the Eco-City Federation of Trade Unions was established, and organisations within the ECAC were converted into independent legal entities.

In April 2012, the Eco-City General Committee of the CPC was established. In May 2012, the two public institutions—Eco-environment Monitoring Centre and Neighbourhood Service Centre – were set up. In August 2012, Tianjin Binhai Foreign Language School was established. In September 2012, Tianjin Eco-City State-owned Assets Administration Co., Ltd. was established. In November 2013, Eco-City Library and Archives was established.

At the start of 2014, the Binhai New Area People’s Government issued notices on the issuing of a *Plan for Integration of Functional Areas of Binhai New Area and Plan for Adjustment of Administrative Division of Some Sub-districts and Towns of Binhai New Area*, to incorporate the 100 km^2 planning area of the Binhai Tourism Area and 18 km^2 planning area of the Central Fishing Port Economic Zone into the administrative range of the TEC; the development models, original policies, investment subjects, and other relevant agreements within the 30 km^2 planning area of the TEC would stay unchanged; the total planning area under the jurisdiction of the TEC would be 148 km^2 after the integration; and there would be 16 organisations within and 11 public institutions under the ECAC after the merger. In 2018, the number of public institutions reached 16.

Conclusion: The Sino-Singapore joint steering mechanism was an embodiment of the systems of the eco-city as a cooperation project between China and Singapore, and played an important role in guiding and supporting the construction and development of the eco-city. The ECAC was operated as a quasi-government, which provided strong protection for the eco-city to adopt innovative measures to promote green development. In order to achieve the mission of “three harmonies and three abilities”, the eco-city must further cement and realise the advantages of the systems and mechanisms of the simple, efficient and highly-authorised ECAC, and must achieve a sustainable, stable and solid legal basis and policy space through institutional development.

Chapter 4

Development Model

Summary

This chapter narrates the development model, characteristics, strengths and practical outcomes of the eco-city.

Under the underlying principles of separating government functions from enterprise management and market-oriented operation, Tianjin Eco-City Investment and Development Co., Ltd. (TECID) and Sino-Singapore Tianjin Eco-City Investment and Development Co., Ltd. (SSTECID) were established as market-oriented, shareholding and professional development enterprises.

In accordance with the status of being an "eco-city practitioner", TECID oversaw land acquisition and consolidation, and the construction and operation of infrastructure and public facilities to create an administration model that integrates investment, construction and operation of infrastructure as one.

As an "integrated regional developer", SSTECID oversaw the construction of infrastructure, development of the residential space and industrial park, and engaged in community building and regional promotion, thereby creating a new model of integrated land development.

Since the start of this project, the development model followed one which was government-led, enterprise-dominant and market-oriented. The enterprise-oriented and market-oriented systems effectively ensured the commercial viability of the eco-city.

1. Basic Principles

Separating government functions from enterprise management: It is made clear in the *Framework Agreement* between China and Singapore that a business consortium will be established to develop and construct the project. Under the principles of "separating government function from enterprise management and market-oriented operation", the relevant departments of both governments and the Tianjin Municipal Government respectively discussed and established enterprise entities to advance the development and construction of TEC. There was no equity investment relationship between the government and enterprises for TEC, drawing clear lines in terms of functions and boundaries. The Eco-City Administrative Committee (ECAC) was responsible for administrative management within the region, and TECID went one step ahead with land consolidation and the construction of infrastructure and public facilities. SSTECID was responsible for the management of land, construction of infrastructure and industrial parks, attracting investments, and property management for the TEC. The ECAC, TECID and SSTECID had clear division of labour and coordinated the project's development. This not only helped the ECAC streamline its administrative system, but also enabled TECID and SSTECID to express their dynamic functions. At the same time, more professional companies were introduced, which drove the rapid construction of the TEC.

Market-oriented operation: The entities responsible for the development and construction of the TEC were two market-oriented enterprises, i.e. TECID and SSTECID. TECID was a state-owned limited company established with a modern corporate system and sound corporate governance structure. SSTECID was co-founded by the TECID and the Singaporean Investment Consortium led by Keppel Corporation. As completely market entities, the TECID and SSTECID operated independently, were responsible for their respective profits and losses, and took part in market competition. For the development and construction tasks stated in the commercial agreement, the two companies referred to market standards and benefited from taking a contractor approach. Through open tenders, the companies entrusted the tasks to third parties to cut costs. This approach was different from the traditional public institution model used in the typical construction and operation of infrastructure and public service facilities.

Enterprise-oriented operation: The TEC adopted an enterprise-oriented operation model for its urban development and construction projects. For projects that were purely for public interests, the government would repurchase them; for quasi-operational projects, the government offered subsidies for investment, operation and maintenance that were gradually reduced; for operational facilities, the government provided subsidies in phases to achieve the ultimate goal of having a completely enterprise-oriented operation. The transformation of traditional business and semi-business projects into market investment projects reduced capital investment and eased investment pressure on the market with financing from TECID. This created a short-term to long-term balance that ultimately resulted in an overall balance for regional development and construction.

Business sustainability: TECID and SSTECID were able to achieve better commercial returns in the investment, construction and operation of urban resources such as land, infrastructure, and public facilities of the TEC. At the same time, it also received government subsidies which provided balance for the large-scale capital investment in the early stages. The two enterprises were also able to seek long-term external financing in place of direct government investment during the course of operation, which reduced or delayed government expenditure and, as a result, effectively lowered the city's operating costs.

2. Development Entities

TECID was established as a state-owned company in December 2007 with the approval of the Tianjin Municipal People's Government in accordance with the relevant provisions of the *Framework Agreement* and the *Supplementary Agreement*. It has six major shareholders including TEDA Investment Holding Co., Ltd., China Development Bank Capital (CDB Capital), and Tianfang Group. Under TECID, the diversified equity structure is diversified, and there is no controlling shareholder, and a relatively high degree of marketisation is present as well.

The orientation of TECID was clearly defined in the *Regulations on the Administration of the Sino-Singapore Tianjin Eco-City* through two main entities. First, it was via a TEC land consolidation and reservation of land within the TEC. Second, it was via an entity which took charge of the TEC infrastructure and public facilities' investment, construction, operation and maintenance, whereby the construction, operation and maintenance of relevant facilities were in accordance with the requirements of the ECAC. This entity also enjoyed the rights to investment, management and income. In addition, TECID also served as a Chinese shareholder of SSTECID to take charge of the overall development of the TEC.

On 1 July 2008, the ECAC, TECID, and Singaporean Investment Consortium signed the Commercial Agreement, and TECID and Singaporean Investment Consortium signed the SSTECID Contract. In July 2009, SSTECID was established with a registered capital of 4 billion renminbi (RMB). It was co-invested in by TECID and the Singaporean Consortium led by Keppel Corporation, with each of them holding a 50% share. Both sides enjoyed even rights and interests in SSTECID (Figure 4-1). At the request of Singapore, a member of the Standing Committee of the Tianjin Municipal Committee cum Party Secretary of Binhai New Area Committee was appointed as the Chairman of SSTECID. The CEO was appointed by Singapore under the principle of reciprocity. According to the agreement between China and Singapore, most of the exploitable land in the TEC would be injected into SSTECID in the form of equity or creditor's rights. SSTECID could develop the land management through independent development, joint development, and third party transfers. One of the important characteristics in the development and construction of the TEC was that the government did not control the exploitable land resources.

Figure 4-1 Schematic Diagram of China-Singapore Enterprise Cooperation Mechanism

3. Infrastructure Operation and Management Model

The "One Road, Three Water" (roads, rainwater, sewage and reclaimed water) parts of the infrastructure construction in the TEC area were invested in by the ECAC, funded by SSTECID, and built by Tianjin Municipal Landscape Design Co., Ltd. TECID invested in the greening project which was repurchased by the ECAC. TECID (or specialised companies) also invested in the energy and communication pipe networks, renewable energy and water treatment, etc. which were repurchased by the government.

According to the *Regulations for Administration of the Sino-Singapore Tianjin Eco-City*, TECID had been given the role of consolidating and reserving land for future use in TEC. TECID's function also served to invest in, construct, operate and maintain infrastructure and public facilities in TEC. In addition, the ECAC has granted TECID 18 licencing rights, including the licencing of land operation, water, gas and heat supply, public transport, garbage disposal, landscaping, environmental sanitation, and commercial facilities, providing the conditions for TECID to build a platform that integrates infrastructure investment, construction, operation and management into one.

With the concept of "investment integration, construction standardisation, operation systemisation, and management informatisation", TECID established itself as the investment and financing entity for infrastructure. Professional companies took charge of projects' specific construction management, operation and maintenance, intensifying the diversification of companies' specialisation. For example, energy companies were responsible for urban tap water, gas and heat supply, and the construction and operation of new energy facilities. This significantly improved the construction and operational efficiency. TECID also unified the standards of infrastructure construction and planned construction for road network-centric infrastructure; it effectively managed the construction of subgrade and roads, and the pipe networks for sewage, rainwater, reclaimed water, tap water, gas, heat and communication, as well as greening on both sides to avoid repeated work and work delays. TECID established a "TEC Public Utilities Operations and Maintenance Centre" that featured a network and information platform, operation and management centre, customer service centre, and operation and maintenance centre. By using information technology, TECID gathered companies with expertise in over 10 different public utilities areas including roads, bridges, drainage, water supply, gas, heat, sanitation, transport and sewage treatment. As a result, business centralisation, resource intensification and management integration were achieved. In addition, it created a geographic information system with 460 km of underground pipe network, and formed a closed- loop management in operation monitoring, emergency command, maintenance and customer service. This improved the efficiency of TEC's infrastructure operation and management, which also became a distinctive feature of TEC.

By the end of 2017, TECID and the various professional companies had completed various infrastructure and construction projects with a total investment of 23.1 billion RMB. The accumulated length of roads built was 82 km, accounting for 83% of the master plan; projects involving a total of four bridges, five pumping stations and nine parks were constructed; a total of 4,550,000 m^2 of green areas was created, accounting for 63% of the master plan; 312 km of water, gas and heat pipe networks were laid and 1,067 hole-kilometre of communication pipe networks were completed; 1,460,000 m^2 of different green buildings were constructed, basically achieving the full coverage of infrastructure within the region, creating the conditions for subsequent urban construction and development.

4. Specialised Operation and Management Model

Based on different areas of expertise, TECID established 11 specialised companies, either as joint ventures or wholly-owned subsidiaries. Of these, five were professional operating companies co-founded with Keppel Corporation or SSTECID to bring in Singapore's advanced technology and management experience. These included an energy company, water company, environmental protection company, green transport company and information park company. Two of the joint ventures in municipal landscape and environmental consulting were undertaken with multi-equity enterprises, and four of the specialised companies were wholly-owned by TECID. These specialised companies engaged in extensive cooperation and established a strategic alliance with both local and overseas well-known research institutes, development enterprises and professional companies in areas such as planning and design, housing development, renewable energy construction and construction of vacuum transport waste collection system. The outcome of their cooperation proved to be positive as good results were achieved. To fully perform their functions in the construction and operation of infrastructure and public facilities, some of the specialised companies have gradually started working with overseas companies to replicate and promote their eco-city experience. The table below shows the core businesses of the various specialised companies.

Table 4-1 List of Main Businesses of TECID's Specialised Subsidiaries

S/N	Company Name	Main Businesses
1	Energy Company	Construction, management, operation and maintenance of heating, water and gas supply; construction, development and utilisation of renewable energy
2	Municipal Landscape Company	Construction, management, operation and maintenance of municipal road and bridge facilities as well as landscape greening projects
3	Construction Investment Company	Regional real estate development
4	Environmental Protection Company	Pollution control, ecological restoration, sanitation cleaning
5	Industrial Park Company	Development, construction, operation and management of National Animation Industry Park
6	Public House Company	Construction and management of public house
7	Urban Resources Company	Development, construction and operation of community centre and other urban commercial service facilities
8	Water Company	Sewage treatment, comprehensive utilisation of water resources
9	Green Transport Company	Operation of shuttle buses and buses, maintenance of transportation facilities
10	Information Park Company	Development, construction, management and operation of the Eco-City Information Park
11	Environmental Technology Consulting Company	Evaluation of environmental effects of construction projects, ecological and environmental planning consulting, restoration technology development, etc.

5. Integrated and Rolling Development Model

Integrated Development. Large-scale land consolidation works have been carried out since the establishment of the eco-city project in 2008. Instead of the traditional construction and development model where land lots were developed, consolidated and promoted separately, an integrated development model with an overall plan was adopted for the eco-city, where the construction of infrastructure and supporting facilities was centrally organised across five comprehensive areas. Construction of water, electricity, gas, heating, road, communication and other public facilities was quickly completed, which significantly increased the economies of scale. According to the three-tiered residential model of "Eco-Area, Eco-Community and Eco-Cell", TECID and SSTECID promoted the development of urban infrastructure, commercial residential housing, commercial facilities and industrial parks in the starting area of 3 km^2. As a result, the image formation of the city was accelerated.

Progressive Development. A progressive development model from south to north was adopted in the construction of the eco-city, with a starting area of 3 km^2, and the construction was scheduled to be completed in three years. On the basis of creating practical experience, the development of the central and northern areas was accelerated. A number of well-known domestic and international real estate enterprises, including Vanke, Vantone, Shimao, Farglory, Keppel, Mitsui, Samsung, Ayala and Sunway, were brought in to create a development model that combined independent and cooperative development. This accelerated the development and diversification of commercial residential building types. By the end of 2017, a total of 31,916 real estate projects were developed in the cooperation zone, with a total building area of 3,780,000 m^2 and total sales area of 3,590,000 m^2.

6. Commercial Feasibility

During business discussions for the eco-city project, Singapore attached great importance to the commercial feasibility of the development model, and carried out intensive consultation with China on land circulation patterns, land prices, investment models for infrastructure and public facilities, the development enterprise's function and main source of revenue, local government support measures and other aspects, through which an overall arrangement for income from short, medium and long-term investments was made. The initial commercial design of "being government-led, separating government functions from enterprise management, being enterprise-dominant and market operation" for the eco-city proved to be effective. Investments in land acquisition and reservation and public facilities construction were first paid for by TECID and returned by the Administrative Committee with fiscal revenues later; SSTECID paid for investments in the construction of the components of "One Road, Three Water", which were later returned by the Administrative Committee with income from supporting fees. A fund circulation system was formed, with the investments and construction first paid for by the developers and later returned through fiscal revenues. This model relieved the pressure of large-scale investment in the early stage of the eco-city

project, promoted rapid growth in business and assets size of TECID and SSTECID, and provided effective support for the acceleration of regional construction and image formation.

As an infrastructure development and operation entity for the eco-city, TECID has developed to become an urban infrastructure and auxiliary function enterprise with a full range of businesses, advanced information-based approaches, centralised green technology, and consolidated and economical resources. Its total assets increased from 3 billion RMB to 17 billion RMB, keeping up a good momentum of realising profits every year, with accumulative profits exceeding 1.9 billion RMB, accumulative tax contributions of about 3 billion RMB and accumulative dividends paid to shareholders of about 240 million RMB. It has published the Corporate Social Responsibility Report for seven consecutive years, achieving a good balance between economic and social benefits. SSTECID, on the other hand, fully utilised the strengths of the cooperation between China and Singapore. It set up professional, international work teams which achieved remarkable results in infrastructure construction, residential development, investment attraction, social development and brand promotion.

Conclusion: Previously, developers in functional areas were often limited by local governments in terms of management and capital due to undefined governmental and enterprise responsibilities, unclear capital boundaries and insufficient driving force for development. By contrast, the eco-city created a “government-enterprise cooperation” in which the developers were not subordinate to local government and were bestowed the rights and obligations of regional development with the setting up of two market-oriented, shareholding and specialised major developers, i.e. TECID and SSTECID. This created a development system that was “government-led, with separate government functions from enterprise management, enterprise-oriented and market operation”, which enabled the developers to realise independent management, self-financing, self- management and self-development. Such an exploration has provided an excellent case for changing government functions and deepening the reform of a market economic system. It also unveiled a new path for development system reform and innovation in China. This contractual supporting service model formed between the developers of the eco-city and the government played an important role in the initial period of construction. However, with the gradual completion of the infrastructure and public facilities, the regional development entered a period of operation and maintenance. For such asset-heavy enterprises, new areas for growth should be fostered and China’s “Go-out” policy for businesses to grow can be launched in a timely manner to expand space for external cooperation. A more important problem was that it is difficult for the industrial parks invested in, and constructed, by developers to rely on holding-type properties to generate a cash flow return that matches the scale of investment. This big contradiction created by large-scale investment and long return on investment required further optimisation of the systems and mechanisms and the exploration of a new operational model for industrial parks.

Chapter 5

Capital Circulation

Summary

This chapter describes the eco-city's capital circulation system that was formed based on the development model of "separating government functions from enterprise management and market-oriented operation", as well as on the system's strengths and achievements.

This capital circulation model ensured that the building of large auxiliary facilities can be completed on schedule, protecting the local government from the accumulation of direct debts.

The development of a new city required the establishment of a financial and taxation system with good structural integrity, clear definition of rights and responsibilities, and unobstructed channels to provide solid guarantees in terms of policies and funding.

Accurate calculation of fiscal balances ensured that development and construction priorities were arranged within means. This prevented rigid expenditures from exceeding financial capacity, reduced the pressure on fiscal balance and helped control the risk of local debts.

Virtuous circulation of capital in the development and construction of the eco-city was the result of continuous implementation of the development model that focused on separating government functions from enterprise management and market-oriented operation. The separation of government functions from enterprise management ensured clear definition of functions and relations between the government and development entities. This created a model in which the government and enterprises were responsible for their respective functions: the enterprises raised capital on their own to invest in construction of the project before the government provided settlements based on the relevant procedures.

1. Capital Circulation

Under the principles of "separating government functions from enterprise management and market-oriented operation", two development entities, i.e., TECID and SSTECID, were established for the eco-city to oversee land development, business development and the investment, construction and operation of infrastructure. TECID was co-funded by five state-owned enterprises in Tianjin and China Development Bank with the ECAC not holding any shares in it. SSTECID was co-funded by TECID and the Singapore Consortium. As fully market-oriented enterprises, TECID and SSTECID operated independently and were responsible for their own profits and losses. This was essentially different from traditional models, which typically lack clear definition of responsibilities and capital relationships between the economic function zone administrative committees and platform companies (Figure 5-1).

According to the *Commercial Agreement*, TECID would raise funds on its own for land acquisition and reservation, and infrastructure and public facilities construction; while the ECAC would make overall arrangements for different fiscal revenues for the purpose of additional coverage, subsidies and repurchases based on the progress of land transfer and project construction. For non-commercial assets, the ECAC would repurchase them and entrust TECID to operate the assets and pay the operating expenses; for operational assets, TECID would own them and the ECAC would be given appropriate subsidies according to operating results and specific conditions. SSTECID would be mainly responsible for the business development in the zone and for completing the "one road, three waters" construction tasks using Singapore's advanced experience in urban construction and management. After the project is completed, the ECAC would arrange to repurchase the assets with revenue from supporting fees.

In September 2014, in accordance with the central government's requirements on local government debt management, non-commercial non-government investment projects could not be financed by platform enterprises. This basically put an end to the construction model, which required payment by infrastructure and public facilities enterprises before repurchase by the government. With the new situation, a direct investment model was adopted for all non-commercial projects of the eco-city. For commercial projects, the enterprises were responsible for investment, while the government provided operating subsidies. This ensured that on one hand, regulatory requirements were strictly imposed, while on the other, the financing and operating advantages offered by the market entities were maximised.

By the end of 2017, the total fiscal expenditure of the eco-city reached 33.8 billion RMB, of which, 13.8 billion RMB was spent on the construction and operation of infrastructure, nearly 10 billion RMB was spent on the construction and operation of public facilities, and over 1.4 billion RMB was spent on subsidising and constructing environmental governance and renewable energy projects. Among these expenditures, nearly 20 billion RMB was paid to the eco-city's development entities, creating a virtuous circle for financial and social capitals.

Practical experience showed that the eco-city's agreement-based model of separating government functions from enterprise management and market-oriented operation stimulated the operational and financial capacity of the enterprises, which was conductive to the rapid raising of massive capital needed for land acquisition, reservation and consolidation, and the construction of infrastructure and public facilities. This helped to accelerate the construction process and reduce capital costs, while also minimising the burden of debt on the local government due to the various infrastructure and auxiliary facilities. As at end-2017, as a result of this model, ECAC had no direct government debt.

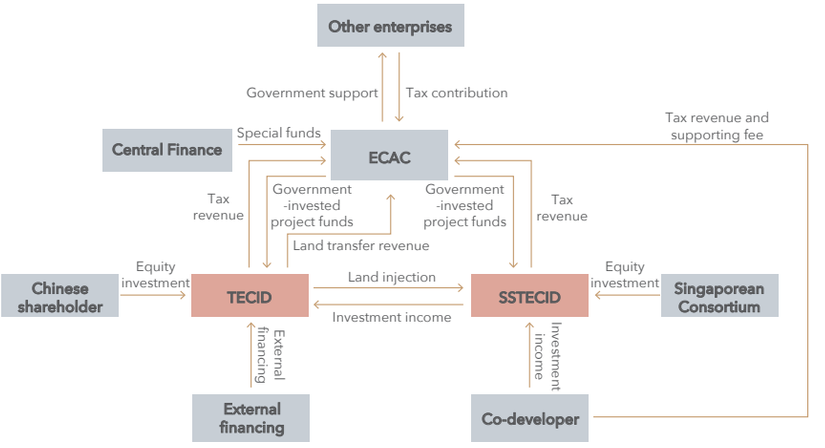


Figure 5-1: Schematic Diagram of Capital Circulation

2. Financial System

Because the eco-city was built on a saline-alkali wasteland and huge investments were needed in ecological restoration and infrastructure, Tianjin city granted to the eco-city a financial support policy of “no giving, no taking, and self-balancing”. This meant that since 2008, government revenues such as a local portion of corporate tax, administrative fees and land-transfer fees generated in the eco-city were fully reserved for environmental governance, development and construction, and the municipal government would not provide any financial support to the eco-city during the policy period.

In December 2014, Binhai New Area People’s Government made adjustments to the financial control systems in various functional areas, and clarified that “for the local portion of different taxes, a full return policy would be implemented by 2020” in the eco-city, and that the policy support period will be until 2020.

At the beginning, Tianjin city and Binhai New Area implemented the policy in the form of “return by application”. On 1 January 2015, TEC Treasury officially started operations. In the same year, TEC Internal Revenue Service and Local Tax Bureau were established, which further improved the financial and tax management functions and system of the eco-city.

A model of “mid-year advance fund issuance and year-end settlement” was formed between the eco-city and the superior financial authorities. The contributing organisations paid fund budget revenues directly to the TEC Treasury.

As at end-2017, the fiscal revenue within the eco-city (excluding the original tourist area and fishing port area before the integration of the three areas) reached around 24 billion RMB, including 19 billion RMB from the public budget and 5 billion RMB from land transfers. The general public budget revenue comprised 4.2 billion RMB at the central level and 14.8 billion RMB at the local level. Tianjin city's financial support policy was crucial in alleviating the financial pressure on the eco-city and promoting ecological restoration, industrial support, urban construction and public facilities. This ensured accelerated initiation, construction and development.

3. Fiscal Balance

Fiscal balance estimation: During the construction of the eco-city, there was always a focus on the estimation of fiscal balance, to provide a reference point for the rational arrangement of various fiscal expenditures and support for the setting of industrial development goals. It also ensured a better grasp of changes in fiscal revenues and expenditures in subsequent periods.

While the project was being negotiated in 2007, Tianjin city made an overall estimate of the aggregate balance of the eco-city's development and construction, which formed a systematic arrangement for balancing the revenues and expenditures in the development of the region.

In 2008, after establishing the ECAC, a fiscal revenue and expenditure forecast model was created based on the eco-city's master plan and annual construction plans to ensure a good grasp of the characteristics of fiscal revenues and expenditures and economic operation during the construction period. It was estimated that by 2020, when the eco-city's cooperation zone is completed, the total investment in fixed assets of the entire community would exceed 216 billion RMB, the average annual investment would exceed 20 billion RMB, the fiscal expenditure would reach up to 56 billion RMB, and the fiscal revenue would amass to around 46 billion RMB. This meant that there would be a financial gap of around 10 billion RMB. This fully reflected the short-term (five years) and medium- and long-term (15 years) fiscal revenue and expenditure of the eco-city and provided a reference for policy-making and the government's investment and financing decisions.

In 2017, the ECAC released the 2017-2035 fiscal revenue and expenditure estimation based on the revised master plan, which was adjusted according to regional area expansion, significant increase in development and construction matters, and substantial increase in overall revenues and expenditures. It is estimated that from 2017-2035, investment in fixed assets of the eco-city would total around 800 billion RMB, of which, 130 billion RMB would invested by the government in infrastructure construction, around 50 billion RMB would be used for social programmes, around 60 billion RMB would be spent on urban operations and maintenance, and around 50 billion RMB would be used for industrial development. During this period, the total fiscal expenditure would reach around 290 billion RMB, and the estimated fiscal revenue would total 250 billion RMB based on an average annual growth rate of 10%. As a result, certain financial gaps would remain.

Revenue structure: The eco-city's disposable financial resources mainly include: tax revenue, revenue from administrative and institutional fees, land transfer revenue, and various subsidies and special funds. From 2008 to 2017, the eco-city's local government general public budget revenue achieved an average annual growth of 30%, and the disposable financial resources increased to nearly 6 billion RMB from 2.2 billion RMB at the start, which reflected a leap in terms of development (Figure 5-2).

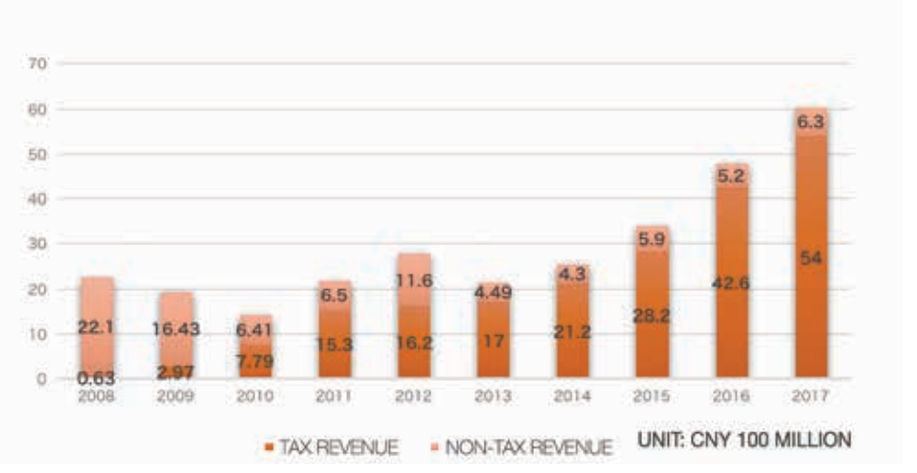


Figure 5-2: Schematic Diagram of the Eco-city's Fiscal Revenue over the Years (2008-2017)

Tax revenue: Tax revenue was the main source of the eco-city's general public budget revenue and was contributed mainly by the enterprises. From 2008 to 2017, the eco-city saw rapid growth in the amount of corporate taxes with an average annual compound growth of over 60%. Real estate, culture innovations, advertising media, book publishing, financial and commercial enterprises were the main contributors of tax revenue. In 2017, besides real estate, tax revenue from other key industries that the eco-city promoted exceeded 3.683 billion RMB, with a year-on-year increase of 32%.

Revenue from administrative fees: Revenue from administrative fees mainly referred to the support fees for municipal infrastructure and non-commercial public facilities, which were collected from various commercial real estate development projects. It was estimated that a total of around 9 billion RMB in municipal infrastructure support fees could be collected for every 30 km² of buildings in the eco-city's cooperation zone, which basically met the needs of "one road, three water" and water, gas, heat supply and greening projects within the area. From 2008 to 2017, a total of 3.412 billion RMB of municipal infrastructure support fees were collected by the eco-city, all of which were used for infrastructure construction and investment, project repurchases and business subsidies for projects. In addition, a total of 462 million RMB of non-commercial public facility support fees were collected, all of which were used for the construction of public facilities, with priority given to educational facilities.

Land-related revenue: The eco-city was built on a saline-alkali wasteland, so the price of land acquisition at that time was relatively low. Although the cost of environmental governance was significantly higher than that of other areas, land values grew after environmental governance was performed and auxiliary facilities were constructed. When the land was transferred and injected to SSTECID, the land-related revenue could basically cover the cost of land acquisition, reservation and consolidation. When the STTECID publicly transferred the land and began independent development, the revenue generated was an important part of the eco-city's general public budget. However, the land-related revenue was affected by macro situations and many uncertainties, which led to large fluctuations in fiscal revenue.

Financial subsidies and special funds: From 2011 to 2020, to support the construction of the eco-city, the central financial authority granted massive financial subsidies to the eco-city to support the eco-city's operation and environmental improvement and construction. Moreover, the eco-city has also obtained special funds such as financial support for pilot sponge cities, and model cities for renewable energy as well as for green buildings.

Expenditure structure: Based on the development and construction sequence and the regional development priorities, the eco-city's fiscal expenditure was mainly geared towards environmental governance, infrastructure construction and operation, people's livelihood and industrial promotion. As at end-2017, the expenditure totalled nearly 33.8 billion RMB.

Environmental governance mainly included saline-alkali land restoration and greening, large theme park construction, sewage reservoir treatment, wetland protection and restoration, riverside landscape construction, water ecological restoration, sewage treatment plant construction, air and noise pollution monitoring and control, etc. The total expenditure in this area was over 10 billion RMB.

Infrastructure construction and operation mainly included the construction and operation of roads, bridges, municipal pipe networks and public greening, and the total expenditure was over 13.8 billion RMB.

Aspects of the people's livelihood included mainly the construction and operation of educational, healthcare, cultural, sporting, secured housing, libraries, museums and other facilities and the total expenditure was nearly 10 billion RMB.

Industrial promotion mainly included subsidies for the construction and operation of industrial drivers such as a national anime industrial park, information industrial park, industrial incubation and transformation base, and the cultivation of industries such as cultural innovation and new-generation information technology. The total expenditure in this area was over 6.6 billion RMB.

Conclusion: An agreement-based investment and operation model featuring a separation of government functions from enterprise management and market-oriented operation was established for the eco-city, which not only ensured that large-scale support was constructed on schedule, but also effectively avoided the risk of government debt. These were fully in line with the essence of the public-private partnership (PPP) model which the State Council has vigorously promoted since 2015. The financial operation of the construction of a new city follows its own objective rules. The revenues and expenditures at different stages were very different. A long-term and proactive plan should be created. When there is significant contribution from the real estate sector, the plan should focus on one or two leading industries and on attracting sustainable, effective and systematic investments in industrial infrastructure, to encourage industrial agglomeration and sustainable economic contribution as soon as possible. This would ensure that when the real estate's contribution gradually reduces in subsequent periods, the region can maintain sustainable development. At the same time, with the gradual expansion of the built-up area, the pressure from maintenance costs of infrastructures and public facilities increased significantly. The rapid expansion of the permanent population also led to a geometric growth of operating expenditure on enhancing the people's livelihood, resulting in the city's operating costs being several times higher than in the early construction stages and posing a great challenge in achieving fiscal balance. This required planning ahead, accurate estimation and rational arrangement of urban operating expenditures at different stages of development. For purely public welfare undertakings with high operating costs, there should be decision-making based on accurate data and strict controls. A market-oriented operation mode should be adopted as far as possible to maximise benefits and reduce costs.

Chapter 6

KPIs Framework

Summary

This chapter describes the preparation, breakdown and implementation of the eco-city's key performance indicators (KPIs) framework, and an overview of the optimised and upgraded version.

The eco-city has been an innovative urban development model which uses a KPIs framework as a guide for the preparation and implementation of the master plan. This model has been replicated and promoted in many other Chinese cities as well.

The eco-city's KPIs framework included four aspects: resource utilisation, environmental friendliness, social harmony and regional coordination. There were 22 quantitative indicators and four guiding indicators that reflected the goals of people living in harmony with economic activities, society and environment, and coordinated development.

These 26 indicators were broken down into specific tasks and imposed on the responsible departments, construction management and land space to create a road map and construction drawings for the implementation of the indicators.

The eco-city's KPIs framework was then optimised and upgraded by benchmarking with other advanced eco-cities in China and abroad. The number of indicators was increased from "22+4" to “30+6” to better adapt to changes in the external environment and the eco-city's developmental needs.

The practice of standardised construction in the eco-city was certified by the International Organisation for Standardisation (ISO). In 2017, the eco-city was granted ISO 37101/37104 International pilot city status under the ISO/TC 268 Sustainable cities and communities standard.

During site selection and business negotiation in 2007, China and Singapore engaged in in-depth exchanges on the development vision and construction standards of the eco-city. Both sides decided to co-develop a KPIs framework that is reflective of the eco-city's core requirements, is of advanced international standard, and is implementable to provide guidance for the preparation of the eco-city's master plan and subsequent construction management. With the rise of “ecological concept” cities, the eco-city's KPIs framework was replicated and promoted in many other parts of China, providing a novel and feasible strategy and approach for sustainable urban development.

1. Original Intention of KPIs Framework

The eco-city was the second flagship project between the governments of China and Singapore, after Suzhou Industrial Park. The leaders on both sides had great expectations for it. They wanted the new China-Singapore cooperation to achieve prominence and become an inspiration for sustainable development in other cities. The eco-city could only be considered a success when it achieved leading international standards.

The Ministry of Construction (MOC) proposed 13 indicators for the construction of the eco-city

On 10 November 2007, the executive meeting of the MOC prioritised for the construction of the eco-city to be sustainable and replicable. The resulting economic effects needed to be agreed upon by the leaders of both countries. They planned for the city to become world-renowned. Therefore, implementation was to be done appropriately through the development and execution of influential standards. MOC proposed 13 indicators including GDP per unit of energy consumption, GDP per unit of water consumption, clean production, water environment functions, pollutant emission, water resources utilisation, ambient air quality, noise, harmless treatment rate of urban domestic garbage and hazardous waste discharge, urban per capita green space, gas popularisation and green buildings. On 14 November 2007, Tianjin city issued a *Letter on the Commitment Opinions on the Indicators of Sino-Singapore Tianjin Eco-City* to the MOC.

In October 2007, Singapore proposed establishing short- and long-term indicators to evaluate the progress of the eco-city project, such as population growth and GDP growth. Singapore also hoped to have a series of other indicators that would measure significant milestones of the eco-city, and predict any potential limitations faced by these indicators. China suggested that the two sides set up a joint team to perform an intensive study on the construction goals and KPIs framework of the eco-city by referencing Singapore's experience. In November 2007, the MOC put forward 13 indicators for the construction of the eco-city, based on Chinese and foreign experience. Tianjin city promised to fully implement them. Singapore believed that several key points must be managed during its construction and proposed a series of specific indicators in the areas of the economy, society and environment.

The construction indicators proposed by both sides quantified the vision of the eco-city and offered a preliminary determination of the construction goals in key areas. At that time, China did not have a unified and clear understanding of an "eco-city", and there was no mature experience to draw reference from. These indicators turned the concept of "eco-city" into specific work goals. China and Singapore decided to establish a KPIs framework of a leading global standard to provide guidance for the drafting of the master plan. This ensured that the indicators were implemented in space and specialised planning, and formed a new model where urban planning and construction were guided by indicators.

On the third day after both countries signed the *Framework Agreement*, then-Minister of the MOC Wang Guangtao and Minister of the MND Mah Bow Tan held talks. Both sides reiterated that the TEC was a new highlight and flagship project of the China-Singapore cooperation with economic, social and ecological benefits; that the outcomes should be shared to benefit the people of both countries; and the project should be influential to the world. There was a need for both sides to work out the standards of the eco-city together, including the goals and indicators in the areas of the economy, resources, environment and social harmony. It was necessary to refer to the existing standards of both countries and the experience of other countries to ensure that the standards catered to the needs of the situation in China and the project's development. They requested that experts from China and Singapore co-develop the standard construction system by mid-January 2008.

Based on the requirements of the MOC, Tianjin city determined the work plan for the drafting of the KPIs framework and the schedule. Tianjin city would organise related departments to study the relevant international indicators and draft a preliminary plan as soon as possible. The city would immediately hold expert consultation meetings, and communicate with Singapore to finalise the plan. By mid-January 2008, the MOC would organise an expert discussion and solicit opinions from related departments. By the end of January, a meeting of Tianjin Eco-city Joint Working Committee would be convened to review the eco-city's construction standards.

Singapore's Key Points of the TEC Project indicator suggestions

All buildings should be green buildings and should at least meet Singapore's Green Mark Scheme standard.

The residential areas should be surrounded by public facilities (shops, schools, etc.), and should have open spaces for residents to interact with each other (neighbourhood centre, neighbourhood garden, etc.) to promote community-building.

Employment opportunities at different levels should be available so that residents can work near where they live, reducing the reliance on transport. 30% of residents should live within the eco-city.

Home office and environmental industries (including research institutes related to environmental protection, and higher institutions) should be encouraged.

There should be a wide range of facilities for recreational, wellness, entertainment and cultural activities, and different types of open spaces and water bodies should be provided in an integrated manner.

Public transport should be given priority and its utilisation should be increased to reduce the use of private cars. Singapore's target was a ratio of 7 (public transport) : 3 (private transport). The use of green vehicles (especially passenger cars and buses) should be increased, and the main mode of travel should be walking and bicycle.

Clean water, air, energy and land should be available. Efficient use of water resources should be promoted through recycling and conservation. Different water supply channels should be available, including rainwater, reclaimed water, desalinated seawater, and South-to-North water diversion. As for drinking water, 100% of the water should be potable. Resources should be used efficiently with new energy and energy reserves.

Pollution should be controlled and reduced from source. There should be an integrated waste management system for centralised waste management to achieve the 3Rs (reduce, reuse, recycle) and ensure that the eco-city's goal of 100% recovery of daily solid waste and wastewater can be realised.

2. Constructing KPIs Framework

2.1 Principles for indicators selection

Principle of being both scientific and practicable: When designing the KPIs framework, the completeness, scientific validity and correctness of the theories were taken into consideration, i.e., the indicators must have a clear scientific basis and data selection should be practicable to ensure that the data is both desirable and measurable.

Principle of being both qualitative and quantitative: The eco-city's indicators should be quantified as much as possible. However, for indicators that are difficult to quantify based on current levels of understanding and are of great significance, qualitative indicators can be used.

Principle of being both distinctive and common: On one hand, the general indicators that were commonly used in China and overseas should be adopted in the KPIs framework as far as possible, to fully reflect the different fields involved in the construction of the eco-city. This facilitates the comparison and promotion between different areas. On the other hand, the region's ecological features should also be considered to highlight regional characteristics.

Principle of being both achievable and forward-looking: For the KPIs framework, whether the goals can be achieved in the short-term and how progressive they are for the long-term must be considered. On one hand, the indicators should be forward-looking while taking into consideration social and economic developments; on the other hand, it is necessary to check if the indicators are achievable in the near future.

2.2 Determination of indicator values

Selection of indicators: Urban indicators in national and international standards with strong versatility and those with ecological characteristics were chosen. This was based on the advanced experience of China and other countries, and in combination with the actual situation of the eco-city site. The definitions, quantitative measurement and qualitative evaluation methods for these indicators were clarified in a scientific way to ensure that every indicator can reflect the progress and status of the eco-city in a certain aspect. This strengthened the role of the KPIs framework as a benchmark and example. At the same time, the indicators were made obtainable and evaluable. Indicators that were within the scope of government inspection were given priority to provide regular reflection of the city's development. This helped city managers evaluate the current situation against strategic objectives, identify problems and gaps, and predict future development outcomes to a certain degree, thus promoting rational development of the city.

Setting of indicator value: Based on the requirements of being an example and being attainable, values from various sources were referenced and compared. These included indicator values in relevant policies and research on ecological construction in advanced regions in China and other countries, as well as current values of advanced cities worldwide. A set of indicator values of leading world standards was finalised after extensive consultation with Chinese and foreign experts in the relevant fields and following scientific and reasonable adjustments based on the region's current situation. Some target values were set at levels that were even higher than those of developed countries. The KPIs framework interpreted the development and construction of the eco-city in terms of resources, environment, economy and society, providing a quantitative standard for the eco-city's goal of "being practicable, replicable and scalable".

2.3 Main contents of KPIs framework

The KPIs framework of the eco-city included four aspects: resource utilisation, environmental friendliness, social harmony and regional coordination. There were 22 regulatory quantitative indicators and four guiding indicators (see Table 6-1), reflecting the goal of "people living in harmony with economic activities, society and environment, and coordinated development."

Table 6-1 Sino-Singapore Tianjin Eco-City KPIs Framework

Regulatory indicator						
Indicator level		SN	Secondary indicator	Unit	Target value	Time limit
Good ecological environment	Good natural environment	1	Ambient air quality in the region	Days	Number of days better than or equal to Class II standard ≥ 310 days/year (equivalent to 85% of a year)	Now
				Days	The days with SO2 and NOx better than Class I standard ≥ 155 days/year (equivalent to 50% of the days at Class II standard)	Now
					Meet the Ambient Air Quality Standard (GB 3095-1996)	By 2013
		2	Environmental quality of surface water in the region		Meet the requirements of Class IV water quality of the current Environmental Quality Standards for Surface Water (GB 3838-2002)	By 2020
		3	On-spec tap water	%	100	Now
		4	On-spec noise level in functional zones	%	100	Now
	Artificial environment coordination	5	Carbon intensity per unit GDP	Tons-CO_2/ million (USD)	150	Now
		6	Net loss of natural wetlands		0	Now
		7	Proportion of green buildings	%	100	Now
		8	Native plant indices		≥0.7	Now
		9	Per capita public green space	m^2/person	≥12	By 2013
Social harmony and progress	Healthy lifestyle	10	Per capita daily water consumption	L/person• day	≤120	By 2013
		11	Per capita daily waste output	Kg/person• day	≤0.8	By 2013
		12	Proportion of green travel	%	≥30	By 2013
					≥90	By 2020
	Complete infrastructures	13	Waste recycling rate	%	≥60	By 2013
		14	Proportion of residential areas with free sports facilities within 500 metres	%	100	By 2013
		15	Harmless treatment rate of hazardous waste and domestic waste	%	100	Now
		16	Proportion of accessibility facilities	%	100	Now
		17	Municipal pipe networks prevalence	%	100	By 2013
		18	Proportion of affordable housing and low-rent housing	%	≥20	By 2013

Table 6-1 Sino-Singapore Tianjin Eco-City KPIs Framework (Continued)

Regulatory indicator						
Indicator level		SN	Secondary indicator	Unit	Target value	Time limit
Economic prosperity and efficiency	Sustainable economic development	19	Utilisation rate of renewable energy	%	≥20	By 2020
		20	Utilisation rate of unconventional water resources	%	≥50	By 2020
	Active technology innovation	21	Number of R&D scientists and engineers per 10,000 workers	Person• Year	≥50	By 2020
	Aggregate balance of employment	22	Employment and housing balance index	%	≥50	By 2013

Guiding indicator				
Indicator level		SN	Secondary indicator	Indicator description
Regional coordination and integration	Natural ecology coordination	1	Ecological safety and health, green consumption, low carbon operation	To take into account the regional environmental carrying capacity, and maintain regional ecological integration, strengthen ecological security, and establish a sound regional ecological security system from the perspective of rational utilisation of resources and energy.
	Regional policy coordination	2	Priority implementation of Innovative policies, and joint pollution control policy in place	To actively participate in, and promote, regional cooperation, and implement the principle of equality in public services; implement regional policies for management by category, ensure coordination and establish a system to ensure environmental improvement in surrounding areas.
	Social and cultural coordination	3	Highlight the features of estuary culture	Urban planning and building designs that extend and highlight the history and culture of the region; protect national cultural heritage and scenic resources; ensure safe production and social security.
	Regional economy coordination	4	Complementary circular industries	A sound urban mechanism that breaks the limitations of administrative division, drives rational development of border areas, promotes rational division of regional functions and market order, and achieves a balance in terms of economic development and jobs-housing ratio.

3. Implementing KPIs Framework

3.1 Breakdown of the KPIs Framework

In January 2009, the TEC issued the *Implementation Plan for Decomposition of KPIs Framework*. Focusing on the core requirement of "being implementation-oriented", the implementation paths of 26 indicators were analysed. The decisive key points were extracted as the core elements, and the key links and control objectives involved were defined according to the core elements. Then, a breakdown implementation roadmap consisting of 51 core elements, 129 key segments, 275 control objectives, 723 specific control measures and 100 statistical methods was constructed. Thus, a new model of urban planning, construction and management driven by quantitative indicators was established.

Building a technical framework: First, the 26 indicators were studied to strictly define their significance and measurement based on extensive investigation, communication and expert discussions. The KPIs framework was analysed to classify the 26 indicators into four categories including society, economy, resource and environment based on the urban system framework. Second, the technical roadmap for the implementation of the indicators was analysed to identify the main pathways, extract decisive key points from factors that would affect the implementation, and define the key segments and control objectives involved according to the core elements. Third, management measures and implementation standards at each stage were put forth according to the key links and control objectives identified based on their characteristics at the three implementation stages of planning, construction and operation management. This was with reference to advanced experience and successful cases locally and abroad. This would ensure that different stages and projects would be constructed and operated according to the corresponding indicators, meeting the requirements of being monitorable, statistical and evaluable. Finally, the responsibilities and obligations of the government, enterprise and the public as implementation entities were specified according to the requirements of the control measures. At the same time, the policies proposed by the functional departments at the stage of planning, construction and operation were clarified to form specific, standardised and operational guides in order to stress the leading role of the government in implementing the KPIs framework.

Dividing the responsibilities of the three parties: The responsibilities of the government, enterprises and the public were clearly distinguished according to different segments and major factors of the implementation

of the indicators. The government incorporated the control measures in its administrative review and approval, process monitoring, supervision and assessment, and other processes. The control measures played a leading role in helping to formulate policies, regulations and technical standards, and realising its administrative functions. The enterprises were responsible for project investment, construction and operation, and the implementation of relevant standards. The public actively participated in the practice of low-carbon life, green consumption, energy and water conservation. They became an important force in implementing the KPIs framework (see Figure 6-1). At the planning stage, the government played a leading role. At the construction stage, enterprises played a more significant role in the building of public service facilities, municipal infrastructure, public buildings, residences, roads and transportation. Enterprise implementation and government supervision were emphasised. At the operation stage, enterprises and the public were not only beneficiaries and implementers of the policies, but also providers of feedback and influencers of policy formulation. The public, in particular, should become a social force that can engage in dialogue with the government and enterprises in urban decision-making, creating a public management model through the interaction between the three implementation entities. This would promote the innovation of the public management system towards “small government, big society”.

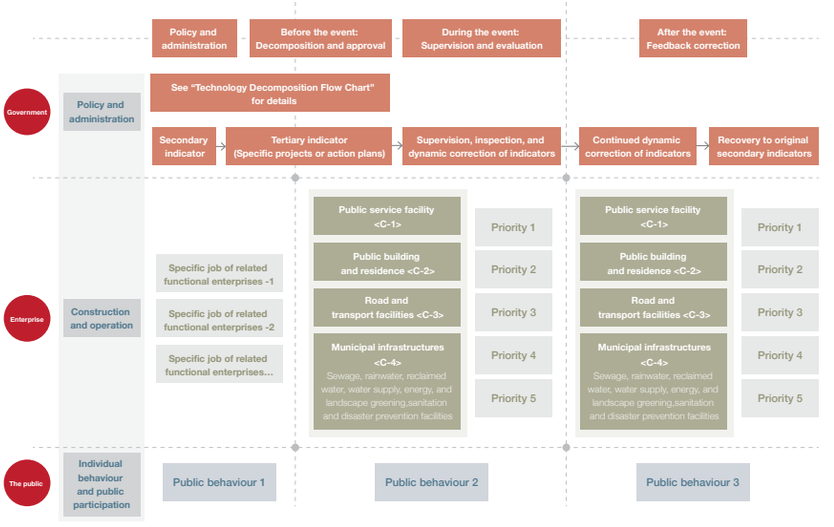


Figure 6-1: Decomposition Framework of Government, Enterprises and the Public

Highlighting the leading role of government departments: The government played a leading role in the breaking down and implementation of the indicators. Therefore, the specific control measures in the technological framework were distributed to the functional departments of the government by breaking down the KPIs framework and creating operational guides for each department (see Table 6-2). In daily work, only through policy guidance, administrative approval and technical control could the indicators be achieved.

4. Implementation Outcomes of KPIs Framework

The number of indicators that met the standards increased each year. In 2011, due to limited statistical data, only five indicators were evaluated for the eco-city. Among them, only three indicators were up to standard: environmental quality of surface water, on-spec tap water rate, and net loss of natural wetlands. Measuring PM10 and PM2.5 pollutant levels, the number of days with air quality better than or equal to Class II (272 days) was below the eco-city’s standard (310 days), so the ambient air quality in the region was unable to meet the standard. Unconventional water utilisation projects were still under construction and rainwater serves as the main conventional water resource. As a result, the utilisation rate of unconventional water resources was only 22%, which was lower than the target value of 50%. By 2017,

Table 6-2 Example Table for Results Framework of Departmental Operation Guide

		P - Planning and approval Site selection > Land approval > Design proposal > Project planning > Construction permit	C - Construction	O - Operation
1. Project approval		P-1-1 It is necessary to combine project design with approval to ensure that there is a neighbourhood park of no less than 1-1.5 hectares next to every neighbourhood centre, and all types of green spaces in residential areas are accessible. (09)	C-1-1 In the project management, the supporting greening of new projects must be checked and accepted at the same time as the main works. (09)	O-1-1 Dynamic adjustments should be made to the land planning that is conductive to the job-housing balance according to the actual situation. (22)
		P-1-2 The green area in residence and public building project should be planned and approved in accordance with greening rate standard. (09)	C-1-2 In project acceptance, it is necessary to ensure that accessibility facilities have been correctly installed, and to review the turnkey project for which contractors are responsible on the housing renovation of the disabled (16)	O-1-2 Adjustments should be made to the distribution of public facilities according to the development situation to meet the requirement of 100% residential support. (22)
2.Implementation supporting system	2.1 Planning conditions or technical requirements	P-2.1-1 It is necessary for systematic planning of four municipal parks within the region and to reinforce the plan. (09)	C-2.1-1 The four municipal parks including Xinjinzhou Central Park and Eco-Environment Theme Park should be constructed in strict accordance with the planning and related design requirements. (09)	O-2.1-1 The construction and gardening departments have collected statistics on the total area of urban green space at various levels by use of satellite remote sensing technology every year since 2013. (09)

Table 6-2 Example Table for Results Framework of Departmental Operation Guide

		P - Planning and approval Site selection > Land approval > Design proposal > Project planning > Construction permit	C - Construction	O - Operation
2.Implementation supporting system	2.2 Policy and management suggestions	P-2.2-1 A housing security policy should be formulated. The citizen admittance standard should be established. (18)	C-2.2-1 If it is necessary to make adjustments to the planned green space for public welfare projects such as urban infrastructure construction, the planning and construction units shall submit their opinions to the ECAC for approval; if it is necessary to occupy public green space for public welfare projects such as urban infrastructure construction and special circumstances, the ECAC should be asked for instruction. (09)	O-2.2-1 In the operation and management of public green space, the property ownership and management subject should be specified. (09)
	2.3 Financial suggestions	P-2.3-1 A special fund for the centralised utilisation of renewable energy and the integrated utilisation of buildings in the TEC should be established in conjunction with financial and legal functional management departments. (19)	C-2.3-1 If it is approved to change the nature of urban green space use, the green space compensation fees must also be paid at an evaluation price not lower than the adjacent land market and included in the annual investment plan of the city for reconstruction and increase of green space area. (05,09)	O-2.3-1 For the use of renewable energy, incentives such as subsidies or fiscal and taxation preferential policy should be implemented in the TEC in the course of its operation step by step. (05,19)

Index

Approval-related
All contents related to project approval, such as additional approvals on an existing basis

Specifications and guidelines
Specifications or guidelines to be issued in planning, construction and operation to achieve indicators

Concrete measures
Key measures that need to be taken in planning, construction and operation to achieve indicators

Financial suggestions
Financial leverage measures and instruments that can be used in planning, construction and operation to achieve indicators

all 22 regulatory indicators were evaluated, of which, 20 met the standard, so the compliance rate was 90.9%. The ratio of affordable housing in the region was 13.8%, which was lower than the target of 20%. This was because at the early stage of the eco-city's construction, the demand for affordable housing was relatively limited, and the amount of commercial real estate projects kept on increasing, resulting in a decline in the ratio. The utilisation rate of renewable energy was 14.08%, which was much higher than China's average, but lower than the target of 20% by 2020. This was mainly because there were not many new renewable energy projects in the eco-city, but terminal energy consumption continued to increase.

Setting deadlines for implementation of indicators. In view of the deadline requirements of different indicators, the eco-city's indicators were divided into three categories: those that must be achieved immediately, those that must be achieved by 2013 and those that must be achieved by 2020. This reflected the urgency of some indicators in terms of urban development and the periodicity in the implementation of certain new concepts. Among the nine indicators that must be met immediately, only two, including on-spec tap water rate and net loss of natural wetlands, were achieved on schedule (since statistics were available in 2011). The other seven could not be measured as the monitoring system and infrastructure were not established yet. Among the 18 indicators that must be achieved by 2013, 11 were met; three lacked sufficient statistical data, including native plant index, per capita daily water consumption and proportion of green transport; and four were not up to standard, including ambient air quality in the area, on-spec noise level in functional zones (night noise level at Type 4A functional zones did not meet the standard), proportion of affordable housing in the region and employment-housing index. This was related to the stage of the urban construction at that point in time. As for the targets for 2020, by the end of 2017, 19 quantitative indicators had been achieved, including nine in ecological environment, seven in social harmony, and three in economic prosperity. As construction and development progressed, three indicators were expected to meet the standards in the long-term, including proportion of green travel, utilisation rate of renewable energy, and proportion of affordable housing in the region.

Highlights of the types of implemented indicators. In terms of the ecological environment, the net loss of natural wetlands in the eco-city was zero, the proportion of green buildings has always been maintained at 100%, and the per capita public green space reached 65.69 sq m^2 per person, indicating the coexistence of the natural environment and human settlements. In terms of social harmony, the indicators were all well implemented, such as per capita daily water consumption, per capita daily waste output, waste recycling rate, harmless treatment rate of hazardous waste and domestic waste, and the proportion of accessibility facilities. This showed the obvious advantages of the eco-city in infrastructure construction and that the lifestyle of the residents was becoming more ecological and green. In terms of economic prosperity, the utilisation rate of unconventional water resources in the eco-city was nearly 60% and the number of R&D scientists and engineers per 10,000 workers reached 541.5 persons per year. These showed that the economic development of the eco-city was sustainable and the city has a high concentration of human talent. In terms of regional coordination, a series of policies on fiscal and taxation investment, industrial development, ecological environment, technology innovation, social governance, and China-Singapore cooperation were implemented. These helped to develop a low-carbon, circular and green economy, led residents in adopting a green lifestyle and developing green consumer habits, and promoted the coordinated development of regional policies, natural ecology coordination, regional economy and social culture.

Internationally recognised implementation outcomes. In 2012, the ISO established the "International Organisation for Standardisation/ Technical Committee for Standardisation of Sustainable Cities and Communities (ISO/TC268)". The Committee drafted a series of standards such as ISO37120 (Sustainable Development of Communities – Indicators for City Services and Quality of Life), ISO37101 (Sustainable Development in Communities – Management System for Sustainable Development – Requirements with Guidance for Use), ISO37104 (Sustainable Cities and Communities – Transforming our Cities: Guidance for Practical Local Implementation (ISO 37101)). The committee fully recognised the standardised construction of the eco-city. In 2017, it granted the eco-city the international pilot city of ISO37101, and the eco-city as a case of reference in ISO37104.

5. Optimisation and Upgrade of KPIs Framework

At the beginning of 2017, China and Singapore decided to upgrade the KPIs framework. The main purpose was to implement China's new deployment in comprehensive promotion of the construction of ecological civilisations, to incorporate the outcomes of sustainable development around the world, and to adapt to the new changes

in the coordinated development of the eco-city and its adjacent two regions. The upgrade was done especially to make adjustments and improvements after 10 years of practical experience with the eco-city. The Ministry of Housing and Urban-Rural Development of the People's Republic of China also made it clear that the evaluation and summary processes should be strengthened when implementing the KPIs framework. In addition, the framework should be revised in a timely manner in accordance with the new requirements and standards proposed by China.

The optimisation and upgrade retained framework's targets in the 2008 version and refined the indicators at each level. The original "3+1" composite indicator system of "environmental health – social harmony – efficient economic cycle – regional coordination and sharing" was also retained. Seven of the original 12 criteria levels were adjusted, and three new ones were included to give a total of 15 criteria levels. In terms of indicators and their values, both advancement and continuity were taken into account and the original indicators were retained as far as possible. As for the setting of indicator value, new requirements and new targets were implemented based on the problems encountered in the implementation of the original KPIs framework, and international indicators were given priority as long as they were achievable. This ensured that the indicators were advanced, comprehensive, representative, measurable and assessable.

A total of 36 indicators were proposed in the new KPIs framework after the optimisation and adjustment process, including 30 regulatory indicators and six guiding indicators. Among the regulatory indicators, nine were retained, three were removed, 10 were revised and 11 new ones added. In the new KPIs framework, the indicators in ecological environment and resources made up the majority of 53%; six new social indicators were added, making it the area with the biggest increase. At the same time, new indicators in certain important areas were added, such as "ecological texture" and "liveable environment" in ecological environment indicators, "urban transport management" and "resident experience" in social indicators, and "technology innovation" in economic indicators. The revised indicators were set for approved for implementation in September 2018.

Conclusion: During project discussions, China and Singapore determined the use of quantitative indicators to provide a framework in terms of construction standards and ecological characteristics for the eco-city to serve as a guide for the drafting and subsequent implementation of the master plan. The KPIs framework co-developed by Sino-Singapore Joint Expert Team was of an advanced world standard at that time, and served as one of the guidelines of the eco-city. Good results were achieved in the eco-city by implementing various indicators in its master plan and specific construction. Practice also showed that the selection of indicators and the setting of their values need to be carried out in consideration with the actual situation of the region, an automated system must be established for indicator assessment, and the measurement methods must be constantly optimised and improved. More importantly, it was necessary to establish an evaluation system based on the KPIs framework to ensure the consistency and continuity of the project's orientation.

Chapter 7

Urban Planning

Summary

This chapter describes the basic content of the eco-city's master plan, and key revisions of it.

According to the requirements of the eco-city's KPIs framework , experts from China and Singapore drafted the first master plan of significance for the eco-city in 2008.

The comprehensive, detailed and precise nature of the plan, especially the market-oriented development model adopted by China and Singapore, ensured the consistent implementation of the development blueprint.

In order to ensure integrated development between the eco-city and its surrounding areas and adapt to the developmental trends of eco-cities around the world, the master plan was revised and updated in 2018. The new master plan was one that had the characteristics of "an ecological framework, city-industry integration, being green, liveable and people-oriented".

Based on the requirements of the KPIs framework, the Sino-Singapore Joint Expert Team drafted a master plan with the goal of coordinating economic, social and environmental developments through “integrated planning”. After 10 years of strict implementation, revisions were made to the master plan in view of changes in the external environment and the eco-city's development needs. This reflected the flexibility of the master plan, which ensured that it moved with the times.

1. Master Plan

At the end of 2007, the eco-city asked the China Academy of Urban Planning & Design, Tianjin Urban Planning & Design Institute, and Singapore’s Urban Redevelopment Authority to jointly prepare the master plan. In March 2008, an outline of the master plan was formed and approved by the Tianjin Municipal Commission of Urban Planning. In September, the *Sino-Singapore Tianjin Eco-City Master Plan (2008-2020)* was approved by the Tianjin Municipal Government. The plan won the Best Survey and Design Award from the Ministry of Housing and Urban-Rural Development (MOHURD).

The 2008 edition of the *Sino-Singapore Tianjin Eco-City Master Plan* drew reference from the relevant experience in the planning and construction of eco-cities in China and abroad. Factoring in the constraints of ecological resources and the environment, and in combination with the actual situation of Tianjin city, the plan adopted concepts such as circular economy, harmonious neighbourhoods and cultural ecological construction. It introduced advanced technologies in the fields of resource conservation, ecological protection, green transportation and green building, and pioneered planning principles and methods that were "guided by indicators", "drew boundaries before layout" and "synchronised with special plans". This fully realised the role of space planning as a leader and coordinator of the integrated plan.

1.1 Preparation principles

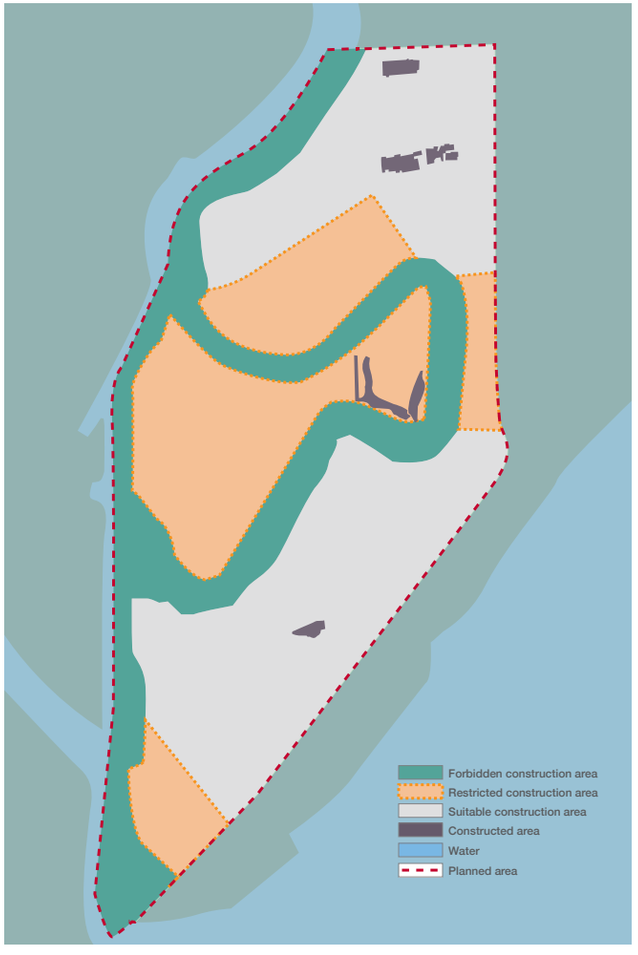
Guided by indicators: The eco-city pioneered the approach in which a KPIs framework was created before the master plan was prepared. In the past, urban construction projects typically started with a master plan and feasibility study, but the construction of this eco-city was guided by a strict KPIs framework. The formulation of the master plan was able to implement the 26 indicators. This incorporated the needs of the economy, society and environment into urban space and land use planning and converted them into special plans for transport, energy and resources. In 2018, after the KPIs framework was upgraded,

the master plan was also revised accordingly. As a result, the requirements of an upgraded KPIs framework were strictly implemented and the model in which indicators serve as a guide for the master plan was further extended.

Supported by special plans: During the preparation of the master plan, 16 special plans were studied simultaneously. These plans covered key areas of urban development and construction such as development orientation, industry orientation, ecological technology and neighbourhood construction, which provided support to the master plan. The studies mainly included areas such as examples of eco-cities, urban orientation, population estimation, development of a circular economy, green transport system planning, green building, construction of a harmonious society and neighbourhoods, housing policies, ecological neighbourhoods, standards for sustainable housing, green waste management systems, and disaster prevention.

Drawing boundaries before layout: The approach of "drawing boundaries before layout" meant that the boundaries of forbidden areas, restricted areas, constructable areas and constructed areas were drawn first based on the integrity of the ecological structure and the appropriateness of land use. This was then used as the basis for further land use arrangements. With the priority given to ecological needs, the master plan was prepared using a “subtraction” method. Based on ecological sensitivity analysis and construction suitability evaluation (Figure 7-1), the boundaries of areas that required protection and control were drawn first, including natural wetlands, buffer areas and areas on both sides of a river. The remaining areas were classified as the construction area of the eco-city. By drawing the boundaries for forbidden areas, restricted areas, constructable areas, and constructed areas, the ecological environment was protected, while controlling urban development. In view of the constraints in terms of resources and the environment, ecological red lines and urban development boundaries were drawn, which formed the basis of the master plan.

Figure 7-1: Suitability Evaluation and Space Control Zones for the Eco-city



Integrated planning: Before China's full promotion of the concept of "integrated planning", the eco-city had already adopted the approach as early as 2008 in the preparation of its master plan. On the basis of integrated planning, which put urban master planning, economic and social development planning, and land use planning together, "ecological environmental protection planning" was further consolidated to give priority to the ecological environment and focus on environmental protection.

1.2 Main contents

Development orientation: The eco-city's orientation fulfilled the basic requirements of China and Singapore, and incorporated the general deployment for the construction of a "resource-conserving and environmentally-friendly" society in China at that time. It reflected China's economic transformation from a "high-input, energy consumption and pollution, but low-output" nation to a "low-input, energy consumption and pollution, but high-output" one. It emphasised that the economic development of the eco-city should not be at the expense of the environment. Instead, it must be built on the basis of structure optimisation, efficiency improvement, consumption reduction and environment protection, and demonstrate the determination and vision in resource conservation and environmental construction. Specifically, the eco-city should be a comprehensive platform for technological innovation and promotion of eco-environmental protection, energy conservation and emission reduction, green building, circular economy, a national centre of eco-environmental training and promotion, a modern high-tech eco-industrial base, a new "resource-conserving and environmentally-friendly" liveable city model, an exchange and display window for the participation in international ecological environment construction.

City size: The population of the eco-city reflected its employment-oriented policies. It was proposed during the preparation of the master plan that various policies and measures be actively adopted to create a market environment that is conducive to enterprise competition and development and encourage diversified investment and entrepreneurship, so as to advance economic development and create more employment opportunities. The eco-city is projected to provide around 190,000 jobs in 2020, with a local employment rate of at least 50%. Based on the above estimation, the master plan determined that by 2020, there will be around 350,000 permanent residents, an external working population of 60,000, and an internal temporary consumer population of 30,000. The total construction area was planned as 25.5 km^2.

Integrated Land Use Planning

Ecological layout: The ecological efficiency of an urban area depends on the presence of a complete, natural ecosystem. The eco-city put the establishment of a fully connected ecological space as its top priority. As a result, an ecological layout of “one island, three waters, and six corridors” was formed in combination with local resources (Figure 7-2). The "green core" of the eco-city – an Eco-island – was created in an area enclosed by the Gudao River and Qingjing River. On the southwestern side of Eco-island, the original industrial sewage reservoir spanning 3 km^2 was remediated and turned into Jinghu Lake. With the Jinghu Lake, Jiyun River and Gudao River as the backbone, six ecological corridors with artificial water bodies, including Huifengxi, Ganluxi, Yinfenglin, Hupoxi, Bailuzhou and Yingwuzhou, were created to form an ecological network that is connected both internally and externally.

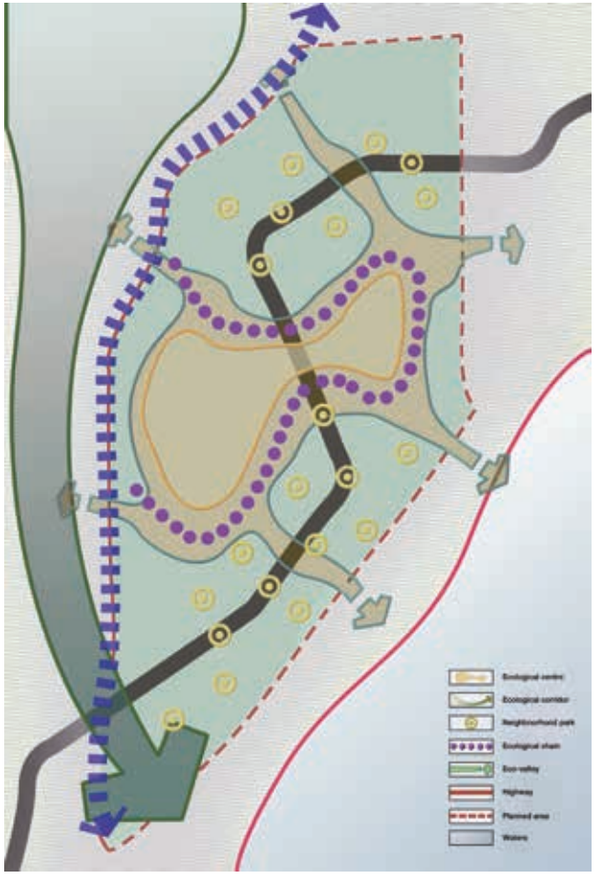


Figure 7-2: Green Space System Planning of the Eco-city

Spatial layout: In order to accelerate the realisation of energy conservation and carbon reduction, and shape a people-oriented neighbourhood and public space environment, the spatial layout of "one axis, three centres, and five areas", mainly connected by rail transit, was adopted based on the principle of "transit-oriented development" (TOD).

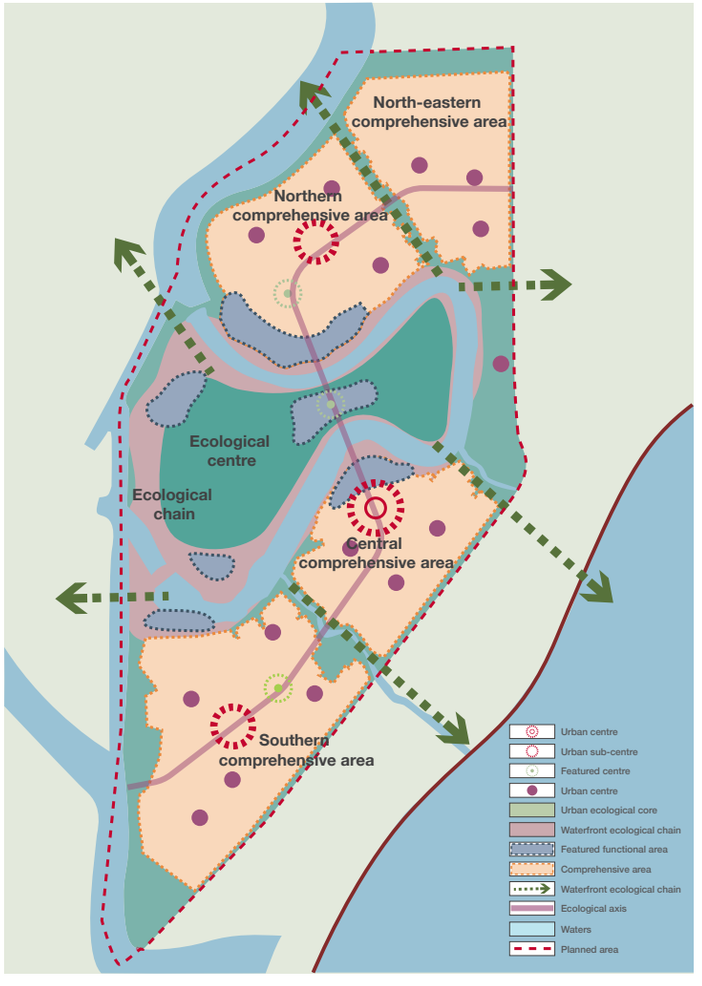


Figure 7-3: Spatial Layout of the Eco-city

"One axis" refers to the "Eco-valley", a green belt that is about 80 m wide and runs through the eco-city. It connects the four comprehensive areas and the Eco-island, and is closely linked to public facilities on both sides. It is a functional axis that integrates transport, landscape, leisure, tourism and disaster prevention into one. The development intensity of areas near rail transit stations was relatively high and gradually reduced as it extended outwards. Taking the two indicators of plot ratio and building height as an example, the land around transit stations were areas with the highest development intensity, with plot ratios of at least 4.0, or second-highest development intensity plot ratios of between 1.6-4.0. The further the land was from a rail transit station, the lower its plot ratio.

"Three centres" refer to the building of an urban centre and two sub-centres. The urban centre would mainly provide office, retail, cultural and entertainment, and tourism and leisure spaces. The two sub-centres were located at the heart of the southern and northern areas respectively and would provide education, healthcare, culture and sports, business, financial and postal services. In addition, the plan also included three special centres: Administrative Office Area, Ecological Forum and Exhibition Creative Area, and Qingtuozi Village Folk Cultural Tourist Area, to form an urban centre system.

"Five areas" refer to five comprehensive areas: the southern area, central area, northern area, north-eastern area, and Eco-island area. Each comprehensive area included a number of eco-neighbourhoods and eco-cells. The areas integrated various functions such as residence, commerce, industry, environment and leisure, and would serve as the carriers of various functions of the eco-city.

Neighbourhood structure: The goal of achieving a local employment rate of under 50% was set in line with the concept of maintaining "city-industry integration and job-housing balance". The traditional mode of separating industry from residence would be abandoned, and the technology-based industrial parks integrated with residential neighbourhoods to reduce commuting traffic and promote job-housing balance, thus enhancing regional vitality. A three-tier residential system of "eco-cell – eco-neighbourhood – eco-area" was planned with reference to Singapore's experience in planning public housing flats based on the "community – neighbourhood – town" model (Figure 7-4).

Eco-cells (grassroots neighbourhoods): These consisted of blocks of about 400 m by 400 m in size and with a total population of approximately 8,000 people (about 3,000 households). Eco-cells were the basic units of land transfer by the eco-city to the market. Developers used them as units of development and construction, and equipped each of them with a certain amount of community-level commercial facilities as required, with a focus on the equalisation of service radius and the diversification of service functions.

Eco-neighbourhoods: These consisted of four to five eco-cells, with a size of about 800 m by 800 m and a population of about 30,000 people (10,000 to 15,000 households). Based on the concept of Singapore's neighbourhood centres and community clubs, one-stop comprehensive neighbourhood centres were planned. These provided the neighbourhoods with government services and residential facilities, such as leisure and sports, medical services, dining and entertainment services, and highlighted the humanistic design and the integration of different functions.

Eco-areas: These consisted of four to five eco-neighbourhoods, which were flexibly arranged in combination with the on-site situation. They offered more complete and accessible public services and facilities, and brought in large-scale commercial complexes and high-end business and recreational facilities.

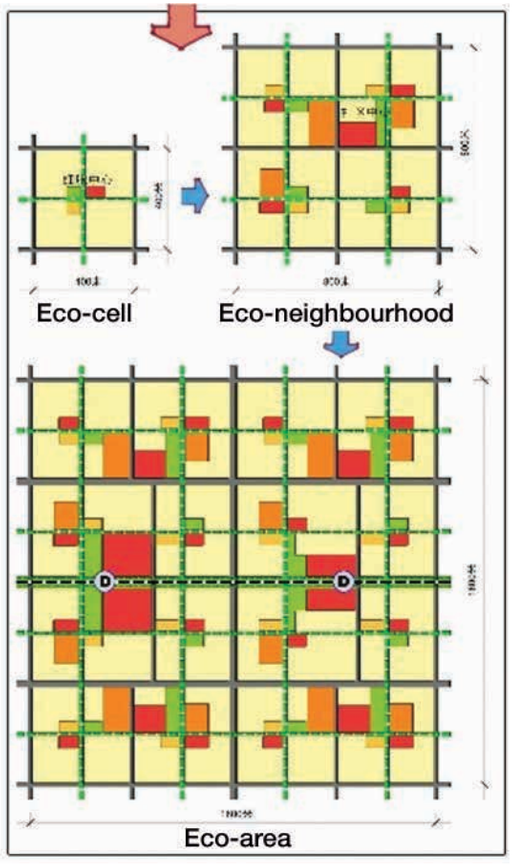


Figure 7-4: Schematic Diagram of the Three-tier Neighbourhood System

Green transport: The eco-city's road network was a breakthrough on the traditional four-level structure featuring fast roads, main roads, secondary roads and branch roads. Instead, the roads were divided into two categories: two-way, six-lane main roads and two-way, four-lane branch roads. In order to encourage slow traffic, the eco-city adopted a special "road network – green road" double chessboard layout in its master plan (Figure 7-5). Under the model, 400 m by 400 m vehicle road networks were separated from 400 m by 400 m green road systems. Then they were sub-divided into smaller blocks of 200 m by 200 m. This ensured a layout of dense road networks in small blocks and created a perception of space where human and vehicular traffic were separated. The plan also strengthened the seamless connection between public transport and slow-traffic systems.

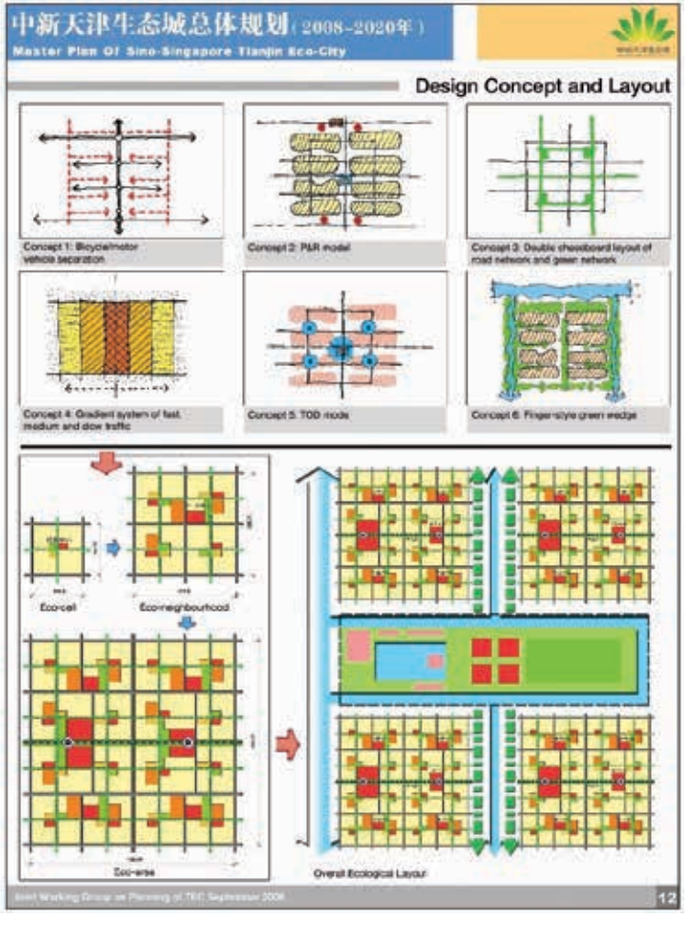


Figure 7-5: Schematic Diagram of Double Chessboard Layout

Municipal planning: The KPIs framework explicitly specified that the utilisation rate of unconventional water resources within the eco-city should not be less than 50%, and that the utilisation rate of renewable energy should not be less than 20%. Therefore, the master plan set out comprehensive requirements on the utilisation of resources and energy. It emphasised the optimal allocation and recycling of water resources, construction of rainwater collection and waste water recirculation systems, providing water supply of different grades, and building a water recycling system (Figure 7-6). These helped to strengthen the ecological restoration and reconstruction of the water bodies. The plan also actively promoted new energy technologies and enhanced the adoption of an energy hierarchy to facilitate energy conservation and improve energy efficiency. It encouraged clean production, energy conservation and

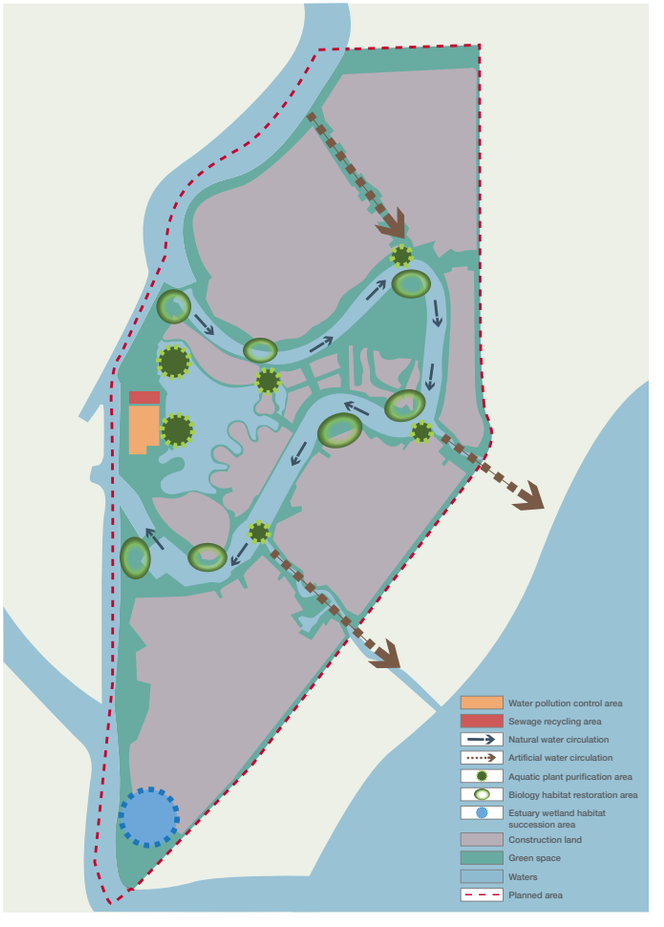


Figure 7-6: Water System Planning of the Eco-city

emission reduction, and gave priority to the development of renewable energy to create an energy utilisation model in which renewable energy and conventional energy are connected and complementary to one another. The plan made use of technologies such as recovery of waste heat by heat pump, integrated supply of cooling, heating and power, and collection of solar energy from pavements to achieve comprehensive energy utilisation. It established a system for separate collection, comprehensive treatment and recycling of solid wastes, and promoted the industrialisation of comprehensive utilisation of renewable resources.

2. Detailed Planning

Another feature of the plan was an implementation mechanism in which the objectives were transmitted progressively through the different levels. During the implementation process, a plan management system with “one regulatory framework and three guidelines” was established to ensure that the plan is transmitted down the levels from special planning to regulatory detailed planning to urban design. This ensured that the master plan was implemented without losing any of its "original flavours". In addition, China and Singapore also established a coordination and communication mechanism to strictly restrict any tampering of the plan.

2.1 “One regulatory framework and three guidelines” management model

The “three guidelines” refer to the guidelines on land use, urban design and ecological technology implementation. Of these, the guidelines on urban design set out the control elements and requirements. The guidelines on ecological technology implementation put forward the requirements for energy conservation and renewable energy utilisation, water conservation and water resource utilisation, green building and green transport. These two guidelines were incorporated into the eco-city's detailed regulatory planning to form general provisions that have the same legal effects as the regulatory framework. When land parcels were being transferred, the above design requirements were converted into the guidelines on land use for the land parcels. This ensured the implementation of regulatory control on land use, and that the requirements of the two guidelines were met. In this way, spatial planning concepts were stringently implemented.

2.2 “One map and one list” management model

The guidelines on land use in the eco-city's detailed plan comprised, specifically, the “one map and one list” model. “One map” refers to a land use layout map at an eco-cells level, which could go down to the level of housing blocks. This provided the basic information on land use control. It was more detailed compared with other parts of China. “One list” refers to a list of design requirements, which included 50 items across nine aspects that echoed the regulatory outline. The items comprised 39 mandatory items and 11 recommended items. The nine aspects were directly linked to the regulatory government departments and defined their respective responsibilities and authorities. The 50 items provided detailed, effective standards for developments to ensure an effective integration of government management and market behaviour.

The eco-city's specific requirements on public facilities and spaces

The eco-city's detailed regulatory plan set out detailed requirements on the configuration of public facilities and spaces. Taking the slow-traffic system as an example, the general provisions of the detailed regulatory plan contained five requirements: width of classification, design requirements, design requirements for intersecting transport systems, access control and form control. In the guidelines on land use, the coordinates of entrances and exits of slow-traffic systems were defined to ensure that the slow-traffic systems that were established independently for each land parcel can be seamlessly connected as a network. In addition, the detailed regulatory plan also specified that both bus stations and the entrances and exits of slow-traffic systems should be provided with non-motor vehicle rental stations to facilitate connection to green transport.

In order to effectively fulfil the requirements for lifestyle services at urban centres (sub-centres), eco-neighbourhood centres, and eco-cell centres, the detailed regulatory plan of the eco-city put forward detailed construction requirements for public facilities and public spaces of neighbourhood centres and cell centres, including project setting, scale, area and construction layout. For example, the plan specified that neighbourhood centres should be provided with 14 facilities across seven aspects including public administration, culture and sports, healthcare, neighbourhood businesses, municipal facilities, lifestyle services and other service facilities. The outdoor activity spaces of these 14 facilities should be

laid with hard pavements and designed in coordination with neighbourhood parks. They should also include rehabilitation facilities and free sports facilities. The cell centres should have public toilets available at the interchange of slow-traffic systems and its concentrated green area should be no less than 70%.

Effective control and construction made the "eco-cell – eco-neighbourhood – eco-area" model one of the project's most successful "experience" offerings worth promoting. It also played an essential role in attracting talented individuals to the eco-city. The model successfully achieved two major goals: first, the first 15-minute lifestyle radius ("15 分钟生活圈模式") across the country was implemented, such that the basic lifestyle needs of the residents could be satisfied by slow traffic without the need to drive; second, the neighbourhood centre provided sound service functions, including supporting facilities such as for healthcare, culture and education that catered to, and were well-received by, the residents.

2.3 Detailed planning guarantees the implementation of special plans

Projects that were directly related to the daily life of residents, such as the construction of municipal services and transport infrastructures, were implemented through detailed regulatory and construction plans.

The special plans covered comprehensive transport planning, pedestrian and bicycle transport planning, and special planning for various municipal infrastructure, including electric power, water supply, rainwater and sewage, reclaimed water, heat supply, gas and high-voltage electricity. These special plans further deepened and defined the master plan from different professional perspectives. The requirements of the special plans for stations and pipelines were implemented through the preparation of the detailed regulatory plan. With the detailed construction plan, the requirements were implemented in the specific design of the project according to the special plans and detailed regulatory plan.

The planning management was based on the "one report and two permits" (site selection report, land use permit and building permit) principle and the construction requirements of green buildings and sponge cities were incorporated into the management process. In combination with existing plan approval processes, audits on green buildings and sponge cities were included without increasing the number of approval loops. A management system closely integrated with the approval process was established to form a regulatory model that covered the entire process of planning, plan preparation, design and construction. The transformation from "reporting after the event" to "notification before the event, approval and control, process supervision and evaluation after the event" ensured that all projects met the green building and sponge city requirements.

3. Revision of the Master Plan

In June 2016, China and Singapore held an eco-city strategy symposium to discuss important issues about the next step of urban development. China and Singapore released a revised master plan to facilitate the incorporation of the Binhai Tourist Area and Central Fishing Port into the scope of management, and to cater to new situations and requirements such as the adjustment of the planned area, rerouting of Metro Line No. Z4, and the construction of the sponge cities. This was done with the opportunity provided by the revision of the master plan for Tianjin city and Binhai New Area and in combination with the new requirements of the upgraded KPIs framework. The revised master plan drew references from the latest practices of advanced cities in China and abroad, especially the Xiong'an New Area. In June 2018, the revision of the master plan was completed and submitted for approval. The revision involved four main aspects: experience replication, integrated development, optimisation and adjustments, and innovative methods.

3.1 Replication of cooperation zone experiences

Replication of experiences in neighbourhood construction: The "eco-residential system" of the Sino-Singapore Cooperation Zone was replicated in the management area. The Green Block 2.0 System featuring "neighbourhood unit + natural system + TOD guidance" was implemented. It promoted and applied the spatial layout model of the Sino-Singapore Cooperation Zone in terms of the scale and size of basic neighbourhood units, residential neighbourhood units, and area units. This created an integrated city-industry layout with the basic block units at a scale of 20 to 30 km^2. It combined public service facilities at different levels with green park spaces, public transport, and urban greenway systems to form more accessible, comfortable, healthy and beautiful supporting facilities. In addition, it advocated a green and low-carbon

lifestyle, and formed a 15-minute lifestyle radius that allowed residents to enjoy the benefits of public policies with high-level planning and high-standard construction. The construction of supporting facilities and environmental engineering projects were started moderately in advance. This broke the boundaries between schools, neighbourhood centres and neighbourhood green spaces, and created neighbourhood supporting clusters featuring complex functions that were open, shared and accessible. As a result, a comfortable and beautiful urban environment was established, which enhanced the attractiveness of the city.

Replication of TOD model: In the original master plan, the Eco-valley that ran through the city was taken as the development axis along which were three urban centres and several sub-centres. The Eco-valley was both a landscape corridor and rail transit line. The master plan was revised with the opportunity provided by the rerouting of the rail transit lines in Binhai New Area (adjusted from the Eco-valley to Central Avenue). This allowed the TOD model to be fully implemented. A high-efficiency, low-cost and low-pollution urban transport system centred on public transport was established in coordination with the land use layout. The development intensity was enhanced along transit stations of the eco-city and neighbouring areas. As a result, rail transit was supported by high passenger traffic generated by high-intensity land use, which ensured coordinated development between land use and transport system. Rail transit was connected with normal bus transit to increase the usage of public transport. Comprehensive development in diverse formats were performed in combination with bus stations to improve land use intensity and utilisation efficiency. This ensured that urban population and employment were mainly concentrated within 500 m from rail transit stations. A complete and continuous network of urban slow-traffic systems was established to connect rail transit and bus stations and connect urban public facilities at all levels to open green park spaces. This provided the solution for the "last kilometre" of residents' travels.

Replication of experience in environmental construction: The concept of sustainable development, the planning method of "drawing the boundaries before layout", the shaping of ecological spaces, and the protection of wetlands in the Cooperation Zone were used as references. The principle of giving priority to the ecology was maintained, while the protection of regional ecological corridors, bird habitats and river systems were strengthened. A large area of ecological wetlands was preserved in the estuary to ensure the organic convergence of ecosystems and to form an ecological layout with regional integration. This ensured a zero net loss of wetlands. Advanced technologies were applied in the areas of ecological restoration and environmental governance. The protection of coastline resources was strengthened to strictly protect the migration passages and foraging areas of migrant birds, control the urban construction and development of surrounding areas, and build the Yi'ou Park in Binhai New Area to create a unique "eco name card" for the eco-city. Multi-level ecological corridors were arranged based on water systems such as Jinghu Lake, Gudao River, Nanwan, and Shell Bank, to construct a composite ecosystem. Linear green corridors such as Dongdi Park, Nandi Coastal Footpath, Haidi Park, and Eco-valley were constructed, and green spaces in parks and neighbourhoods were connected to create an eco-city where water bodies, greenery and urban constructions are integrated and linked. A sound water circulation system was established in combination with the existing water system with artificial rivers to form a multi-stage water circulation system consisting of naturally enhanced circulating ecological water system, artificially enhanced circulating ecological water system, and self-circulating landscape water system.

3.2 Advancement of integrated development

Integrating the urban spatial layout: In light of the major changes like the expansion of the planning area from 34 km^2 to 118 km^2 and adjustment of the rail transit line from the Eco-valley to the Central Avenue, the master plan needed to be revised to ensure the integration of the original eco-city, Binhai Tourist Area and Central Fishing Port in terms of spatial structure. The main centre of the original plan at Gudao River was moved to the vicinity of Nankai High School (light rail station) at the Central Avenue to meet the development needs of TOD, and reflect the layout design that spreads out from the main centre. With the principle of coordinated development with surrounding areas, the spatial structure was further improved to couple public service corridors with the ecological corridors, and combine open space with service centres to form a spatial layout of "one axis, two wings and three corridors". "One axis" refers to the central high-efficiency dynamic axis formed along the Central Avenue. "Two wings" refers to the integrated service wing on land and the tourism and leisure wing in the sea area. "Three corridors" refers to the north-south public service and landscape corridors in three areas including the eastern, central and western areas.

Optimising the urban centre system: The plan adopted an urban centre system based on “two centres and three sub-centres”. “Two centres” refers to municipal comprehensive service centres established around commercial, tourism and leisure, and transport hubs. These were formed at two rail transit stations, namely, Nankai High School and Yushadao. “Three sub-centres” played an important role in terms of professional services. The Nanwan Sub-centre focused on tourism, leisure, and vacation services; the High-speed Rail Sub-centre focused on a transport hub, commercial business, tourism and leisure services; and the Central Fishing Port Sub-centre gave priority to sea-related sports, and cultural exchange services.

Redefining the urban size: Based on the substantial increase in area, on the premise of ensuring liveability and taking into account factors such as economic development and job-housing balance, the plan determined that by 2035, there would be about 600,000 permanent residents, 510,000 employees, and 28 million tourists every year, and a total of 97 km^2 of construction land.

Adjusting the proportion of planned land use: From the overall development perspective, the proportion of land use was recalculated according to urban function needs. There would be 25.5 m^2 of residences, 8.4 m^2 of public service facilities and 15 m^2 of commercial service facilities, accounting for 26%, 8.5% and 14.8% of the total construction land respectively. In addition, there would be 19.8 m^2 of road and transport facilities, accounting for 20%. Moreover, 30 m^2 of ecological green spaces were planned to highlight the features of ecology and liveability

3.3 Optimisation and adjustment

Upgrading urban development orientation: Leveraging the overall deployment of coordinated development of the Beijing-Tianjin-Hebei region, actively transferring non-capital functions from Beijing and ensuring good connections with other surrounding cities, the plan strived to build a national green development demonstration zone in China and turn the eco-city into an “international leisure bay, green eco-city, and future smart port” in the Beijing-Tianjin-Hebei region. The plan will set the direction of industrial development in consideration of the industrial conditions as set out in the "integration of three districts" plan and the "northern ecology" conservation policy in Binhai New Area's master plan. Building on the cultural and creative industries, the Sino-Singapore Cooperation Zone introduced other innovative industries such as eco-environmental protection, digital information and new Internet industries and vigorously promoted international education and medical services. Binhai Tourist Area gave priority to electronic chips, big data, intelligent manufacturing, cultural tourism, marine ecological leisure, marine health services and marine education and research development. The Central Fishing Port seized the the opportunity provided by the opening of a commercial port and made use of advantages in terms of external traffic, including waterways, railways and highways, to create a port for aquatic products, agricultural by-products, cold chain logistics and commerce and trade. The port became an international trading platform that integrates exhibition, sales, processing and catering into one.

Exploring new directions in resource utilisation: On the basis of meeting the indicators for green buildings 100%, the following revisions were made to the master plan: (1) To further explore the cutting-edge technologies in the field of green building to construct pilot passive housing projects, demonstrate and promote prefabricated building; (2) Actively carry out testing on zero-energy and ultra-low-energy buildings, and cultivate green building industry clusters in the eco-city; (3) Further strengthen energy conservation and emission reduction, and continue to develop and apply renewable energy resources such as solar energy, wind energy, geothermal energy, ground-source heat pump, water source heat pump and biomass energy to realise the coordination and linkage of multi-types of renewable energy and explore a distributed energy supply model that is compatible with cluster development with the goal of 20% renewable energy utilisation rate; (4) Realise separate collection, pneumatic transport, sorting, treatment and recycling of garbage in the eco-city with the help of smart platforms based on existing garbage collection and points exchange systems; and (5) Carry out the construction of a pilot sponge city in an all-round way, and effectively control rainwater runoff to reduce pressure on the municipal pipe network and enhance urban flood control capacity. This would ensure water security, conserve water resources, restore water ecology, and reduce the heat island effect, creating a pleasant regional climate and minimising the impact of urban development and construction on the ecological environment.

Shaping characteristic urban spaces: In order to build a unique eco-city and prevent it from looking the same as other cities, great importance was attached to the control of the eco-city's urban design. The revision of the master plan involved the urban design of many regions. Although the urban design was not a prescribed action in the preparation of the master plan, the urban designs of Linhai New Town,

the main centre, and the northern part of the tourist area were included to ensure a distinctive development for each area. Each area's urban design ensured that they had different spatial forms and features. Among them, the central area featured an annular radial spatial layout around the TOD node of the main urban centre, where a municipal service centre featuring commercial, tourism and leisure, and transport hubs was built at the rail transit station Nankai High School. Linhai New Town adopted a laidback urban model with "narrow street blocks and a dense road network", where a large-scale water landscape was created as a public open space with the resources from Nanwan and the coastal area. The spatial layout of Linhai New Town around Nanwan maximised the urban landscape interface, with Nanwan and surrounding areas serving as the key points in the design and control of coastal area. As a result, the overall hydrophilicity of the reclamation area was enhanced to create a special northern aquatic ecological town. Bay-type and island-type coastlines were adopted. Urban functions were planned based on marine culture. As for development intensity, a low-density, low-intensity cluster layout was given priority.

3.4 Planning innovation

Launching a pilot project for "flexible planning": With the guidance of the MOC, and by referencing Singapore's managerial experience in "white sites" (in the process of development and construction of Marina Bay, Singapore has achieved flexible land use and improved land value and urban vitality by setting up white sites), the pilot project for flexible planning was launched in the eco-city to solve the relationship between strategic reservation and recent development, and achieve a balance between rigid control and flexible market demand, so as to improve the flexibility of plan implementation and sustainable development of the city. In the revision of the master plan, the concept of "flexible planning" was incorporated into its scope. It required the exploration of feasible ways to achieve land miscibility and functional compatibility for special areas by setting up commercial white sites in combination with a rail transit station, setting up flexible industrial planning spaces in combination with the northern industrial zone, and referring to the operating rules of the "white site" system in Singapore.

Preparing an action plan: After the master plan was approved, a new action plan was prepared to achieve a few aims: Implement the revised master plan; match the spatial planning with economic development; determine the construction indicators, make plans for fixed assets investment in four categories including housing, facilities, people's livelihood and industry; determine major initiatives from four aspects including transport, service, environment and industry; and implement relevant contents. This helped to establish the implementation plans for each key development area of the city.

Assessing the implementation effects: The implementation of the plan was assessed and revised on a regular basis, so that timely adjustments could be made in line with changes in the external environment. The implementation of spatial planning was assessed in an all-rounded way (master plan, detailed regulatory plan, urban design, special plans). The development orientation, economic functions, urban structure, spatial form, scale of land use, traffic organisation, planning layout, land use and business layout were reviewed, and recommendations were made. The advantages, disadvantages, challenges and opportunities of the eco-city were identified, and problems and deficiencies were reflected objectively to make timely adjustments.

Conclusion: A city is a complex system with multiple sub-systems that include not only hard systems such as transport network, building clusters and public places, but also soft systems such as governance policies and financing mechanisms. When formulating urban and management plans, a global perspective must be adopted to treat the city as a unified whole. The environment, society and economy sub-systems must be integrated to determine the near and long-term development goals in advance and prioritise development matters. This requires policy-makers to be far-sighted. If the master plan does not keep up with the times, then there will be a high cost to pay in the later stages. The practice of “integrated planning” and “drawing the boundaries before layout” guided by an ecological KPIs framework in the eco-city was an innovative approach. The cluster development of land unified spatial and transport planning, which also implied the design of “a neighbourhood with services within walking distance” that minimises travel distance, reduces urban carbon footprint, and helps ensure green travel. The detailed regulatory plan management system with “one detailed regulatory plan and three guidelines” was formulated and the “five-year action plan” was prepared to determine key projects and deadlines for the implementation of the master plan. Changes in the external environment meant that the master plan must be flexible. It must be revised and upgraded based on new situations on a regular basis to provide effective guidance for the development and construction of the eco-city.

Part 3

Green and Low-Carbon

This section describes the practice and outcomes of the eco-city in terms of ecological remediation, environmental transformation, green landscaping, resource utilisation, green transport and green building from the green and low-carbon perspectives. In the construction of these urban subsystems, maximisation of environment transformation, ecological remediation, resource conservation and energy consumption reduction were the eco-city's defining characteristics and basic requirements. It was also an important component of the eco-city's main pillars.

As the eco-city was constructed on an environmentally degraded saline-alkali wasteland, ecological remediation and environmental reconstruction were given top priority. The outcomes in terms of environmental construction were obvious. A sewage reservoir that had remained polluted for 40 years was turned into “Jinghu Lake”, a place that people could get close to. An old wasteland was transformed into an oasis, the wetlands were completely preserved and remedied with a wide range of native plants being planted, allowing birds, fish and other creatures to breed there.

The eco-city's urban development and construction advanced in accordance with the requirements of the KPIs framework in an all-rounded way. In order to meet the goal of achieving a 20% utilisation rate of renewable energy by 2020, a comprehensive energy utilisation system for solar energy, wind energy, geothermal energy and biomass energy was established. To meet the goal of a 50% utilisation rate of unconventional water resources by 2020, a water resource utilisation system centred on rainwater collection, sewage treatment, reuse of reclaimed water and introduction of desalinated sweater was established. To hit the target of a 60% waste recycling rate by 2013, a system featuring source separation and collection, pneumatic pipeline recycling and centralised terminal disposal was established. With the goal of reaching a 90% green travel rate by 2020, a green transport system supported by rail transit, clean energy public transport and slow-traffic system was established. To meet the requirement of having only green buildings, a design evaluation standard and a full life cycle management system were established.

This section echoed the eco-city's missions of “resource conservation and environmental friendliness” and embodied the ideology of people living in harmony with nature.

Chapter 8

Environmental Construction

Summary

This chapter describes the practice and achievements in the management of saline-alkali wasteland in the eco-city.

The eco-city was constructed on a saline-alkali wasteland with a harsh environment. Over the last decade, the eco-city remained committed to the protection of the area during development, remediation during construction and optimisation in subsequent stages. It succeeded in the management of a "sewage reservoir" that had accumulated industrial pollution for 40 years and established a comprehensive treatment programme that received over 50 national patents, paving the way for a novel, world-leading management of a polluted site.

The polluted site management programme has since been replicated in Baiyangdian Lake of Xiong'an New Area, Tanghe River in Anxin County, Hebei Province, Yi River in Yishui County, Shandong Province, Qingshuitang in Zhuzhou City, Hunan Province, Dagu Sewage River in Lingang Economic Zone, Tianjin, and Yuhuan City, Zhejiang Province.

Under the concept of sponge city construction, the eco-city was developed and constructed in an all-rounded way and was included in the second batch of pilot projects for sponge cities in China.

The saline-alkali wasteland has been completely transformed by referencing saline-alkali management technologies and programmes. With a green coverage rate reaching 50%, it created a remarkable "first impression" for the eco-city. And on the basis of extensive cultivation and planting, and testing of survival rate, more than 200 adaptable plant lineages covering trees and shrubs were grown, with a proportion of local adaptable plants of up to 70%. Moreover, large-scale ecological landscape projects were constructed, such as Yongdingzhou Ecological Wetland Park, Yi'ou Park, Seawall Park, Sino-Singapore Friendship Park, Ganluxi, Huifengxi, and the Old Course of Jiyun River. This created open spaces and public activity areas in the city and an ecological landscapes that integrated rivers, lakes, grasslands, wetlands, forests and beaches.

Clear waters and lush mountains are invaluable assets and a good ecological environment is most beneficial to the people's well-being. From the beginning, the eco-city was committed to a development strategy that gives priority to ecology. The goal of the eco-city was to create a beautiful home with a blue sky, green mountains and clear waters. Great efforts were made to promote three major environmental construction projects, namely, ecological remediation, waterscape reconstruction, and saline-alkali land greening to make the beautiful ecological environment the primary attraction of the eco-city and an asset for future generations.

1. Prioritising Pollution Control and Remedying Historically Polluted Sites

For 40 years, the sewage reservoir had been polluted by industrial wastewater from chloralkali process plants, with the water quality of worse than Grade V which means the water basically loses its self-purification capacity. As the sediment of the sewage reservoir was seriously polluted, benthic aquatic organisms found it difficult to survive. In this case, its management and remediation became a major problem in the construction of the eco-city. There were 2.15 million m^3 of polluted wastewater and 3.85 million m^3 of sediment polluted by heavy metals (Figure 8-1). The eco-city needed this to be managed first in order to thoroughly improve the environment (Figure 8-2).

Figure 8-1: Original Appearance of Sewage Reservoir in TEC

Figure 8-2: Sewage Reservoir after Management – Jinghu Lake

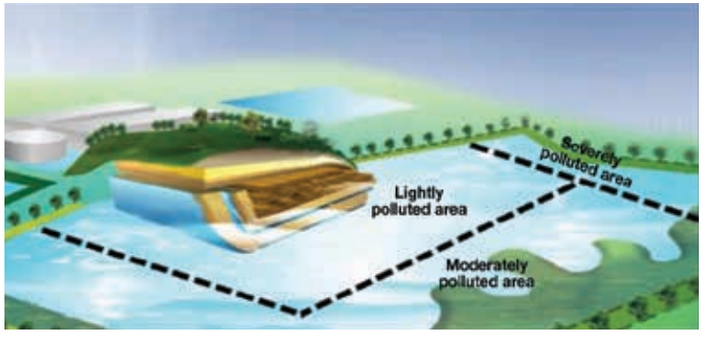


Figure 8-3:Schematic Diagram of Classified Management of Polluted Areas of Sewage Reservoir in TEC

Figure 8-4: Technology Roadmap for Sewage Reservoir Management

1.1 Joint efforts

As there was no precedent for the management of such a large-scale polluted site, the management principle of "thorough eradication without future trouble, scheme optimisation without failure, active promotion by grasping the timing, reasonable cost, and focusing on effectiveness" was established for the eco-city. On account of the gaps in the relevant standards for sewage reservoir management in China, authoritative research institutions were tasked with preparing the Sediment Remediation Limits of Contaminated Surface Water for Sino-Singapore Tianjin Eco-City through risk assessment and calculations. This provided a basis for the management of the sewage reservoir. The sewage reservoir was divided into lightly polluted area, moderately polluted area, and severely polluted area for classified management according to the remediation limits. As a result, both scientific management and conservative use of funds were achieved to prevent incomplete remediation or excessive remediation (Figure 8-3).

Research institutes created a joint team for key research projects on sediment management of the sewage reservoir. Lab-scale tests such as mechanical dehydration, geotube dehydration, natural drying, stabilisation and solidification and haycite firing were carried out for the sediment polluted by heavy metals, and comprehensive technical trials such as physicochemical pre-treatment and biotreatment were carried out for sewage treatment. A technical system was developed and successfully applied to the project, covering "environmental dredging of severely polluted sediment in lakes and reservoirs – geotube dehydration and volume reduction – solidification, stabilisation and recycling" (Figure 8-4).

Based on this technical roadmap, the moderately and severely polluted sediments were sealed and transported ashore by means of environmental dredging. They were then subjected to the treatment for heavy metal stabilisation and flocculation by means of pipeline online dosing, and then filled inside the geotube in the dehydration area. The sediments can be dehydrated using gravity without energy consumption. After dehydration, the severely polluted sediments were taken out of the bags and transported away, and fired into haycite by rotary kiln incineration technology to realise the immobilisation of heavy metals and the recycling of sediment. The moderately polluted sediments, on the other hand, were subjected to high-standard sealing disposal in the impermeable dehydration area, which was built in the largest landscape park in the surrounding areas – Jinghushan Environment Theme Park, by backfilling with soil. The sewage in the sewage reservoir was pre-treated by an iron-carbon internal electrolysis

process, which improved its biodegradability, and then discharged after being treated by Yingcheng Sewage Treatment Plant. The in-situ solidification and stabilisation technologies were adopted for the management of lightly polluted sediments. The treated sediments were used as subgrade soil to achieve recycling. Meanwhile, after the management of sewage and polluted sediments, the soil at the bottom of the reservoir was over-excavated for the construction of North Island, South Island and Wuzhi Island around the sewage reservoir, with a land area of 1.5 km^2 being added.

1.2 Step-by-step implementation

The sewage reservoir management project lasted for three years and was implemented in four stages:

The first stage involved the pollution investigation and assessment and preliminary work of the project. A point sampling scheme was prepared in accordance with the relevant standards, and environmental risk assessment and lab-scale and pilot scale tests on management and disposal technology were carried out after a standardised, comprehensive, in-depth and detailed investigation of the environmental background of the sewage reservoir. Meanwhile, the proposal for the sewage reservoir management project was completed and the project was submitted for approval.

The second stage involved project design and organisational management. The feasibility study report of the sewage reservoir management project, the standard for sediment remediation limits of contaminated surface water, project environmental impact assessment report, and project geological survey report were prepared. The licenses such as project construction planning permit, project land approval, builders' license were applied for and granted by government. A testing laboratory was set up at the project site to ensure the quality control of the management project.

The third stage involved project implementation. It mainly included the island-building landfill project, sediment dehydration and volume reduction treatment project, project on disposal of severely polluted sediment out of area, sewage pre-treatment and treatment project, project on in-situ management of sediment, and dredging and island-building project. Several participation organisations were tasked with providing daily summaries and deployment, process optimisation, and quality guarantee to achieve seamless connection and flow process so as to ensure the completion of the project on schedule.

The fourth stage involved monitoring and acceptance. After project completion, the post-project work such as final acceptance of the project, planning acceptance, project archives acceptance, safety acceptance evaluation, environmental monitoring and acceptance evaluation were carried out, and the settlement and deformation of landfill for the Eco-island was observed on a regular basis. The quality of leachate and the underground water in surroundings were monitored as well.

1.3 Replication and promotion

The project completely mitigated the impact of the sewage reservoir on the surrounding areas and downstream water systems and is also fully compliant with the standards and passed the environment inspection. On the basis of management practice, the relevant participants jointly applied for a number of research projects such as the "National Science and Technology Support Program during the 11th Five-Year Plan Period", the "Second Batch of Major Independent Innovation and Industrialisation Projects in Tianjin", and the "Major Independent Innovation Projects in Binhai New Area", and received more than 15 million RMB from the Ministry of Science and Technology, Tianjin, and Binhai New Area. The scientific achievements concluded from the project which were published in "Set of Key Technologies and Applications for Environment Management and Ecological Reconstruction of Severely Polluted Lakes and Reservoirs" won the first prize in the 2013 National Science and Technology Support Program organised by the Tianjin Municipal People's Government and the People's Government of Binhai New Area (Figures 8-5 and 8-6). It obtained more than 50 national patents represented by "A Method for Treatment of Sludge Polluted by Heavy Metals", forming a patent pool covering the management of polluted lakes and reservoirs, polluted site management technology, landscape water remediation technology, etc. A number of independent research and development technologies filled China's gaps in this field (see Figure 8-7). "The Sediment Remediation Limits of Contaminated Surface Water for Sino-Singapore Tianjin Eco-City" provided a scientific basis for the management, acceptance and evaluation of the sewage reservoir, and is recommended to the Ministry of Environmental Protection as a local standard of Tianjin. The eco-city's polluted site management programme has since been replicated in Baiyangdian Lake of Xiong'an New Area, Tanghe River in Anxin County, Hebei Province, Yi River in Yishui County, Shandong Province, Qingshuitang in Zhuzhou City, Hunan Province,

Figure 8-5: Certificate of Scientific and Technological Progress Award of Tianjin Municipal Government

Figure 8-6: Certificate of Scientific and Technological Progress Award of Binhai New Area

Figure 8-7: Patent Products

Dagu Sewage River in Lingang Economic Zone, Tianjin, and Yuhuan City, Zhejiang Province. CCTV reported on the achievements in the management of sewage reservoir with the Former Sewage Reservoir Turned into an Ecological Lake Today, which further enhanced the influence of the sewage reservoir management scheme of TEC.

2. Improving Resilience and Developing Pilot Projects for a Sponge City

A sponge city is a new-generation concept of urban storm water management. It means that the city has good “resilience” in adapting to environmental changes and coping with natural disasters caused by rainwater. It can also be called a “water-resilient city”, and, in international terms, refers to the “construction of low-impact development storm water system”. When it rains, the land absorbs, stores, seeps and purifies water like a sponge, and it “releases” the stored water and makes use of it when needed.

At the start of the eco-city project, the advanced experience of Singapore in low-impact development, storm water management, and water resources utilisation was fully borrowed from to perfect the drainage and flood control system, construct a rainwater utilisation and ecological security pattern, and strengthen the construction of a sponge city by means of low-impact development, water supply and water replacement, water circulation and ecological wetland treatment. In April 2016, Tianjin city was included in the second batch of pilot sponge cities. The eco-city is one of two pilot cities with an area of 22.8 km^2.

2.1 Improvement of drainage and waterlogging prevention system

While the sewage reservoir was remediated for the eco-city, the old river course was dredged and retained. The river system corridors such as Huifengxi were excavated to enable interconnection and form the eco-city's ecological landscape and create a natural sponge. Therefore, it played an important role in rainwater storage and regulation (see Figure 8-8). During the planning stage, the entire city was divided into six catchments according to topographical conditions.

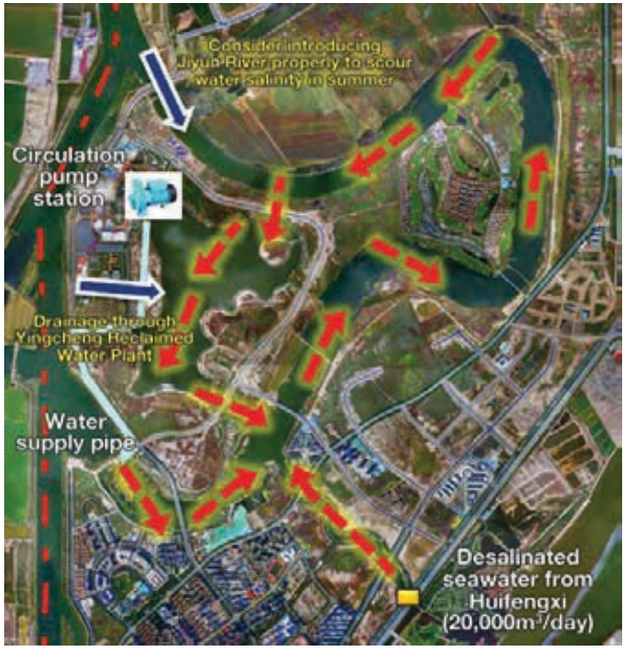


Figure 8-8: Diagram for Water Cycle Scheme (after 2018) in TEC

The entire terrain was raised by means of the vertical design of the site to enable rainwater to be drained – by gravity and with a pumping station – into scenic waterbodies such as the old river course, Jing Lake and Huifeng Creek. Before a storm, the water level of the rivers and lakes will be lowered properly through a warning system to enhance rainwater receivability. Project construction was guided by the low-impact development principle. Sponge facilities such as a sunken green belt, rain garden and rainwater storage tank were constructed to store rainwater and drain it. This reduced and slowed the discharge of rainwater and relieved the pressure on the rainwater pipeline network, ensuring safety for the city. Through overall process control, no ponding and inland inundation phenomena has occurred over the 10 years since the construction of the eco-city.

2.2 Utilisation of rainwater resources according to local conditions

The eco-city was in severe shortage of water resources. Its annual evaporation was far beyond the annual precipitation and annual landscape recharging demand was 18,500,000 m^3 accumulatively. To this end, rainwater collection was strengthened for the eco-city. The collected rainwater was used as landscape recharging water after being purified by the green spaces. The annual collection was almost 3 million tons, accounting for about 16% of landscape recharging water. The green landscape is constructed by making use of undulant landforms to create sunken spaces that enable rainfall to infiltrate into the subsoil, thus conserving water and reducing frequency of irrigation. For residential area construction projects, considering that precipitation in Tianjin is most intensive in July and August, if rainwater collecting facilities were provided separately, these facilities would be left unused most of the time, which would lead to an operating burden. Therefore, rainwater collection and utilisation facilities were provided for public house projects, the capacity of which was subject to both precipitation and demand. For residential projects, it was recommended to provide small, simple and easily maintainable facilities, for example, a rainwater tank, so as to provide convenience for residents to utilise rainwater.

2.3 Organic combination of sponge facilities with landscape, public space and city function

With regard to the combination of sponge facilities and landscape, ecological shorelines were used for both sides of the river system to reduce hard paving, providing pleasant waterfront space for residents and reducing rainwater pollution in rivers through green belt filtration of surface rainfall runoff, thus ensuring stable water quality. As for the combination of sponge facilities and public spaces, in open public spaces or centralised green spaces, sunken green belts, rain gardens or bio-swales were built depending on local conditions to weaken the sense of “stiffness” of the space and improve intimacy with humans, thus enriching the functions of the place. And as for the combination of sponge facilities and architectural functions, for office buildings and school buildings, roof gardens were built to enable retention and purification of rainwater, thus meeting demand from office staff and students for relaxation and exercise.

2.4 Exploration of new patterns of sponge city construction on saline-alkali soils

The eco-city used five-step key technology comprising drainage, storage, permeation, purification and use, and retention, and created a six-level sponge city retention and storage facilities featuring road green belts, permeable paving for a slow traffic system, green spaces, hollows (seepage wells), seasonable rainwater wetlands and brackish river/lake wetlands (see Figure 8-9).

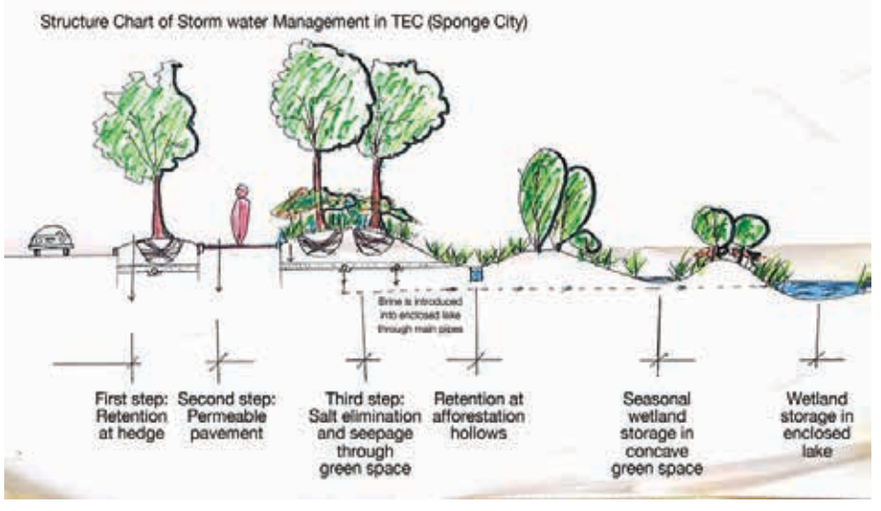


Figure 8-9: Structural Drawing for Sponge City Rainwater and Flood Control in TEC

Ganluxi sponge city construction project

Ganluxi is an important ecological corridor in the eco-city and recreational area for residents. At a length of 750 m horizontally and 120 m longitudinally, the sponge city construction project covered an area of 89,000 m^2, of which the landscape water system covers an area of 10,600 m^2, divided into two parcels in the east and west respectively. The landscape water system is located in the middle of the two parcels and surrounded by green spaces. The project was designed to reach 85% of annual runoff control rate and 60% of annual Suspended Solid (SS)

removal rate. Additionally, collection and reception of rainwater on municipal roads by green spaces was implemented on a trial basis under the project.

The sponge city construction scheme under the project takes the landscape water system as the centre with stepwise lowering terrain from the outside to the inside to enable the rainwater to flow from green spaces, gardens and squares to the middle of the site. Sponge facilities such as sunken green belts, permeable pavement, intercepting rainwater inlets, vegetation buffer zones, and rainwater wetland were used to purify the rainwater. The rainfall runoff finally flowed towards the landscape river system, reflecting the systematic control philosophy that combines "source reduction, in-process control and end remediation".

Source reduction facilities included sunken green belts, permeable pavement and intercepting rainwater inlets. Squares, parking lots and sidewalks were paved with permeable concrete, the total area of which was 16,000 m^2. Intercepting rainwater inlets were used on roads in the garden to reduce rainfall runoff pollution at source.

In-process control facilities included a vegetation buffer zone. The buffer zone was located around the landscape water system in order to lower the surface runoff speed through vegetation interception and soil seepage. Rainwater can be purified while it is flowing towards the landscape water system and the purified rainwater was used for ecological water recharging, so as to meet the requirement for total runoff and runoff pollution control.

End remediation facilities included a waterfall landscape system and rainwater wetland. In the eastern project site, a stepwise waterfall landscape system was built together with a rainwater wetland in order for end-treatment of water and to strengthen internal circulation of the water system, thus improving the self-cleaning capacity of the water.

Furthermore, specific to the highly salinised and alkalised soils in the eco-city, plants with high desalinisation performance such as Amorpha fruticose, Tamarix chinensis, Nitraria tangutorum Bobr. and Limonium bicolor as well as plants adaptable to salty and alkali environments were planted, such as reeds, Suaeda salsa, cogon-grasses and Typha angustata. Efforts were also made to discover the best arrangement for sponge city vegetation with high rate of survival and desirable landscape effect. These practices played a demonstrative role.

3. Creating a green network and liveable ecological space

3.1 Saline-alkali soil reclamation

Saline-alkali soil reclamation is always difficult in the urban landscaping of coastal cities in China. Soils within the eco-city had the characteristics of high salinisation, low concentration of organics and available nitrogen, poor physical properties, as well as a high level of groundwater that was mostly saline water or brackish water (see Figure 8-10). Therefore, the question of how to create an ecologically liveable environment on the saline-alkali soils was a practical issue faced by the eco-city.

The eco-city founded a reclamation and vegetation technology that integrated the physical, chemical and ecological aspects, and was quite different from the traditional soil dressing method to improve saline-alkali soils. This technology was granted a national patent of invention. At the land levelling stage, original soil dumping, borrowed soil filling, balance of excavation and filling, and soil mixing were used to avoid the horizontal movement of salt in soils, making the salt gather at the soil surface. Then, through airing and cleaning, physical properties of the soils were adjusted to reduce soil salinity to the greatest extent, thus improving soil quality and gradually restoring and improving the self-adjusting capacity of the land ecosystem. The new technology was completely applied to the total of 87,000 m^2 of gate landscaping for the eco-city. It was a water-saving integrated (physical, chemical and ecological) improvement and vegetation technology for a saline-alkali bottomland. The saline-alkali soils occupied by vast stretches of salt ponds and prawn ponds became an ecological oasis (see Figure 8-11).

Figure 8-10: before Remediation of Saline-Alkali Soils

Figure 8-11: after Remediation of Saline-Alkali Soils

Detailed practices for greening construction on saline-alkali soils

Replace the highly salinised soils. For highly saline-alkali soils, the technologies of sub-surface pipe drainage and planting with soil dressing were used. For soil dressing, in addition to purchase of soils from other areas, further consideration was given to using slightly or moderately salinised soils that have been improved in the eco-city, so as to balance the soils and reduce ecological damage to other regions, in three main ways:

(1) Use slightly salinised soils: For slightly or moderately salinised soils, technologies of salt-leaching, salt isolation, salt blocking, fertilising, planting of halophytic and native plants and community assembly were used for comprehensive improvement.

(2) Leach the salt by rainwater: In the low-impact development-oriented core measures, collection and storage of rainwater by blind shafts and seasonable rainwater wetland was also a key technology for rainwater salt-leaching, and an innovative concept to address ecological issues by means of ecological technologies.

(3) Collect and purify rainwater by wetland: A phytocoenosium led by a brackish wetland was built to create a community of native plants and halophytic plants such as reeds, bamboo reeds, Acorus calamus, Spartina anglica, willow herbs, Tamarix chinensis and Amorpha fruticose. This enabled the native plants to be planted with natural soils, thus achieving the effect of economic balance, controllable rainwater and flood water, water quality purification and ecological harmony.

3.2 Local adaptable saline-alkali tolerant plants

Phytocoenosium distribution was closely related to soil salinity. At the start, some salt-tolerant plants were growing in the low marine plain area where the eco-city was located. They were distributed depending on the difference in soil salinity. The soil contained a high concentration of salt around the salt pond on the east side of Hanbei Road and at the estuary of New Yongding River. Only a few salt-tolerant plants like Suaeda salsa grew there. There were no plants in some sample plots. In the area surrounded by the old course of Jiyun River, the soil contained a high concentration of salt and more varieties of

Tamarix chinensis planted on the demonstration section of the old river course (wind resistant and saline-alkali tolerant, capable of growing on highly saline-alkali soils)

Spartina anglica planted on the wetland outside the Jiyun River embankment (adaptable to the mesolittoral zone with 20% of salt concentration in soils)

Malus spetabilis Royalty planted in Huifengxi Park (tolerant of salt and alkali as well as infertility)

Suaeda salsa planted in Yongdingzhou Park (tolerant of salt and alkali as well as infertility)

Figure 8-12: Typical Halophytes Selected to be Planted on Saline-Alkali Soils

plants were growing there, including slat-tolerant plants such as Suaeda salsa, Tripolium vulgare Nees and Apocynum venetum, and low salt-tolerant plants such as reeds, goosefoots and Kochia scoparia. At the intersection of the east bank of Jiyun River and the old river course, the soil contained a low concentration of salt and a wide variety of plants grew there, including herbs and shrubs as well as a few arbours. Hence, for the greening of the eco-city, apart from regular plant selection, the selection of local salt and alkali tolerant plants was given particular attention according to soil conditions (see Figure 8-12).

The variety of plants was gradually increased stage by stage and batch by batch for the eco-city basedon the reduction of salinity of the soil and the extent to which the plants can adapt to the saline-alkali soils. Moreover, a combination of arbours, shrubs and herbs was considered, with deciduous species accompanied by evergreen species to maximise the natural beauty of plants, enrich stratification of landscapes and improve the phytocoenosium structure. For highly salinised soils, on the basis of engineering improvement, halophytes and salt-tolerant plants were planted to create a featured regional halophytic vegetation landscape. Furthermore, annual herbs should be interplanted with perennial shrubs to maximise the greening and landscaping effect and ensure landscape diversity, diversity of species and system stability of green spaces. With increasing improvement of garden application technologies, the perennial flowers and flowering shrubs fit well with the surrounding environment and played their expected role of enriching the urban landscape. The reasonable arrangement also ensured good continuity and completeness of visual landscape effects.

3.3 Open ecological spaces

The eco-city focused on the embodiment of intensive and ecological development by insisting on giving the ecology the priority and utilisation of resources while protecting the environment. On the basis of water pollution control and saline-alkali soil control, the water environment was combined with water landscape creation, creating a complex ecosystem of lake water, rivers and green spaces, and an open green spatial structure comprising one island, three water bodies and six corridors (see Figure 8-13). This formed an ecological layout that organically combined natural and artificial ecologies.

Following the theory of “matrix – corridor – patch”, the eco-city created an “ecological centre” at the land enclosed by Jing Lake, Wenjin Islet and the old course of Jiyun River. This, together with protective construction for the sewage reservoir remediation in Yingcheng, formed the main open public space in the eco-city. It created an ecological framework comprising a wedge-shaped green corridor, riverside landscape belt and eco-valley, and built a “green vein” that integrated landscape, environment, relaxation and other functions. With the various gardens and street parks as the green patches, it created a spatial pattern of ecological urban landscapes that relied mainly on a green island and green valley with a green network and green pearls in perfect harmony. It created a scene of a green island and valley lying, six corridors radiating, green network intertwined and pearls dropped on a jade plate. By strengthening the connection between the ecological centre and peripheral ecological systems, an open ecological spatial layout was created to boost the integration of regional ecological systems. This made the eco-city an environmentally-friendly and ecologically liveable garden city with good water systems.

Figure 8-13: Ecological Pattern of One Island, Three Waterbodies and Six Corridors in TEC

Figure 8-14: Yongdingzhou Park

3.4 Ecological microenvironment

Complete wetland and water systems were preserved and a bird habitat was reserved in the eco-city. By means of water ecosystem rehabilitation and soil reclamation, a convenient urban outdoor resting system was built, creating an ecological environment with a beautiful, liveable and harmonious environment. An ecological island, eco-valley, ecological corridors, waterfront landscapes, theme parks and street corner greenbelts were built successively, accumulating an abundance of experience in saline ecology building. Yongdingzhou Park (Figure 8-14), Eco-valley Park (Figure 8-15) and Animation Park (Figure 8-16) were distributed in series and in linear arrangement. Four waterfront landscapes - Old Course of Jiyun River (Figure 8-17), Huifengxi ecological corridor (Figure 8-18), Seawall Park (Figure 8-19) and

Figure 8-15: Eco-valley Park

Figure 8-16: Animation Park

Figure 8-17: Old Course of Jiyun River

Figure 8-18: Huifengxi Ecological Corridor

Figure 8-19: Seawall Park

Shell Bank Wetland Park (Figure 8-20) – were developed at a certain scale, becoming an ideal place for cultural, relaxation, entertainment and fitness activities of the residents. The city-level park under construction – China-Singapore Friendship Garden (Figure 8-21) – will become an "urban drawing room" of the eco-city. China-Singapore Friendship Garden was based on the concepts of sustainable development, ecological restoration, species acclimatisation and wetland protection. With clustered greenhouses and internal garden as a core, relatively centralised spaces were established to create special landscapes, making it an important place for cultural and recreational activities for residents of the eco-city.

Figure 8-20: Shell Bank Wetland Park

Figure 8-21: Design Sketch for China-Singapore Friendship Garden

Conclusion: In the pursuit of prosperity and affluence, in most cities, environmental protection would give way to industrial development, or even be totally ignored. The ideas of green development are reminders that it would be too late to regret when some resources are lost. The pursuit of economic benefits should give priority to environmental protection and be based on long-term planning. Dynamic compensation or remediation measures should be taken for environmental degradation issues caused by earlier construction. The site selection of the eco-city aims to reflect the benchmarking and demonstrative effect that an ecological city can be built even under poor initial conditions. Therefore, polluted environment remediation, renovation and utilisation have been a prerequisite and fundamental constraint on construction, but also an opportunity for utilisation of the strong resources of both countries. At the early stages of master planning, the water bodies, wetlands and green areas to be protected were listed separately, forming a set of environmental protection planning. By mobilising social capital, the eco-city creatively developed a set of highly cost-effective technologies for remediation and improvement of the polluted soils and saline-alkali soils to support urban development. These technologies set the local standards for remediation of the polluted sites and have become a model that is used all over the country. With the mission of creating a replicable and scalable model, the eco-city has been active in aligning with China's approach of "going out", building a technical engineering centre for polluted site remediation for the purpose of promoting and applying this technology to remediation of polluted lakes and reservoirs in other regions of China. The considerable investments made in R&D and environmental remediation at the early stages generated great returns. Thanks to the good environment and a beautiful lake view, the value of surrounding lands and real estates increased significantly. The residents enjoyed remarkable improvement of living standards brought by environmental remediation. This practice changed the old thinking that regarded ecological maintenance as restrictions, instead inspiring the people to treat, from the heart, the environment as an important part of their family assets and to be willing to protect the ecological environment that is closely linked with their well-being. Having a good environment also made the city more attractive to investors and talented individuals from other areas.

Chapter 9

Resource Utilisation

Summary

This chapter describes the practice and achievements in conservative, intensive, comprehensive and circular development and utilisation of urban resources .

With the goal of 20% utilisation rate of renewable energy, a comprehensive energy utilisation system for solar energy, wind energy, geothermal energy and biomass energy was established in the eco-city. Here too, the first comprehensive demonstration zone for smart power grids in China and a comprehensive platform for energy data decision-making analysis and management in urban areas were built.

With the goal of 50% utilisation rate of unconventional water resources, a comprehensive water resources utilisation system centred on rainwater collection, sewage treatment, reuse of reclaimed water and use of desalinated seawater was established. A sewage treatment plant and a recycling water plant were established by referencing the NEWater plant in Singapore, with a daily recycled water production capacity of 21,000 tonnes, making it an important base for ecological industry.

With the goal of 100% harmless disposal rate of waste and 60% and more recycling rate of waste, a waste disposal system featuring source reduction, classified collection, airtight transportation and centralised disposal was established. With the recycling rate of kitchen waste reaching 100%, it pioneered the implementation of smart waste recovery management systems and created an incentive mechanism with points that can be used to redeem goods.

With the requirements of the eco-city's mission, great efforts were made to promote conservative, intensive and circular utilisation of resources, and explorations in the development and utilisation of renewable energy, use of unconventional water resources, and recycling of solid wastes were carried out to basically establish an urban resource recycling system.

1. Utilisation of Renewable Energy

With the goal of a 20% utilisation rate of renewable energy, and on the basis of energy conservation, great efforts were made to develop and utilise solar energy, wind energy, geothermal energy and biomass energy in the eco-city based on the regional renewable energy (Figure 9-1).

1.1 Promoting regional energy conservation and consumption reduction in an all-rounded way

In the planning for energy conservation, a mixed land layout was implemented, with the residence, industry and public services being laid out in a comprehensive manner, shortening the residents' commute to work, shopping and leisure, reducing commuting energy consumption.

In terms of building energy conservation capacity, green building was emphasised to implement four-step energy conservation in an all-rounded way and to reduce heating energy consumption. It took the lead in realising metered heating charge in all residential quarters, and more than 80% of residents realise energy conservation and cost reduction. All residential buildings were equipped with solar water heating systems.

In terms of transport energy conservation, a green transport model that focused on buses and gave priority to green transport was established to guide residents in travelling green. All buses in the area were clean-energy vehicles.

In terms of industrial energy conservation, modern service industries were given priority to create energy-conserving and environmentally-friendly industrial agglomerations and build a sustainable industrial system featuring low input, high output, low consumption, low emissions and recycling.

1.2 Developing and utilising new type energy properly

Solar energy resources were actively developed and utilised: According to the special plans on renewable energy in the eco-city,

the solar power capacity was 45.44 megawatts. By the end of 2017, PV projects such as the Green Belt in Central Avenue, High Voltage Electric Corridor in Northern Area, Oxidation Ditch Cover of Yingcheng Sewage Plant, Parking Lot of Service Centre, Roof of Animation Industrial Park, and Roof of Northern Industrial Park were implemented. In 2017, 14.32 million kWh of new energy power were generated.

Ground source heat pump technology was vigorously promoted: Heat pump technologies such as ground source heat pump, deep geothermal heat pump, sewage source heat pump and desalinated seawater source heat pump were adopted to make full use of various geothermal resources. By the end of 2017, 25 ground source heat pump projects were built, with a construction area of 990,000 sq m, achieving one quarter of the planning tasks. It was estimated that by 2020, there will be a total of 6.88 million sq m of construction area for ground source heat pumps, with the contribution rate of renewable energy of up to 9.84%.

Wind energy resources were actively developed: Breaking through the construction and operation model of conventional wind farms, Jiyun River Mouth Wind Farm Project was built with an energy output of 3.81 million kWh in 2017.

Biomass energy was fully utilised: Kitchen waste was utilised to develop biomass energy so as to realise resource recycling. A project for biogas preparation from organic waste is set to be implemented by 2020. The project will dispose of 100 tonnes of organic waste such as kitchen waste per day, and produce 1.6 million m^3 of biogas per year, with an annual net biomass energy output of 17.25 million kWh and renewable energy contribution rate of 0.68%.

PV Power Generation Project in Central Avenue

BIPV Project in Parking Lot of Service Centre

Distributed PV Project in Amine Industrial Park

Jiyun River Mouth Wind Power Generation

Figure 9-1: Renewable Energy Projects in TEC

Multi-energy complementation technologies were explored: The Animation Park Energy Station and Wind & Solar Hybrid Street Lamp are typical examples of the eco-city's exploration of multi-energy complementation technologies. In the Animation Park Energy Station, distributed energy technology was applied, and regional energy stations were set up to integrate many energy technologies such as ground resource heat pump, combined cooling, heating and power system, water energy storage system, electric refrigeration system, flue gas hot-water lithium bromide system, and photo-voltaic (PV) power generation system. The building integrated PV design was applied in its exterior wall, and new building materials such as light-transmitting PV panels and agglomerated stone were adopted there. Nearly 800 “wind & solar hybrid street lamps” were provided in Yongdingzhou, Animation Industry Park, and Northern Industrial Park by use of wind and solar energy resources, covering about 12 km of roads, saving 500,000 kWh of power every year, with good economic and environmental benefits.

1.3 Building a smart energy management platform

In 2010, a comprehensive demonstration project for smart power grids was pioneered, and the eco-city was included in the “Comprehensive Demonstration Zone for Smart Power Grids”, “Innovation Demonstration Zone for Smart Power Grids”, and “Comprehensive Demonstration Zone for Urban Energy Interconnection” by the Chinese Government and Tianjin city.

The Comprehensive Demonstration Project for Smart Power Grids that the State Grid Corporation of China (SGCC) has built in the eco-city integrated the most advanced technologies of smart power grids in power generation, transmission, transformation, distribution and utilisation at that time. A total of 12 sub-projects in six major links and one platform were constructed under this project from the perspective of the unified integration of power flow, information flow and business flow. In 2011, the Comprehensive Demonstration Project for Smart Power Grids was officially put into operation in the eco-city, becoming the smart grid project with the widest coverage area and the most complete functions in the world. In 2014, on the basis of the Comprehensive Demonstration Project for Smart Power Grids in the eco-city, the SGCC launched innovative technologies and model demonstrations such as plug-and-play of distributed generation, optimal allocation of multiple clean energy resources, active distribution network, smart power utilisation interaction,

charging and battery swap service for convenient electric vehicles, and big data public service for power distribution and utilisation, building two service platforms including energy interconnection and coordinated control platform and smart two-way interaction platform. In 2017, the construction strategy of "global energy interconnection" of the SGCC was continued in the eco-city, and Tianjin Electric Power Company and Binhai Power Supply Company jointly selected the eco-city as "Comprehensive Demonstration Zone for Urban Energy Interconnection" for further research and construction. In terms of daily service terminals, smart business halls were built in the eco-city, with the concept of "interconnection" to provide users with open counters, smart guides, and same screen display mode.

A comprehensive energy information service platform for smart parks was built. The eco-city was a pioneer in demonstrating and applying key technologies for smart energy utilisation. It completed the energy-conserving transformation of 100% industrial and commercial users, and realised the integrated energy access and combined control of four CCHP energy stations in the Animation Park, Science Park, Industrial Park and Information Park, providing 12 services such as optimised power utilisation management and energy efficiency forecasting and early warning. The comprehensive energy efficiency level and the local energy consumption capacity of distributed energy in the parks increased by over 10%. The regional megawatt smart microgrid in the Animation Park of the eco-city was not only a sub-project of the Innovation Demonstration Zone for Smart Power Grids, but also a "863 Project" in China. Its distributed PV penetration rate was higher than 15%, the local PV consumption rate was 100%, and the power supply reliability reached 99.99%. In the park, the State Grid Tianjin Electric Power Company also carried out a study on the comprehensive coordinated control of multi-level energy such as PV, wind power, distributed energy storage, megawatt microgrid, electric vehicle, CCHP, and flexible load. This ensured the centralised and rational allocation and consumption of energy, substantial improvement of energy efficiency, and economical and efficient operation of power grids after being put into use. On the demand side, the smart home has been further built to achieve automatic demand response, and at the same time, technologies such as big data analysis and mobile Internet have been introduced to build a comprehensive energy information service platform. This core technology achievement has been successfully promoted in more than 100 smart parks in China such as Jiangsu and Zhejiang.

The eco-city actively explored the urban management model based on energy big data. It pioneered the building of an energy management platform that covers renewable energy and conventional energy, energy supply and consumption, and updates regularly, enabling automatic collection, monitoring, management and deployment of energy data, realising the visualisation and early warning of energy management, and the integrated cooperation and centralised management of energy systems, playing an important role in organising energy supply, deployment and energy conservation in the eco-city to realise the balance between supply and demand and reduce energy costs.

2. Utilisation of Unconventional Water Resources

With the requirement of a 50% utilisation rate of unconventional water resources, the eco-city upheld the concept of "broadening resource channels" and "reducing resource consumption" based on its own conditions. It focused on the utilisation of unconventional water resources and the control of total water consumption, establishing a water resource supply guarantee system centred on municipal water supply, rainwater collection, sewage treatment, reuse of reclaimed water, seawater desalination under the principle of water resource utilization of "ecology, water conservation priority, multi-source development, recycling, quality-based water supply, and optimal allocation". By referencing Singapore's experience in water resource utilisation, it checked and ratified various water supply quotas, and controlled the leakage rate of pipe networks, with water-conserving facilities and appliances being promoted in an all-rounded way and quality-based water supply being implemented. By the end of 2017, the sewage treatment rate of the eco-city reached 100%, the utilisation rate of unconventional water resources reached 59.64%, and the surface water quality reached Grade IV. It made a useful exploration to alleviate the water shortage in the northern region and was approved as a national pilot project for sponge cities in China in 2016.

2.1 Implementing a survey on water resource supply and demand

The average annual precipitation was 545 mm and the average annual evaporation was 2,025 mm in the eco-city, with the evaporation much larger than precipitation. The empirical value of evaporation and permeation losses was 1,400 mm, and the precipitation period was highly concentrated in summer from June to September. The eco-city was located at the junction of Jiyun River and New Yongding River. The water quality of the Jiyun River was generally Grade V or worse, and its water volume was decreasing year by year. New Yongding River is a land

stream where the four rivers in the northern part of Haihe River Basin flow into the sea. It is an important channel for flood drainage. But it suffers serious sediment deposition and can only meet the needs of production and living. The ecological water cannot be guaranteed.

The water supply source of the eco-city mainly depended on external water diversion, underground water and partial desalination of seawater. The external water diversion mainly included the water diversion from Luanhe River, South-to-North water diversion, and underground water diversion from Yuelong. The eco-city boasted a large number of landscape water bodies, including Qingjing Lake, Old Course of Jiyun River, and Huifeng Creek, with a water area of 4.17 km^2, and a water body of over 11.13 million cubic meters. Due to the large amount of water evaporation and infiltration, and low rainfall, but large demand for landscape water in Tianjin, the water needed to be replaced two to three times per year to maintain water level and quality. For this reason, the eco-city made full use of rainwater and effluent from sewage plants as replenishments. While satisfying the production of recycled water, 50,000 to 60,000 tonnes of landmark Grade A effluent from sewage plants would be utilised per day in the short-term, and about 90,000 tonnes per day in the long-term.

In 2017, the average daily water consumption of the eco-city was 18,300 m^3 per day. Currently, the region was in the stage of development and construction, thus greening and construction water consumption account for a higher proportion, with strong potential for unconventional water source replacement. With the accelerated pace of residential settlements, the proportion of water consumed by residents and public buildings has increased rapidly. 10% and 25% of the water for life and public buildings can be recycled water respectively. Moreover, for industrial water consumption, tap water and unconventional water resources can be allocated flexibly and supplied based on quality as needed.

2.2 Developing and utilising unconventional water resources widely

By referencing the "Four National Taps" framework of Singapore, the eco-city established its own unconventional water resources development and utilisation system based on its own water resources.

Seawater desalination: The Sea Freshwater Project of Beijiang Power Plant, which was 10 km away from the eco-city, boasted a daily production capacity of 300,000 m^3. The eco-city planned to construct two sea freshwater booster pumping stations and a direct seawater diversion pipe network to bring in desalinated seawater.

Sewage treatment: In October 2010, the TEC Sewage Treatment Plant was completed and put into operation, with a daily treatment capacity of 100,000 tonnes per day. The current daily treatment capacity can reach 70,000 m^3, with the effluent quality of Grade I-B. Since 2013, the Sewage Treatment Plant has been upgraded, with the water quality standards being raised to Grade I-A and Landmark Grade A, meeting the requirements of Grade IV surface water for landscape water. Some of the treated water is discharged to the surface, supplementing the city's landscape water so as to maintain and improve water quality, while the rest is used as a source for recycled water.

Recycled water: By referencing Singapore's experience in "NEWater", a new recycling water plant has been built in the TEC Sewage Treatment Plant. Its water production capacity was 21,000 m^3 per day at the end of 2017, and its effluent quality met the standard for vehicle washing water as stipulated in The Reuse of Urban Recycling Water – Water Quality Standard for Urban Miscellaneous Water Consumption (GB/T1892-2002). It is mainly used for construction miscellaneous uses, municipal sprinkling, greening and part of public buildings, industry and storage, effectively reducing municipal water supply.

"Four National Taps" resolved Singapore's crisis of water resources

In the world, water shortage is an important factor that limits urbanisation. Many big cities in developed countries are facing a crisis of depletion of water resources. As a small island country, Singapore is particularly deprived of water resources. Its per capita hold of water resources is the second lowest in the world. The country was basically dependent on Malaysia's water supply. In order to safeguard national water security and improve water supply reliability and self-sufficiency, the Singapore government prioritised the issue of water resources as a national strategy and launched a unique plan of "Four National Taps", that is, to establish a water source system integrating "seawater desalination, NEWater, domestic catchment areas, and external water supply". Now, the utilisation rate of unconventional water resources in Singapore has reached 60%, and it plans to increase this to 80% and 85% by 2030 and 2060, providing a good example of water resource management for the world.

Catchment area (rainwater collection): At present, there are 17 reservoirs and a storm water catchment system in Singapore, accounting for two-thirds of the total land area of Singapore. The Marina Barrage built in November 2008 is one of the five major water supply projects in the world. The Singapore government attaches great importance to the environmental protection of catchment areas and has formulated a train of strict and detailed measures, including legislation, regulation of land use, requisition of land, migration of illegal households and anti-pollution. The government stipulates strict control over construction that is incompatible with the water supply plan in industrial layout and land use planning to protect the quality of environmental water in catchment areas.

External water supply: In terms of imported water, Singapore concluded two water supply agreements with its neighbour Malaysia in the 1960s. According to the agreement, before 2011, Singapore will import 325 million litres of fresh water per day from Johor, southern Malaysia, at a price of MYR 0.03 (about USD 0.01) per 1,000 gallons (4,540 litres) of untreated "raw water"; from 2011 to 2061, the daily supply of fresh water imported from Johor will increase to 946 million litres. After 2061, both sides will discuss the specific water supply separately according to the actual water consumption in Singapore. In addition, Singapore has concluded a water supply agreement with Indonesia, which stipulates that Singapore and Indonesia will work together to develop freshwater resources in Riau, Indonesia, with some of them being supplied to Singapore through submarine pipelines.

NEWater: "NEWater" is the most effective and attractive part of Singapore's efforts to meet its water needs. Singapore's "NEWater" is a kind of recycled water produced by advanced membrane technology and ultraviolet disinfection, which further purifies secondary treated domestic sewage. It has high social and economic benefits, which not only reduces water consumption, but also lowers water cost. In Singapore, a small amount of NEWater is injected into reservoirs and then sent to waterworks after being mixed with natural water, where it will reach drinking standard after further treatment and serve as an indirect drinking water supply. By relying on NEWater, Singapore has taken the lead in the field of sewage treatment and recycling, realising the transition from dependence to self-reliance. There are four NEWater plants in Singapore, with the total output reaching 30% of the total demand for water supply in the country.

Seawater desalination: Surrounded by seas, Singapore boasts a unique advantage in seawater utilisation. It has become an important part of Singapore's water supply management by desalinating seawater to increase and expand its water supply. Singapore is actively developing seawater utilisation technology. SingSpring Seawater Desalination Plant is the first national seawater desalination plant in Singapore, which can produce 136,000 m^3 of desalinated water every day. It is one of the largest membrane seawater desalination plants in the world. This plant is also the first cooperation project between the water agency PUB and private enterprises. It is designed, built, owned and operated by private companies. The fresh water produced is transported to reservoirs owned by PUB for treatment, and then sent to users, capable of satisfying 10% of Singapore's water demand.

For the establishment of a water-related KPIs framework and water resources management of the eco-city, Singapore's experience in water management was used as a reference, but there was a significant difference in precipitation between Tianjin and Singapore. The demand for greening water and ecological water supplement was basically zero in Singapore, but was huge in the eco-city. According to the current water resources allocation plan of the TEC, by 2020, the utilisation rate of unconventional water can reach 83% if the ecological water supplement is included.

2.2 Promoting regional water conservation in an all-round way

In the eco-city, water-conserving technologies, appliances and facilities were adopted to conserve water resources and alleviate water supply pressure. The water conservation guidelines were issued and 33 specific measures such as the automatic monitoring system for pipe networks, including 14 ones for the planning stage, eight ones for the construction stage, and 11 ones for the operation stage, have been taken to guide the achievement of indicators in stages and in a systematic and progressive manner.

In terms of indicators and technical measures adopted, water transport and distribution were given priority. The measures linking effectiveness assessment with water-conserving subsidy were introduced, and efforts were made to control the leakage rate of municipal water supply pipe networks below 7%, and that of building water supply pipe networks below 3%. As for water conservation, special emphasis was put on the transformation of enterprise water utilisation technology and the enhancement of enterprise water utilisation management, with the goal of industrial water conservation being clarified and the water withdrawal rate per 10,000 RMB of GDP increased being set, to effectively control the water consumption of traditional "major consumers". Drought-tolerant plants were given top priority in greening, recycled water and rainwater were encouraged, and sprinkler irrigation and drip irrigation technologies were adopted. In line with the principle of better water for better place, quality-based water supply was implemented.

In terms of appliances and facilities, the water-conserving product access system was promoted vigorously. The *Recommended List of Water-conserving Products for Eco-City* was formulated, stipulating that water-conserving faucets, toilets, kitchen and bathing facilities must be adopted for all buildings, and three-level measurement should be implemented for domestic water, that is, to measure through user meter, floor meter, and main meter of the community respectively, to ensure the terminal's "consumption reduction" control.

Table 9-3 Water Conservation Measures for Public House in TEC

Object	Measures
Outdoor landscape design	The ABC Water, a water purification system, was arranged along the main axis of slow traffic system and neighbourhood gardens. Rainwater was recycled and purified through plant cultivation and pebble spreading, which can ensure a beautiful environment at the same time as well.
Landscape green space irrigation system	A planting structure was adjusted and an appropriate proportion of grassland was arranged. A complete green space irrigation system plan was created. Water-conserving irrigation technology was adopted. Irrigation was done in combination with weather condition. Domestic sewage was recycled.
Water-conserving system	A quality-based water supply scheme was implemented. Municipal reclaimed water was used for greening irrigation and road cleaning, that is, urban recycled water source (the water source is temporarily replaced by municipal water supply before the market conditions were complete). The municipal water supply was used for the rest of the water supply sources. A drainage system featuring rainwater-sewage diversion and sewage-wastewater confluence was adopted, where the sewage and wastewater were discharged into the municipal sewage pipe network after being treated by septic tanks.
Reclaimed water	Reclaimed water was mainly used for toilet flushing, outdoor sprinkling and greening. Non-potable water such as greening, vehicle flushing and reusable recycled water came from unconventional water sources such as recycled water and/or rainwater.
Water-conserving facilities	Water-conserving appliances were used in accordance with certain standards. The establishment of standards played a guiding role in the project.
Water resources management	The material composition of pipes and pipe fittings conform to Chinese national standards. Building automation system was connected to the unit water meter to automatically detect the leakage of pipe networks. High-precision water meters were used. The selection of underground pipes should try to avoid leakage of pipe networks. Unit water meters were linked to water fees.

3. Disposal and Utilisation of Solid Waste Resources

The eco-city established a whole-process waste disposal system featuring "source reduction, waste segregation, separate system, and comprehensive disposal", with a separate waste collection rate of up to 80% and a recycling rate of kitchen waste of up to 100%. In April 2015, the eco-city was included in the first batch of demonstration zones for waste classification in China.

Implementing waste diversion and classification management:

Under the principle of "big diversion and small classification", the "construction waste, domestic waste, kitchen waste, and green waste" were diverted on a large scale. The domestic waste in residential areas was divided into five categories: recyclables, kitchen waste, harmful waste, other waste and bulky waste. The waste in dining places such as hotels and restaurants was divided into three categories: recyclables, kitchen waste and other waste. The waste in public places such as bus stations (bus shelters), parks, amusement parks, and gas stations was divided into two categories: recyclables and other waste. The waste in government agencies, office areas of enterprises and public institutions, and schools was divided into two categories: recyclables and other waste. The recyclables in large office areas were further subdivided into paper, beverage bottles and cans, and other plastics. The waste classification in residential areas was given priority. Three communities were selected for pilot projects on waste source reduction and classification in cooperation with property companies. The waste was classified according to recyclable waste, poisonous and harmful waste, unrecyclable waste, kitchen waste and bulky waste. Guidance and supervision on waste classification were carried out simultaneously (Figure 9-2 and 9-3).

Figure 9-2: Waste Classification and Collection Facilities

Figure 9-3: Waste Bag

Promotion of waste classification

Exhibition halls were established to publicise, educate and promote waste classification, collection and transportation. The Municipal Solid Waste Management Exhibition Hall in the eco-city promoted the theme of "harm of waste", "pneumatic transportation system" and "beautiful homes". The interactive visual display allowed visitors to feel as if they were there, to understand and learn the whole process of waste classification, waste disposal technology and other related contents visually, which attracts visitors and tourists to understand waste classification more quickly and comprehensively, as it attaches importance to waste classification, and encourage more people to start waste classification. In the waste recycling exhibition hall "Sanitation Home", the current situation of waste recycling in the eco-city was displayed, the advanced waste disposal technology of the eco-city was introduced, and the benefits of waste recycling were publicised. There was an ecological garden in the exhibition hall, which showed the whole process of the environmental ecological chain covering waste classification, outdoor disposal, pneumatic pipeline transportation to waste pumping stations, airtight transportation by sanitation vehicles, and waste recycling. Moreover, the smart waste classification, scientific operation and physical case, as well as the achievements of the eco-city in waste recycling, were also shown in the exhibition hall.

In addition to building exhibition halls, the relevant staff of the eco-city also regularly provided guidance and publicity to residents on waste classification through "red vest" community activities. The promoters wore red vests and conducted surveys with the community. They recorded the residents' problems in waste classification in questionnaires and answered questions on the problems residents encountered in the process of waste classification. They also publicised the work flow of waste classification and reminded residents to claim waste classification bags. Moreover, Tianjin Eco-City Environment Protection Co., Ltd., law enforcement units, volunteers, and property administrators carried out promotion activities on "promoting eco-living and moving towards a green civilisation" from time to time in various forms, such as quizzes with prizes, green tote bag painting activities, community poster designing, and distribution of classification instruction manuals. With these promotion activities, the awareness rate, participation and accuracy rate of residents on waste classification were improved.

Building smart waste recycling platforms: Residents were encouraged to participate in the classification and recycling of domestic waste by means of points redemption. As a result, a smart waste recycling platform integrating classification, collection, transportation, disposal and points redemption took shape. After the residents in the eco-city applied for free point cards, they were able to put recyclables through the platform to get points and accumulate them on the card. The points can be used to redeem goods at the store. At the end of 2017, the eco-city had invested in a total of 25 smart terminals for waste classification and issued 10,147 point cards, with the participation rate of residents exceeding 60%. 77.33 million points were generated (equivalent to 773,300 RMB) and 60.11 million points were redeemed (equivalent to 601,100 RMB).

Constructing a pneumatic transportation system for domestic waste: In May 2009, the eco-city established the first pneumatic transportation system for dry/wet classified domestic waste in China (Figure 9-4) that comprised four independent subsystems (Figure 9-5), each of which contained a public pipe network, a central collection station, and a property pipe network. At present, the pneumatic waste transportation system covers about 5.6 km^2, 11 blocks, and 35 eco-cells in the southern area of the eco-city. It serves 100,000 people, with a total designed transportation capacity of 87.2 tonnes per day and a total investment of 347 million RMB. The design, build, own and operate (DBOO) investment mode was adopted in system construction, i.e., government authorisation, and enterprise investment. During the construction stage, the government was responsible for supervising and providing services to the project to ensure the quality and progress of the project construction. During the operation stage, the government regularly authorised enterprises to operate the system to create a standardised operation and management process. The instruction manuals for system operation, maintenance and standardised operations were prepared for the eco-city to form a standardised operation system covering operation, maintenance, overhaul, and safety operations. The airtight, automatic and mechanised methods were adopted in the pneumatic transportation system for domestic waste to save manpower and material resources, avoid secondary pollution and save space in residential areas.

Next, another four pneumatic transportation systems for waste will be built in the central area of the eco-city. These will cover 4.8km^2 and 27 eco-cells and serve 19,400 people, with a total designed transportation capacity of 51.88 tonnes and a total investment of about 125 million RMB.

Figure 9-4: Schematic Diagram of Pneumatic Transportation System for Waste in TEC

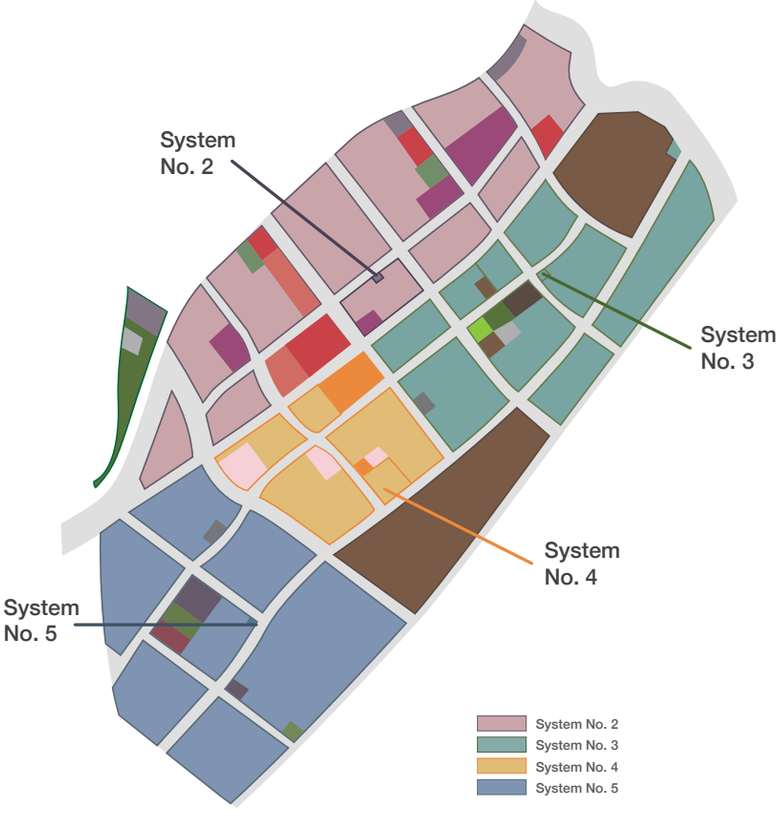


Figure 9-5: Schematic Diagram of Pneumatic Transportation System for Waste in Southern Area of TEC

Constructing kitchen waste disposal stations: A centralised kitchen waste disposal station was established in the eco-city, where different processes were adopted for microbial aerobic degradation based on the characteristics of kitchen waste. The kitchen waste with less lipid content can be transformed into organic fertilisers with high nutritive element content through aerobic decomposition, which can be used for flowers and plants conservation, to good effect. As for the kitchen waste with high lipid content, waste lipids can be extracted through sorting, feeding, aerobic decomposition, oil water separation and water treatment, and finally turned into biodiesel or industrial soap powder. For other wastes, the surrounding sanitation facilities can be used for recycling or harmless disposal.

Conclusion: With the requirement of 20% utilisation rate of renewable energy, the comprehensive energy development and utilisation such as solar energy, wind energy, geothermal energy and biomass energy were explored extensively in the eco-city. By the end of 2017, the utilisation rate of renewable energy was 14.08%, which was still far from the target value. While further controlling the total urban energy consumption of the eco-city, it was necessary to take effective measures to increase the scale of renewable energy utilisation. The eco-city was located in a water-deficient area and the aim was to explore new ways to resolve the problem of water supply in water-deficient areas. To achieve the goal of 50% utilisation rate of unconventional water resources, a water resource supply guarantee system centred on municipal water supply, rainwater collection, sewage treatment, reuse of reclaimed water and seawater desalination was established in the eco-city with reference to Singapore's experience in water resource utilisation. Proper waste disposal is an important symbol of urban civilisation. The pneumatic transportation system for waste constructed by the eco-city effectively resolved the secondary pollution problem of waste in the course of its transportation. Residents in the eco-city were encouraged to participate in the classification and recycling of domestic waste through a points redemption programme which achieved remarkable success. However, there was still room for improvement in terms of refinement of waste classification. The formation of good waste classification habits for all residents also required relatively long-term guidance and cultivation.

Chapter 10

Green Transport

Summary

This chapter describes the planning and construction of green transport in the eco-city and the outcomes.

With the commitment to the Transit-Oriented Development (TOD) model, the eco-city planned green travel facilities supported by rail transit, clean energy buses and slow-traffic roads.

With the "Eco-valley" as the axis, the internal rail transit network was seamlessly connected with the external rail transit in urban areas as planned.

Under the concept of "narrow roads, dense networks", the proportion of planned road areas reached 15%, which met advanced international standards.

In order to embody the concept of "slow traffic first", 235 km of sidewalks and community greenways were planned, with a density of 9.4 km per km^2, which is far greater than 4.3 km per km^2 for motor vehicles. Extensive slow traffic roads connected community, business, landscape and other urban life functions to form a complete green travel system, with a green travel rate of 60%.

On the basis of the master plan, the *Integrated Transport Planning of Tianjin Eco-City* was prepared for the construction and management of transport infrastructure, which proposed the construction model of subsystems such as road networks, public transport and greenways. The eco-city's transport system was constructed under the guidance of integrated transport planning.

1. TOD Model

The TOD model was proposed by Peter Calthorpe, an American urban planner, in 1993. Prior to this, Singapore had practised this model successfully. Since there were many similarities between the eco-city and Singapore's New Towns in terms of relative location and background conditions, both China and Singapore agreed to adopt the TOD model to promote intensive urban development.

In order to achieve the goal of a 90% green travel rate, the eco-city, guided by the concept of TOD, defined its rail transit system in its master plan, which turned into an integrated public transport system with changes such as the merger of the three areas.

Ten years ago, the functions of the cities around the eco-city were not yet developed, and the land was relatively isolated. Therefore, there was a light rail line planned within the eco-city (Figure 10-1) according to the master plan. Around this light rail line, a main centre and two sub-centres were laid out as the main axis of the eco-city's development. This 50 m-wide corridor would temporarily serve as the main green axis of the eco-city, "Eco-valley", before the light rail line was constructed. High-intensity development was carried out in the areas near the rail transit station in the eco-city, including its main centre and sub-centres with a plot ratio of 4.0 and 2.5-4.0 respectively. The plot ratio of the areas within 800 m of rail transit stations was controlled between 1.2 and 1.6, and that of the peripheral areas was controlled below 1.2. With this arrangement, the eco-city's residence and employment areas were concentrated within 800 m along the rail transit line, which allowed the eco-city to be easily connected with other areas of Tianjin city, thus providing a guarantee for the goal of 90% green travel rate.

With the rapid expansion of Tianjin's peripheral areas, adjustments have also been made to its rail transit planning accordingly. In 2010, the People's Government of Binhai New Area reorganised and evaluated the master rail transit plan of Binhai New Area. It upgraded the Tianjin-Binhai Light Rail Line to an urban high-speed rail line and changed the rail system from light rail to urban high-speed rail. The changes in the ground rail system and service orientation made it no longer suitable for the route selection where the rail line passes through the eco-city directly. In this case, the Metro Line No. Z4 was adjusted to the Central Avenue. The original "Eco-valley" within the eco-city would continue to serve as a corridor for internal light rail, linking the functional centres and connecting with the station Nankai High School of Metro Line No. Z4 for transfer. The concept of the TOD model was also applied in this new adjustment. Under the guidance of this concept, a regional service centre was set up in the station Nankai High School.

Figure 10-1: Original Light Rail Route inside TEC

The lag in rail transit construction and the rerouting have made the eco-city's demand for public land transport more prominent. Over the past decade, the eco-city has focused on the construction and management of conventional public transport infrastructure, line operation services and smart transit information service. In the construction of hard facilities, bus transit lanes and supporting facilities were fully taken into account in the eco-city's road planning. The bus operating speed can reach 25 to 30 km per hour, and the bus admission rate can reach 100%. The non-motor vehicle lanes bypassed bus platforms (Figure 10-2) and sidewalks, avoiding the conflict between bus access and non-motor vehicles. The number of buses in the eco-city reached 14.7 vehicles per 10,000 persons, which was far higher than the national standard's 12 vehicles per 10,000 persons. Four bus lines that were operated internally were free of charge. By the end of 2017, the Tianjin Eco-City Bus Company had 44 buses, all of which were clean energy vehicles (Figure 10-3). The Public Transport Map and the Transit Trip Guide for Tianjin Eco-City were prepared, 60 smart electronic station boards were put into operation and a mobile bus app "Traffic in TEC" was launched to introduce smart bus services.

Figure 10-2: Bus Stations in TEC

Figure 10-3: Clean Energy Bus in TEC

2. An Accessible Dense Road Network System

One of the important manifestations of the TOD concept was the dense road network that was applied in the eco-city's road network system. This was a far-sighted practice 10 years ago in an era when many cities were still advocating widening roads and constructing expressways.

Planning concept of dense road networks

In 2008, the eco-city's master plan (30 km^2 of the cooperation zone) proposed the planning concept of dense road networks, advocating that the basic road grid spacing of motor vehicles should be 400 m by 400 m and that the cross greenway should be provided in the middle of the motor vehicle road network for pedestrians and bicycles only. This achieved a unique double chessboard layout of roads and greenways that divided the eco-city into 200 m by 200 m blocks to realise the layout of small blocks and dense road networks.

This road network structure is an innovative advance on the traditional four-level model of fast roads, arterial roads, secondary trunk roads and branch roads. It provided a safe, convenient and highly accessible slow traffic network for pedestrians and bicycles while meeting the traffic demand of motor vehicles. In terms of road functions, the major roads of the eco-city generally corresponded to Chinese national standard arterial roads and some secondary trunk roads centred on traffic functions, while the secondary roads generally corresponded to national standard secondary trunk roads and branch roads. The 200 m greenway system inside the block was the key to building a small block and dense road network, providing space for green transport and low-carbon travel in the eco-city.

The dense road network can disperse road traffic flow, reduce compound traffic of most roads, and lower the incidence of traffic jams. It allowed pedestrians to cross streets in a shorter distance and made travel more convenient. In addition to the advantages in traffic functions, it can also improve the economic benefits of the land, and its junction areas provided suitable space for small businesses in various service neighbourhoods, making the urban morphology more adaptable and the land use more efficient.

The advancement of the road network planning concept of TEC Cooperation Zone was also reflected in its world-leading road area ratio. According to the earliest land use and integrated transport plans of the eco-city, the planned roads covered an area of 22.89 km^2, accounting for 15% of the total construction land area. This reached the upper limit of 8 to 15% for small cities required by relevant Chinese regulations. In fact, this figure has reached the road area ratio of the world's advanced cities. According to the statistics released by Li Dihua from Peking University in the "13th Five-Year" Development Ideas and Strategy Seminar of Tianjin Eco-City in 2016, the road area ratios of countries and cities including Singapore, London, Tokyo, New York and Barcelona are generally between 10% and 25%. With the planning model featuring wide roads and big blocks still widely adopted in most cities of China and the road area ratio being generally less than 10%, the road network planning and actual construction of the eco-city have taken the lead in adopting advanced international concepts.

Outcome of practice in road network planning

The Tianjin Eco-city Cooperation Zone featured a trunk road network of 43.3 km long and a road network density of 1.72 km per km^2, a branch road network of 44.6 km long and a road network density of 1.77 km per km^2. Compared with the recommended values in the standards, the density of the current trunk road network was slightly higher, while that of the branch road network was slightly lower. This phenomenon showed that although there was an advanced road network planning concept for the eco-city at that time, in the actual process of urban infrastructure construction, trunk roads are given more priority compared to branch roads.

By the end of 2017, there were 212 km of roads built in the three areas of the eco-city, with the overall road realisation rate of about 40%. Among these, there were 81 km of roads built in the original Tianjin Eco-City Cooperation Zone, with a road realisation rate of about 70% and a construction land completion rate of 42%. The road construction was ahead of the land parcel development and construction (Figure 10-4).

Figure 10-4: Schematic Diagram of the Roads Built in TEC

With the spatial expansion after "the merger of the three areas", construction of the roads within the eco-city will be further accelerated in the next few years, and the eco-city should continue the planning concept of a dense road network, especially to complete the urban branch road network and greenway network within the area.

Rapid construction of external traffic corridors

At the initial planning of the transport system, the eco-city positioned its relationship with the outside world, proposing the goal of "regional integration", i.e., the eco-city docking with the central area of Tianjin and to integrate into Binhai New Area (Figure 10-5). Therefore, the integrated transport plan defined the planning of external traffic corridors of the region and made detailed provisions on the grade and capacities of several important roads that served as external traffic corridors. This was also the reason that the planning and implementation of external traffic corridors in the eco-city was ahead of other areas such as the road network, rail transit and bus system.

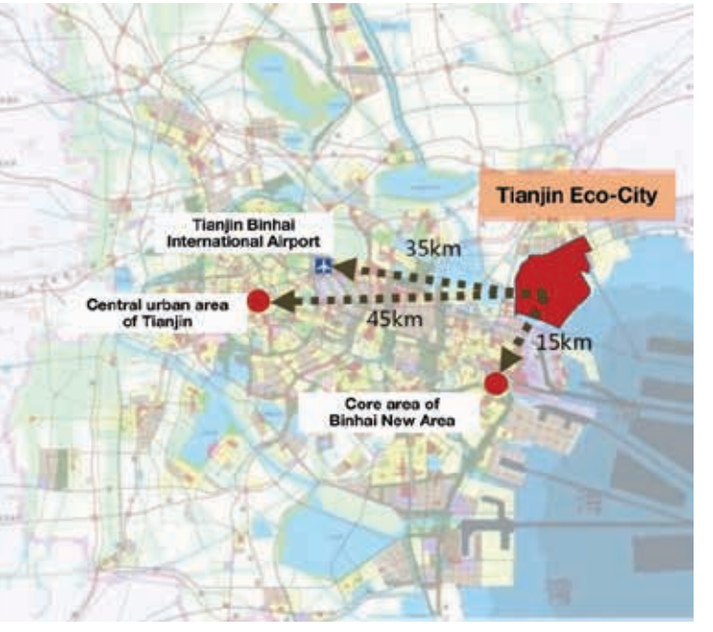


Figure 10-5: Schematic Diagram of TEC's Location

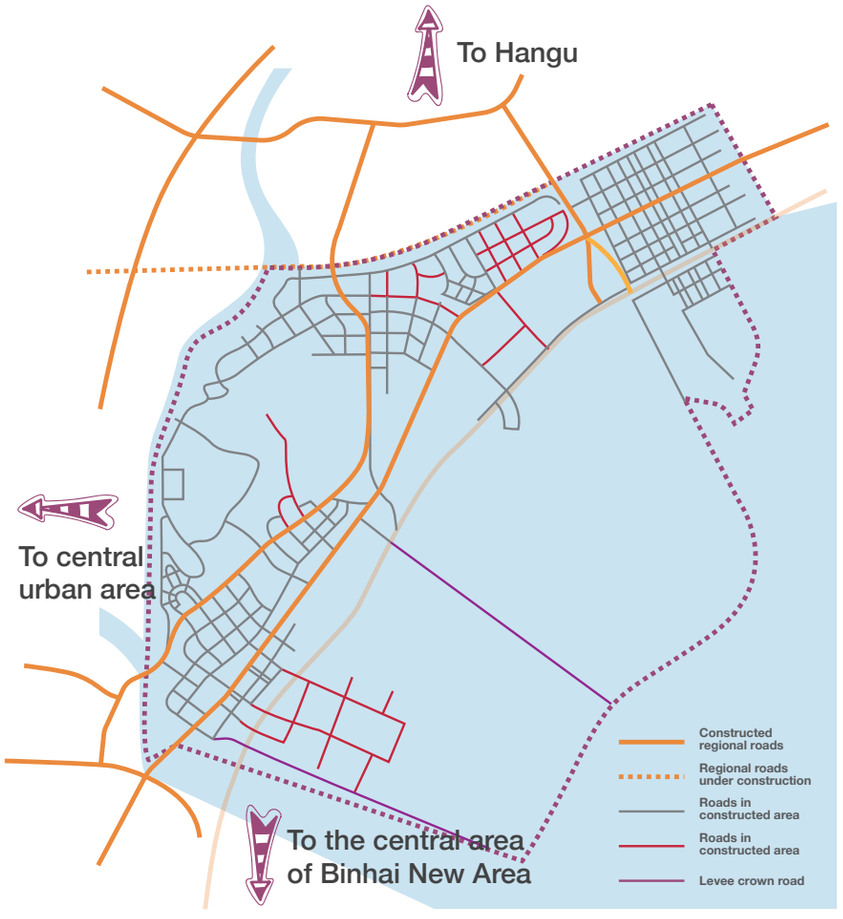


Figure 10-6: Schematic Diagram of External Corridors of TEC in the early Planning

The *Integrated Transport Planning 2009* contained reasonable planning of the eco-city's external traffic corridor, further strengthening the connection between the eco-city and major areas around it (Figure 10-6).

At present, the eco-city has formed an external highway network layout that connects the central urban area of Tianjin city to the west, the core area of Binhai New Area and Tanggu District to the south, and Hangu District to the north. Except for the Beijing-Hong Kong Expressway, the other roads in the external traffic planning have been built.

In *Integrated Transport Planning*, specific predictions and regulations were made for the travel time of several key areas for the external traffic of the eco-city. The following is a comparison with the actual situation today:

Table 10-1 Traffic Time between the Eco-city and the Main Attractions

From TEC to:	Tianjin Airport	Urban areas of Tianjin city	Central Area of Binhai New Area	Binhai North Station of High-speed Rail
Integrated Transport Planning	60 minutes	60 minutes	20 minutes	15 minutes
Water-conserving facilities	50 minutes (Jinhan Expressway)	60 minutes (Tanghan – Gangcheng)	20 minutes (Haibin Expressway)	25 minutes (Hanbei Road)

It can be seen that the eco-city provided smooth access to Tianjin city, Tianjin Airport and the central area of Binhai New Area, and the travel time now is consistent with planning. Hanbei Road serves as the main connection between the eco-city and Binhai North Station of High-speed Rail, which passes through the central area of the eco-city. It has high traffic and complex road signals, resulting in a relatively low travelling speed. Therefore, the actual travel time between the eco-city and Binhai North Station failed to meet the expectations.

According to the survey of residents in 2015, external traffic accounted for 30.4% of the total travel demand, while cars have become the most important mode of external traffic, accounting for 72% of the total external traffic. With the increase of resident population and employment opportunities in the eco-city, the demand for external transportation will soar rapidly. As a result, the traffic pressure on several major corridors will rise accordingly. Moreover, due to the expansion of administrative divisions, the planned external corridors will gradually turn into rapid motorised corridors within the region, and its attractive traffic characteristics will also change accordingly. The question of how to identify the new traffic demands in the future and deal with them, and then reorganise the external traffic corridors of the eco-city will become one of the important issues for discussion in the new master plan.

The construction of the Rapid Transit Rail No. Z2 and Z4 to connect Beijing and Tianjin have already started. Meanwhile, it is necessary to study the rapid commuter bus system in advance so as to attract more traffic and long-distance commuting travel by buses in the Beijing-Tianjin-Hebei region.

3. A Slow Traffic Network

The construction of a green transport system in the eco-city, on the one hand, relied on the planning concept of TOD and a dense road network; on the other hand, it also relied on the construction of a slow-traffic system, that was made clear at the very beginning. The green transport planning placed the priority on walking and cycling, followed by travel by bus, rail transit, taxi and private car, which shows the emphasis of the eco-city on walking and cycling.

All municipal roads and communities in the eco-city were constructed in strict accordance with the principle of "separation of man from vehicles and separation of motor vehicles from non-motor vehicles", and greenways and motorised corridors were independent from each other. A greenway was a special road for non-motor vehicles inside the city and also an important part of the urban slow traffic network. Any motor vehicles other than emergency vehicles were prohibited. It can be divided into a recreational greenway and commuting greenway based on its traffic characteristics. Also, it can be divided into a greenway network on both sides of motor vehicle lanes, in neighbourhoods and in parks based on its location.

Laying out a "four-board" slow traffic space

The "four-board" road was very popular in China in the 1980s and 90s. It refers to the practice of using a 2 to 5 m-wide green belt as the isolation belt for motor vehicles and the isolation belt for separation of motor vehicles from non-motor vehicles, so as to clearly divide the two ways of a road into motor vehicle and non-motor vehicle traffic zones (Figure 10-7, and 10-8), thus beautifying urban spaces while ensuring the safety of bicycles. This is quite necessary for a country with a large number of bicycles. However, in the past 20 years, meeting the traffic demand of cars has been given the priority in motorised development. As there were more and more lanes, green belts were once considered a waste of road space.

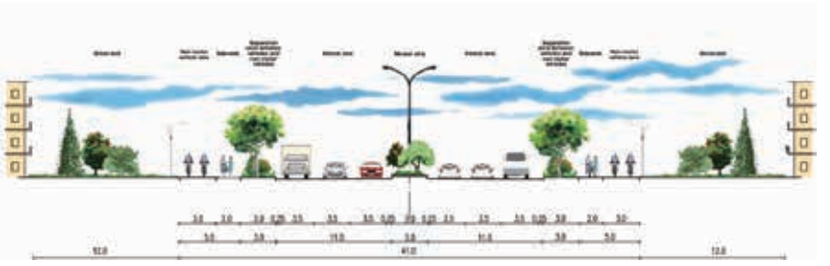


Figure 10-7: Section View of Arterial Roads in TEC

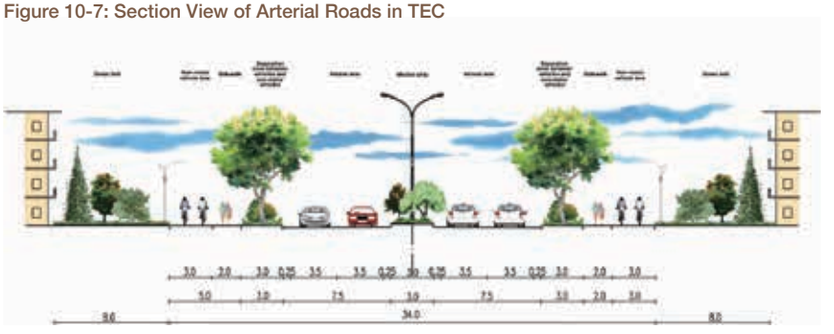


Figure 10-8: Section View of Secondary Trunk Roads in TEC

Fortunately, from the beginning, the eco-city has firmly adhered to the concept of prioritising green transport and gave green transport full priority in terms of road design, especially with the adoption of the "four-block" cross-sectional design model in the planning to ensure space for pedestrians and non-motor vehicle lanes. The "four-board" also became an important feature of the eco-city's road planning.

The greenway in residential and commercial areas was 5 m wide, and in industrial parks it was 3.5 m wide, which brought good shading to the pedestrian and non-motor vehicle lanes, and greatly improved the road and urban landscape.

Road facilities guarantee a slow traffic experience

In the eco-city, not only has the green system been well laid out through the design of road section, but a variety of road facilities was also provided to ensure the convenience, comfort and accessibility of the greenway.

Greenway systems were generally provided with blocking piles (Figure 10-9) to prevent motor vehicles from entering or occupying sidewalks. In addition, the intersection of greenway and crossing facilities and roads were all accessible (Figure 10-10), making it easy for the elderly, parents pushing baby carriages and people in wheelchairs to travel, reflecting the "people-oriented" design concept.

In order to ensure pedestrian safety, pedestrian refuge islands were provided at the intersection of municipal roads (Figure 10-11). The design standard promulgated by China in 2012 stipulated that an intersection with crossing distance over 16 m should be provided with a pedestrian refuge island. However, the transport facilities that conform to the design specifications in form and size had already been available in the eco-city in 2009. It has to be said that the eco-city's concept was quite advanced.

Greenway system helps green travel

In the greenway planning, in addition to the 115 km sidewalks and non-motor vehicle lanes on both sides of motor vehicle lanes, there was a 120 km greenway system planned in the cells, which meant that the planned greenway totalled 235 km (Figure 10-12). The concept of pedestrian and non-motor vehicle road network density was innovatively proposed in the eco-city. The pedestrian and non-motor vehicle road network density there was 9.4 km per km^2, which was much higher than that of motor vehicles' 4.3 km per km^2, reflecting the concept of giving slow traffic priority.

Figure 10-9: Blocking Piles for Greenway

Figure 10-10: Accessibility Design for Crossing Facilities

Figure 10-11: Pedestrian Refuge Island

Figure 10-12: Slow Traffic Road

According to the survey of residents in 2015, 69.6% of the residents travelled within the eco-city, including 45% on foot and 14% by non-motor vehicle, which meant nearly 60% of the travel within the eco-city was by greenways. This was the highest compliment to the greenway system construction of the eco-city. It was the comfortable footpaths, bicycle lanes and good road shading that attracted a large number of residents to travel green.

Challenges of space constraints and connectivity

In the planning and design plan, some greenways were pedestrian and non-motor vehicle shared greenways, i.e., sidewalks (2 m wide) and non-motor vehicle lanes (3 m wide) sharing one path, resulting in space constraints for pedestrians and non-motor vehicles and a possibility

of interference. In practice, the same pavement on sidewalks and non-motor vehicle lanes also enabled the coexistence of pedestrians and vehicles.

At present, the residential and employed population in the eco-city is less than one third of its limit, and the pedestrian and bicycle traffic on the roads was not very heavy. This problem was not prominent. However, with further development of the eco-city and the increase in population, such phenomena are bound to cause issues.

In the actual development of the land parcel, the cross greenway in the planning scheme has not been fully realised. In order to ensure the continuity of the greenway system, the eco-city stipulated that the inside of the 400 m by 400 m land parcel transferred should be provided with a cross slow traffic system in accordance with the planning. However, the greenway inside the developed land parcel was often enclosed and accessible by residents only. A positive case study was a community of Keppel, which raised the platform through a three- dimensional design to ensure the opening of the slow traffic greenway within the residential areas (Figure 10-13). Through the two-storey platform (Figure 10-4) and the pedestrian corridor, the greenway was connected, and the semi-underground parking space was expanded in this community. The three-dimensional design proved ingenious. Not only did it take into account the residents' demand for residential safety and the public's demand for open space, but it also improved the parking supply. For the next stage of road construction, the key issues to be addressed are as follows: How to ensure the right of pedestrians and bicycles for roads under the condition of limited space, how to ensure the connectivity of the greenway system and its connection with transport hubs in actual construction, and how to introduce more functions for the greenway system after the "big green" to strengthen the residents' sense of participation.

Figure 10-13: Cross Slow Traffic Road in Keppel Community

Figure 10-14: Two-storey Slow Traffic Platform inside Keppel Community

Conclusion: By referencing Singapore's experience in traffic organisation and arrangement, a comprehensive supporting model of an eco-residential neighbourhood and neighbourhood centre was established. Neighbourhoods were seamlessly connected with urban slow-traffic roads in the eco-city, reflecting a "green travel" layout that reduced people's travel times and encouraged them to walk or cycle. This was a fruitful practice. At the same time, the rail transit-based public transport planning model made large-scale residential and commercial complexes to be concentrated near traffic stations. This urged residents to choose bus transit and offered an effective solution to green travel. In fact, the motor vehicle lanes in the eco-city were deliberately planned to be less spacious with the aim of discouraging travel by private cars. However, the change in people's travel habits was a relatively slow process, which required strong willpower, and more importantly, a guarantee of green travel facilities. In 2015, the proportion of travel by green transport in the eco-city was about 60%, which was far higher than the average in China, but still fell short of the goal of 90%. The eco-city will accelerate the implementation of major green travel initiatives, continue to optimise a slow-traffic system and its friendly connection with supporting facilities, and strengthen the demonstration value of green travel solutions with practical effects.

Chapter 11

Green Buildings

Summary

This chapter describes the eco-city's innovative measures and practical outcomes in terms of green buildings.

Right from the start, the eco-city set a mandatory indicator of 100% green buildings. It is currently the only area in China that fully implements green buildings and has been approved by the MOC as a green building base in northern China.

Even before the technology and benefits of green buildings were widely accepted by the building industry, the eco-city has already pioneered systematic green building solutions. These mainly included evaluation standards, management practices, incentive policies, supporting measurements, green construction and a goal system. Some of this experience has been replicated and promoted in China and overseas.

The eco-city developed green building design guidelines, design standards, evaluation standards and administrative measures, and introduced technical management regulations for green construction. These formed a green building management system that covered the entire life cycle from planning, design, construction and operation to evaluation. In addition, it set up an independent, third-party review and evaluation agency, and benchmarked the green building standards with Chinese national standards.

All newly constructed and unfinished building projects in the eco-city passed the green building review, achieving the goal of 100% green buildings. A total of 82 projects were granted the national green building label. Of these, 45 projects including the Low Carbon Experience Centre and Public Housing Exhibition Centre were awarded the three-star national green building label, 30 projects were granted the two-star national green building label, and seven projects were given the one-star national green building label. Moreover, three projects were further granted the green building operation label. Moreover, three projects were further granted the green building operation label.

The eco-city explored and promoted new technologies through initiatives such as pilot passive housing projects, fabricated building construction, building industrialisation and optimisation of carbon emission across the entire life cycle of the buildings.

The eco-city developed green building evaluation standards and made them mandatory requirements. Green building management, standards management and evaluation systems were created to oversee the entire life cycle of the buildings. Incentive policies were introduced and a list of high-efficiency and low-cost technologies suitable for local adoption was published to ensure that the construction of green buildings was done at a high standard and on a large scale. As a result, all buildings were certified as green buildings. The eco-city was an area with the largest concentration of green buildings in China.

1. Developing Green Building Standards

In 2009, the eco-city issued the green building evaluation and design standards to ensure that the relevant standards were already in place before construction took place. In 2017, the eco-city issued and enforced the revised Singapore Tianjin Eco-City Green Building Evaluation Standard (DB/T29-192-2016) and Green Building Design Standard for Sino-Singapore Tianjin Eco-City (DB/T29-195-2016), Technical Management Regulations for Green Construction of Sino-Singapore Tianjin Eco-City (DB/T29-198-2016), and Guidelines for Operation and Management of Green Buildings in Sino-Singapore Tianjin Eco-City. Together, these constituted the green building standards system for the Sino-Singapore Tianjin Eco-City, which covered all aspects of green building design, construction, operation and evaluation and defined the local green building standards for designers, constructors, builders and operators.

The eco-city's green building evaluation standard is China's only local green building standard that is directly recognised at the same level as Chinese national standards. It is the outcome of design optimisation based on national standards and Tianjin's industry regulations. It set out specific requirements for relevant stakeholders involved in green building development, including government administrations and green building planners, designers, constructors, operators and consultants. Some of the provisions and quantitative indicators were configured at levels that were higher than Chinese national standards. Based on the natural geographic conditions of the eco-city, the Design Standard provided methodological descriptions on aspects such as planning

and landscape, building design, structural design, Heating, Ventilation and Air Conditioning, water supply and drainage design and electrical design. It offered guidance for green building designers. The Technical Management Regulations for Green Construction stressed green construction planning and specified green construction management measures, including environmental protection measures, material-conserving measures, water-conserving measures, energy-conserving measures and emergency plans. It introduced regulatory indicators for material wastage, construction energy consumption, and construction water consumption, and included content on occupational health. The structure of the Technical Management Regulations for Operation and Management of the Eco-City was different from other standards systems in China. It was innovative and applicable to the eco-city. It included four aspects: restrictive indicators, management requirements, technical requirements and behaviour guidance.

The eco-city's green building standard was stricter than the Chinese national standard. It was divided into four grades. Of these, the basic certification was equivalent to the one-star national standard, but the platinum grading surpassed the three-star national standard. The eco-city set out more extensive and targeted conditions in terms of "four conservations and one environmental protection" by combining the characteristics of local climate, resources, natural environment, economy and culture. For example, in view of the characteristics of the saline-alkali land on which the eco-city was built, requirements for land improvement and treatment were included. In consideration of the lack of water resources, higher requirements for the utilisation rate of unconventional water resources were set. The eco-city's standards integrated the strengths of international standards and Singapore's Green Mark system. It pioneered a green building scoring system in China and promoted performance-based design approaches to allow developers to achieve green building more flexibly. At the same time, they also encouraged energy conservation and renewable energy utilisation. In terms of energy conservation, the weight coefficient has been increased further as well.

The eco-city's green building standard system was China's first complete green building planning and construction standards system. It focused on evaluation standards that worked in coordination with other design, construction and operation standards. In October 2016, the MOC approved the benchmarking of the eco-city's green building evaluation standards against Chinese national standards. In 2017, the new edition of the Green Building Design Standard for Sino-Singapore Tianjin Eco-City was completed.

On this basis, the eco-city issued the Energy Consumption Baseline of Green Buildings for Sino-Singapore Tianjin Eco-City (Trial) (TECB 2001-2004), which provided the foundation for energy

Figure 11-1: Schematic Diagram of the Development of Green Building Standards for the Eco-city

consumption evaluation and management in terms of the design, construction and operation of individual buildings. It effectively guaranteed the realisation of the eco-city's energy conservation and emission reduction goals. This was China's first quantitative energy consumption standard for green buildings that is created based on urban energy conservation and emission reduction goals. At the same time, the Building Energy Consumption Simulation Manual for Sino-Singapore Tianjin Eco-City further specified the type, version and parameter requirements for energy consumption simulation software for the eco-city's green buildings. The eco-city also introduced Technical Management Regulations for Green Construction of Sino-Singapore Tianjin Eco-City (DB/T29-198- 2016), which focused on green construction planning, construction site layout, the "four conservations and one environmental protection" principle, green construction inspection and acceptance, and other areas. It integrated civilised construction, environmental protection and construction conservation, and supported green building management (Figure 11-1).

Globally Representative Green Building Evaluation Standard

China's Green Building Evaluation Standard

The Evaluation Standard for Green Building issued by the MOHURD mainly involves indicators in six areas: land conservation and outdoor environment; energy conservation and energy utilisation; water conservation and water resources utilisation; material conservation and material resources utilisation; indoor environment quality; operation management (residential buildings) and comprehensive full life cycle performance (public buildings). The main indicators are divided into three categories: regulatory, general and preferential. Among these, regulatory indicators are mandatory for green buildings, while preferential indicators mainly refer to items that are relatively difficult to achieve and have higher requirements. For the same target, regulatory, general or preferential indicators may be proposed based on needs and possibilities. Depending on the degree to which the general and preferential indicators are met, green buildings are classified into three grades in ascending order: one-star, two-star and three-star.

Green Mark Evaluation System

The Singapore Government (Building & Construction Authority, BCA) launched the Green Mark scheme for green buildings in 2005 to foster the development of green buildings. The aim was to implement environmentally-friendly and sustainable development concepts into the planning, design and construction of new buildings to reduce the impact on the environment. The Green Mark evaluation system involves both new and existing buildings. The evaluation indicators can be divided into the following categories: (1) Energy efficiency: to improve the energy efficiency of buildings, encourage good building design methods, and select energy-efficient equipment; (2) Water-use efficiency: to improve the water-use efficiency of buildings; (3) Environmental protection: to reduce the impact of design, construction, material and resource selection on the environment; (4) Indoor environmental quality: to improve indoor environmental quality through design, including air quality, thermal comfort, noise control and sunlight exposure; and (5) Miscellaneous aspects: to exert beneficial effects on the environment through innovative technologies and approaches. There are four ratings: certified, gold, gold plus, and platinum.

LEED Evaluation System

The LEED system, developed by the U.S. Green Building Council (USGBC) in 1996, is an international green building certification system that focuses on the full life cycle of a building and is applicable to almost all types of buildings. The LEED evaluation system mainly includes evaluation indicators in six areas: sustainable site design, effective use of water resources, energy and atmosphere, raw materials and resources, indoor environmental quality, innovation and design. The areas are then further divided into two to eight sub-areas to give a total of 41 indicators. Each area consists of a few prerequisite criteria and many scoring indicators. A building will only be certified if all prerequisites are met. Except for a few hard prerequisite indicators, the other scoring indicators are non-mandatory and are only used to tabulate a score. These indicators can be adjusted to supplement a project. Based on the final score, a building will receive a rating of certified, silver, gold or platinum.

CASBEE Evaluation System

In April 2001, Japan established the Japan Green Building Council (JaGBC) and the Japan Sustainable Building Consortium (JSBC). The two organisations worked together to study and develop the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in order to improve and promote the assessment of buildings' environmental efficiency.

CASBEE is a way to assess and grade a building's environmental efficiency. It considers the hypothetical space between the land boundary and the peak of a building as a closed system for building environmental efficiency evaluation. Under this system, buildings are assessed from two perspectives:its environmental quality and efficiency (Q=quality) and external environmental load (L=load). Both Q and L categories contain around 80 sub-items. Each sub-item is evaluated using a five-level scoring system, with Level 3 (three points) being the benchmark level. Level 1

(one point) is awarded when only minimum conditions are met, and Level 3 is given when the average standard is achieved. During evaluation, four effective tools are used depending on the stage and user applications: preliminary design tool, environmental design tool, environmental impact tool, and sustainable operation and update tool. Currently, CASBEE has been implemented in many Japanese buildings.

2. Implementing the Full Life Cycle Management

In order to achieve the goal of 100% green buildings, the eco-city formulated the *Interim Provisions on Green Building Management of Sino-Singapore Tianjin Eco-City* in 2010 to ensure complete management of green buildings across the entire development and construction process. In line with the complete management of buildings, the eco-city established a mandatory green building management system which was closely linked to the approval process of the existing planning and management system. The eco-city developed a green building evaluation method and construction approval procedure that covered the entire process including planning, design and construction (Figure 11-2). The requirements of passive technology, active equipment and renewable energy utilisation were fully implemented to ensure the green building goals were achieved.

The eco-city incorporated the management of green buildings into the planning and construction management procedures, and included the green building evaluation without additional approval process on the basis of site selection report, land use permit and building permit ("one report, two permits" for short) specified in the Urban and Rural Planning Law of the People's Republic of China to ensure that energy consumption and carbon emission requirements were put in place. In order to resolve the issues of multiple management of green buildings, the eco-city innovatively implemented complete evaluation of green buildings in four areas, i.e. building energy efficiency evaluation, renewable energy demonstration city project acceptance, energy conservation project acceptance and green building evaluation to realise the goal of "four-in-one". During the planning and drawing stage, the eco-city first checked the green building designs. More importantly, it reviewed the implementation of green building designs during the plan acceptance stage to ensure that the project meets the requirements of the green building standards.

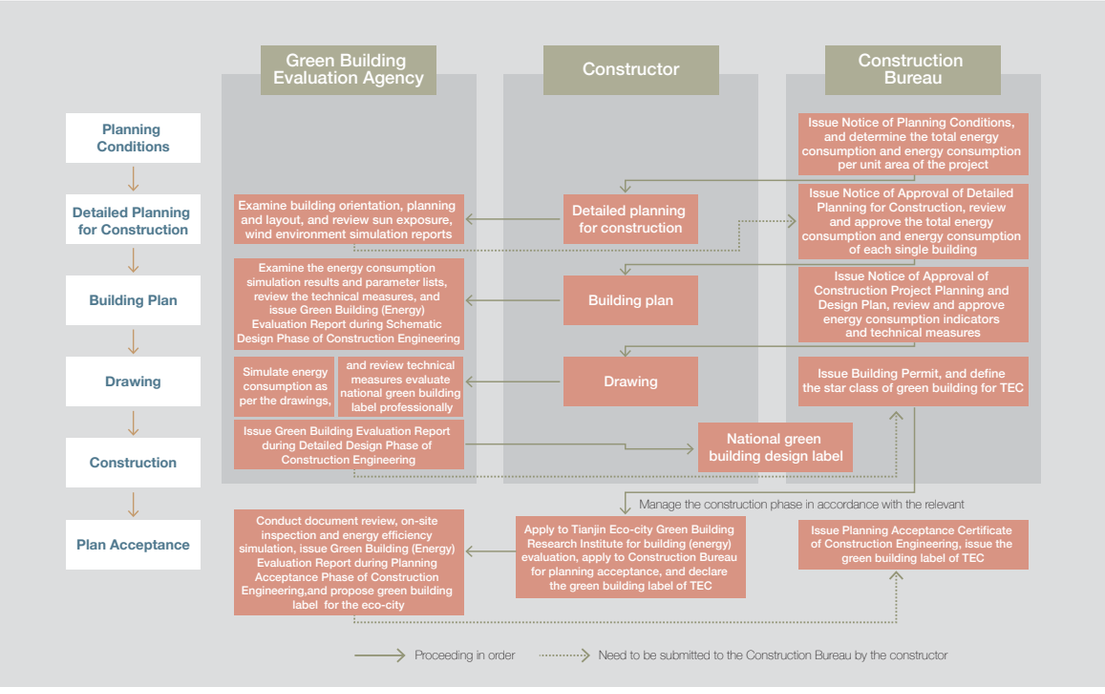


Figure 11-2: Flow Chart of the Eco-city's Green Building Management

3. Introducing Incentives and Support Policies

In 2014, the eco-city set up a special fund for green building, a special fund for renewable energy building application and a special fund for green building technology research and development, and established administrative measures to support the development of green building in a standardised and sustainable manner. Policy guidance and encouragement ensured good results even before green buildings were widely recognised.

The special fund for green buildings was used to reward highly-rated green buildings. The reward increased as the green rating increased. This helped to alleviate higher green costs in the early stages of development. The special fund for renewable energy building application was for construction projects that adopted renewable energy technology. It subsidised solar water heating demonstration projects based on the total area of solar panels used, and Ground Source Heat Pump (GSHP) demonstration projects based on the number of GSHP wells. In March

2013, the ECAC and MND signed a cooperative agreement on scientific and technological research and development in green building and related fields. The two bodies jointly provided special funding support for the development of more effective green building technologies. This eased the initial investment pressure through financial incentives and subsidies, and helped promote sustainable development in green buildings.

4. Setting up Third-party Evaluation Agencies

In order to further define the rights and responsibilities of green building-related entities and avoid a situation in which government departments have to serve as both regulator and participant, the eco-city worked with a number of national scientific research and design institutes to establish the Tianjin Eco-city Green Building Research Institute (Green Building Institute). The Green Building Institute provided independent third-party review and evaluation services for green buildings in the eco-city, and assisted government authorities in the evaluation, management and control of green buildings across the entire process from design and construction to operations.

Evaluation and technical review of green buildings in the area were entrusted to the Green Building Institute. The Green Building Institute conducted green building evaluation and technical review across three phases: planning and design, construction and project acceptance. It provided opinions based on quantitative indicators such as building energy consumption, renewable energy utilisation rate, and unconventional water source utilisation, that were used as the basis for approval by construction authorities. This improved the impartiality, professionalism and scientificity of green building evaluation.

5. Applying Energy-conserving and Environmental Protection Technologies Extensively

The eco-city actively explored and applied advanced and suitable green building technologies based on the requirements of “four conservations and one environmental protection”. With full consideration given to the level of economic and social development, resource endowment, climate conditions and building characteristics, the eco-city adopted passive energy conservation technologies, including the rational use of building integrated renewable energy technology, regional-level renewable energy technology, distributed energy supply technology, rainwater collection and reclaimed water utilisation technologies, to construct localised, cost-effective, replicable and scalable green buildings. By adopting localised, applicable and passive priority technologies, the eco-city's incremental green building cost was basically controllable. One-star buildings had no incremental cost other than those that were mandatory, two-star buildings' incremental cost was between 20 to 50 RMB per m^2, and the increment cost for three-star buildings was between 50 and 300 RMB per m^2. Except for projects with special needs, the incremental cost of most projects was less than the upper limit. The eco-city applied a large number of “four conservations and one environmental protection” technologies in individual building (see Table 11-1~6 for details).

Table 11-1 Technologies Related to Land Conservation and Outdoor Environment

Category of Technology	Major Technology Examples	Main Function
Land-conserving technology	Underground space utilisation	Utilise land resources intensively and conservatively
Outdoor environmental planning technology	Outdoor wind environment simulation	Control the wind speed in outdoor spaces through building layout optimisation to create a comfortable outdoor wind environment.
	Sun exposure simulation	Improve the sunshine received by the buildings through building layout optimisation to enhance indoor comfort.
	Heat island simulation	Improve thermal environment in the area to enhance thermal comfort.
	Outdoor permeable pavement	Implement rainwater collection to reduce surface runoff.
Greening technology	Multi-level greening with trees, shrubs and grasses	Create beautiful landscapes and enhance the ecological functions of green spaces.
	Roof greening	Increase the greening capacity within the site.
	Vertical greening	Improve the thermal insulation performance of building envelop.
Landscape design	Man-made wetland landscape	Collection and treatment of raw rainwater
	Sunken green space and rain garden	Regulate and store rainwater.
	Ecological waterscape design	Maintain water environment sustainability and improve biodiversity.

Table 11-2 Passive Energy-conserving Technology

Category of Technology	Major Technology Examples	Main Function
Building shape design	Shape coefficient control	Reduce heat dissipation area and lower heating and air-conditioning energy consumption.
External building envelope thermal insulation technology	Improving the thermal insulation performance of insulation material for external wall and roof	Lower heating and air-conditioning energy consumption.
	Improving the thermal insulation performance of doors and windows	Lower heating and air-conditioning energy consumption.
	Appropriate window-wall ratio	Reduce heat loss of north-facing external windows.
	Airtightness	Reduce heat loss, and lower heating and air-conditioning energy consumption.
	Watertightness	Prevent doors and windows from water seepage.
	Integrated sun-shading coefficient	Reduce building air conditioning energy consumption
Natural lighting technology	Appropriate external window-wall ratio	Make full use of natural lighting.
	Installing light wells in underground garages	Reduce lighting energy consumption in the daytime.
	Installing tubular daylighting system in garages	Reduce lighting energy consumption in the daytime.
	Design of the house layout featuring bright kitchen and bathroom	Lower lighting energy consumption.
	Installing reflectors for external walls	Increase the depth of daylight zones and improve the uniformity of indoor illumination
	Providing indoor natural lighting with roof skylights	Lower lighting energy consumption.
	Ventilation and lighting in public elevators and bathrooms	Reduce basement's lighting energy consumption, and improve its comfort.
	Ventilation and lighting in public elevators and bathrooms	Lower lighting energy consumption.
Natural ventilation	Installing openable external windows in smokeproof enclosures, frontrooms, garages, staircases and bathrooms	Help with fire fighting and reduce the power consumption of mechanical smoke exhausts

Table 11-2 Passive Energy-conserving Technology (Continued)

Category of Technology	Major Technology Examples	Main Function
Natural ventilation	Installing ventilation louvers in underground garages	Reduce the energy consumption required to meet the air ventilation needs of underground garages.
	Summer oriented layout and design	Create a good outdoor wind environment and facilitate indoor ventilation.
	Installing openable fans on the external windows of glass curtain walls	Reduce the energy consumption required for air conditioning and air ventilation needs during the transition season.
	Atrium with thermal pressure ventilation, and openable skylight	Reduce the energy consumption required for air conditioning and air ventilation needs during the transition season.
	Installing exhaust shaft and top turbine vent	Reduce the energy consumption required for air conditioning and air ventilation needs during the transition season.
Building shade	Movable aluminium louvered shade	Reduce air conditioning energy consumption.
	Electric aluminium external shade	Reduce air conditioning energy consumption.
	East/West exterior vertical shade	Reduce air conditioning energy consumption.
	Electric internal shade for atrium	Reduce air conditioning energy consumption.

Table 11-3 Active Energy-conserving Technology

Category of Technology	Major Technology Examples	Main Function
Heating	Low-temperature hot water floor radiant heating	Improve indoor thermal comfort and save on heating energy consumption.
	Supply of heat source at heat exchange stations	Reduce heat loss during heat exchange.
	Installing automatic differential pressure control valve at heat inlets	Help heat balance and avoid local overheating.
	Vertical surface mounted fan coils applied at heating terminals	Raise heating efficiency.
Air conditioning	Various energy-efficient air conditioning equipment	Save on air conditioning energy consumption.
	Air conditioning systems installed based on zones and levels.	Reduce air conditioning energy consumption by rational selection of air conditioning system based on the building function of different parts.

Table 11-3 Active Energy-conserving Technology (Continued)

Category of Technology	Major Technology Examples	Main Function
Frequency conversion technology	Applying frequency conversion technology in water and air systems	Lower energy consumption.
Energy-efficient equipment	Energy-efficient elevators and electrical equipment	Lower energy consumption.
Active ventilation	Mechanical ventilation	Improve indoor air quality.
	Fresh air heat recovery	Cut down on heat loss.
Temperature and humidity control	Single-room temperature control	Lower heating energy consumption.
	Automatic temperature control system	Lower heating energy consumption.
	Electric thermostatic control valve	Lower heating energy consumption.
Lighting equipment and system	Various energy-efficient lamps	Lower lighting energy consumption.
	PIR motion sensor switch	Shorten the start-up process of lighting equipments and lower energy consumption.
	Adopting intelligent control approaches such as light control, stored program control and time control	Shorten the start-up process of lighting equipments and lower energy consumption.
Intelligent control system	Anti-theft intercom and residential security systems	Improve building security.
	Electronic security guard patrol system	Improve building security.
	Intelligent garage management systems	Provide convenience for users.
Energy consumption monitoring	Energy consumption sub-metering systems	Help monitor and calculate buildings' energy consumption breakdown to reduce operating energy consumption.
	Water, electricity and gas remote metering system	Help the municipal systems in the area to monitor and count the building energy consumption and reduce labour costs.
Comprehensive utilisation of energy	Cold storage and heat storage systems	Lower air conditioning and heating energy consumption.
	Recycling of exhaust air heat, excess heat and waste heat	Lower energy consumption.
Renewable energy	Ground source heat pump	Lower heating and air conditioning energy consumption, and reduce carbon emissions.
	Solar thermal systems	Save power consumption efficiently with mature technology.
	Solar Photovoltaic (PV)	Save energy consumption.
	Wind power generation	Save energy consumption.

Table 11-4 Technologies Related to Water Conservation and Water Resources Utilisation

Category of Technology	Major Technology Examples	Main Function
Water-efficient appliances	Water-efficient faucets	The flow rate is less than that of traditional faucets.
	Water-efficient toilets	The single flush volume is less than that of traditional toilets.
Water-conserving measures	Water sub-metering device	Save on water resources.
	Water-conserving cooling technology	Save on water resources.
	Water conservation in public bathhouse	Save on water resources.
Water quality guarantee	UV disinfection technology for water supply	Improve tap water's quality.
	Ozone disinfection technology for reclaimed water	Improve reclaimed water's quality and remove odour.
Reclaimed water utilisation	Toilet flushing	Raise the utilisation rate of unconventional water sources and save on water resources.
	Landscape water replenishment	Raise the utilisation rate of unconventional water sources and save on water resources.
	Replenishment for cooling water	Raise the utilisation rate of unconventional water sources and save on water resources.
Rainwater utilisation	Rainwater infiltration	Facilitate surface water conservation and improve soil.
	Constructed wetland for rainwater infiltration	Save on treatment cost, the filtered rainwater can be used for greening and watering, and water resources can be saved on.
Quality-based water supply	Installing quality-based water supply system	Raise the utilisation rate of unconventional water sources and save on water resources.
Water-conserving irrigation	Drip irrigation	Save more water than traditional irrigation approaches.
	Micro irrigation	Save more water than traditional irrigation approaches.
	Mirco sprinkler irrigation	Save more water than traditional irrigation approaches.
Reducing pipe network leakage	Pipe selection	Select the pipes with good durability.
	Planning of pipe distribution network	Reduce pipe network leakage.
	Pipe laying	Lay out outdoor pipe network properly.

Table 11-5 Technologies Related to Material Conservation and Material Resource Utilisation

Category of Technology	Major Technology Examples	Main Function
Material-conserving design	Building shape, moulding elements, and optimum structural design	Save on the use of building materials.
Material selection	Eco wood air conditioning louvers	Save on the use of metal louvers.
Waste as raw material	Slag hollow brick	Save on soil resources.
	Eco board exterior wall	Recycle building materials and save outer eave materials.
Recyclable material	Steel structure	Recycle building materials.
Integrated construction and decoration	Exquisite renovated apartments	Lower construction energy consumption and reduce secondary pollution.
Kitchen and bathroom standardisation	Uniform kitchen and bathroom size	Save on decoration materials with modular design and unified material selection.
Construction industrialisation and prefabrication		Improve the quality of walls, doors and windows, and interior decoration, shorten the construction period, and save on labour costs.

Table 11-6 Technologies Related to Indoor Environmental Quality

Category of Technology	Major Technology Examples	Main Function
Building design optimisation	Spatial layout effectively reduces noise interference	Reduce noise interference.
	No obvious visual disturbance in the main rooms	Maintain indoor environment view.
	Special acoustic design	Improve the sound quality of rooms with acoustic requirements.
Air quality monitoring	Installing an air quality monitoring systems	Improve indoor air quality.
	Installing a carbon monoxide concentration monitoring device in underground garages	Improve air quality.

Table 11-6 Technologies Related to Indoor Environmental Quality (Continued)

Category of Technology	Major Technology Examples	Main Function
Air quality purification equipment	Indoor air purifier	Improve indoor air quality.
Healthy internal wall coating	Diatomite powder coating	Adsorb formaldehyde to improve indoor air quality.
	Photocatalyst healthy coating	Release negative ions to absorb formaldehyde, so as to improve indoor air quality.
Internal wall material	Energy storage and humidity control internal wall materials	Use the materials' heat storage performance to improve indoor thermal comfort, and save on heating and air conditioning energy consumption.

6. Typical Cases of Green Buildings

Low-Carbon Experience Centre: Located in Tianjin Eco-City Science Park (Figure 11-3), the Low-Carbon Experience Centre is a green office building with Singapore elements. It mainly has a steel structure and a building area of 13,000 m^2, including one basement and five floors that cover an area of 9,899 m^2. It was co-developed by Sino-Singapore Tianjin Eco-City Investment and Development Co., Ltd., BCA and the former International Enterprise Singapore. The Low Carbon Experience Centre aims to achieve low-carbon construction and low-carbon operation. By adopting a full-life-cycle operation and management model,

Figure 11-3: Low Carbon Experience Centre

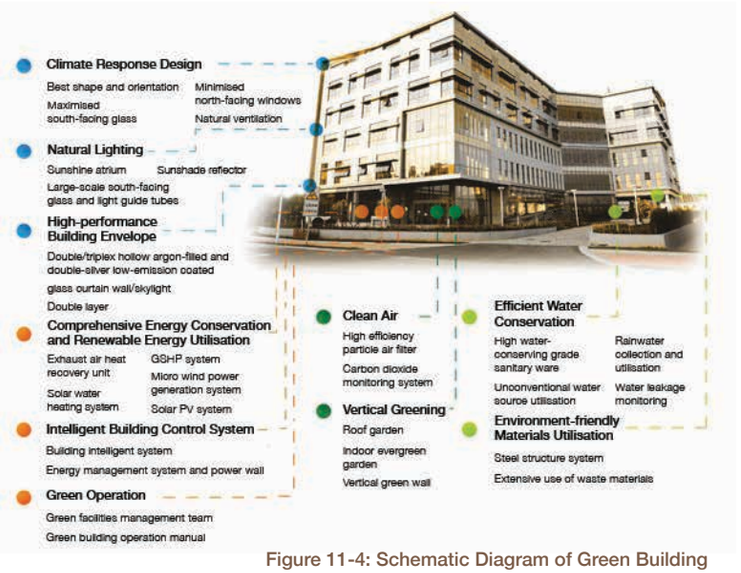


Figure 11-4: Schematic Diagram of Green Building Technology for Low Carbon Experience Centre

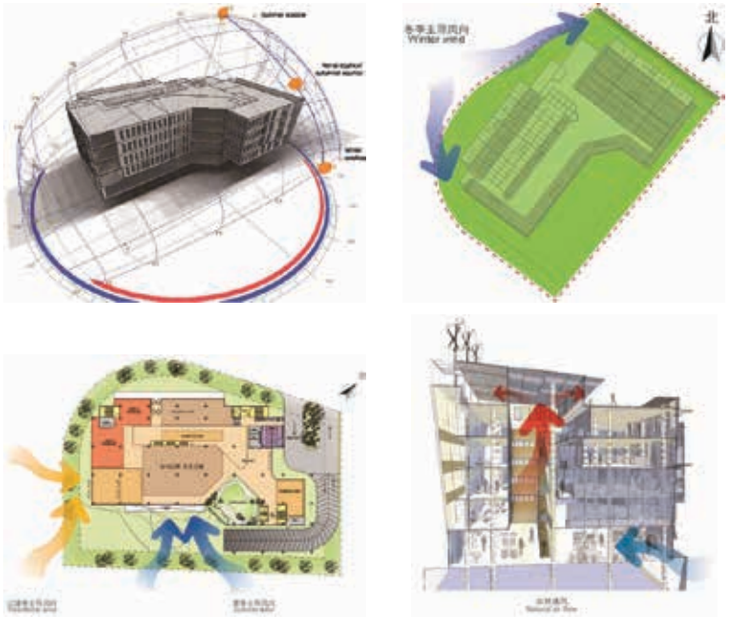


Figure 11-5: Schematic Diagram of Building Shape and Orientation

it extensively used ecological technologies in areas such as clean energy and carbon emission reduction, and embodied the design concepts of "back to nature" and "response to climate", "resources and environment" (Figure 11-4). This building won the first Green Mark Certified Platinum award in China and temperate areas, the Three-star Green Building Design Label in China, the Sino-Singapore Tianjin Eco-City Green Building Evaluation Standard Platinum Award, and the Three-star Operation Label according to the latest national green building evaluation standard.

Climate response design: The best shape and orientation were adopted to create a good external microclimate environment. Natural ventilation design allowed the buildings' annual energy consumption to be reduced by 2%. The openings of the northern walls were kept as small as possible to shield against winter winds and reduce heat loss (Figure 11-5).

High-performance building envelope: Double/three-layer hollow argon-filled and double-silver low-emission coated glass was applied in skylights and curtain walls to reflect outdoor solar heat in summer and prevent indoor heat loss in winter. The north-facing double layer design allowed north-facing households to open windows for natural ventilation and natural lighting without feeling cold (Figure 11-6). Besides, the space between the double layers created an indoor green shared space for users.

Natural lighting: 50% of the building's glass was in the south, and 20% on the roof skylight, while light guide tubes were installed to draw light underground. These maximised the natural lighting and expanded the field of view. The sunshade reflector allowed natural light to extend deeper into rooms while blocking solar radiant heat (Figure 11-7).

Figure 11-6: Double Skin Structure of Building

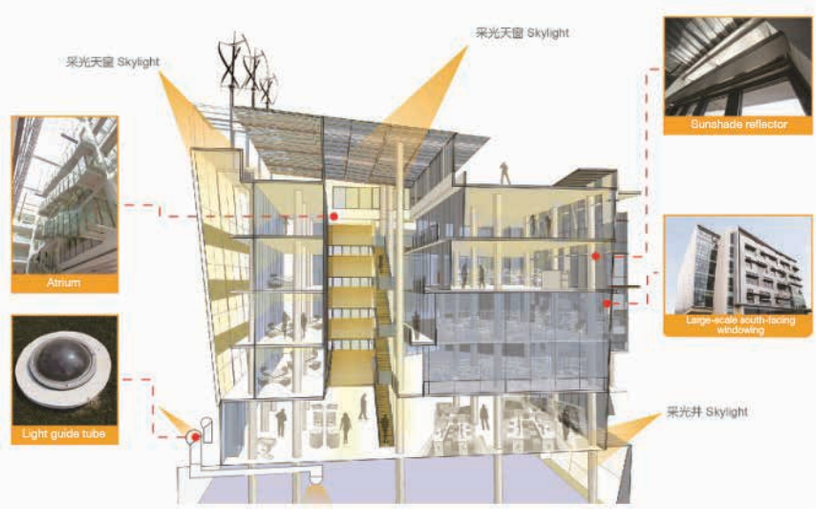


Figure 11-7: Schematic Diagram of Natural Lighting Design for Atrium

Efficient water conservation: Adopting high-grade water-conserving sanitary wares enabled the water conservation rate to be 40% higher than that required by the eco-city's green building standard. The construction of rainwater collection and utilisation systems satisfied 5% of a building's water needs.

Comprehensive energy conservation and renewable energy utilisation: Energy equivalent to 4% of buildings' energy consumption was recovered using exhaust air heat recovery units. This satisfied the annual electricity demand of 30 ordinary households. In combination with site conditions and building shapes, GSHP, solar water heating, solar PV and micro wind power generation systems were installed to satisfy buildings' cooling, heating, electric and hot water needs. The renewable energy system could satisfy 60% of the building's cooling, heating and domestic hot water demand, and the power generation met 12% of the building's electricity demand (Figure 11-8).

Air purification: Fresh air systems were equipped with a high-efficiency air filter, which filters more than 90% of PM2.5 pollutants. Return air systems were equipped with a carbon dioxide concentration detector to monitor indoor air quality, thus ensuring good ventilation.

Environmentally-friendly materials: Adopting a steel structure system allowed a recyclable material utilisation rate of 30%, which was three times as required by the eco-city's green building standard. Waste materials were extensively used. For example, roof steps were made of waste materials to ensure the "conversion of trash into functional materials".

Intelligent building control: The energy management systems could track the buildings' energy consumption, water consumption and renewable energy operation in real time, and analyse, monitor and control such data on an hourly basis individually. In addition, they can work with weather stations on the roof to achieve optimal operation in different seasons and improve building energy efficiency constantly.

Vertical greening: Building indoor evergreen gardens and green walls that filtered indoor air and formed a green climate core created evergreen, dynamic spaces that allowed tenants and users to enjoy indoor greenery throughout the year (Figure 11-9).

Green operation: Establishing a green facility management team to maintain liveability, and preparing special green building operation manuals for green building operation ensured the efficient operation across the entire life cycle.

The Low Carbon Experience Centre Project aims to be a "living lab" that tests and demonstrates green building features, energy-conserving building technology and renewable energy applications, and provides users and visitors with an experience-oriented, interactive and educational green journey.

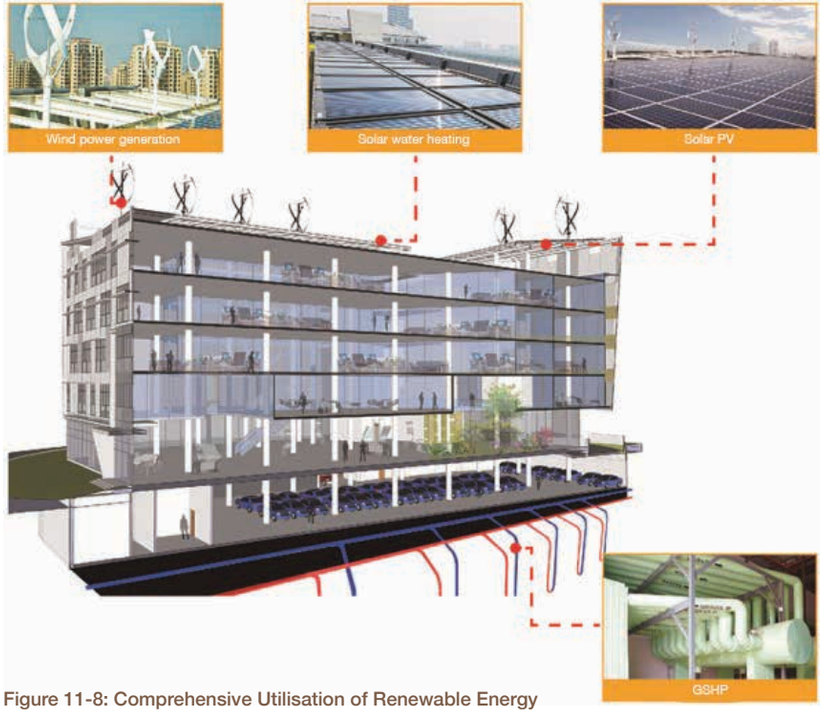


Figure 11-8: Comprehensive Utilisation of Renewable Energy


Figure 11-9: Gardens and Vertical Greening in Winter


Figure 11-10: Roof Garden

Figure 11-11: Roof Farm

Zero-carbon Building: Sino-Singapore Tianjin Eco-City Public House Exhibition Centre

A zero-carbon building means that the building's energy consumption is fully supported by the renewable energy generated by the site, and the building does not consume coal, oil, electricity and other energies. With a building area of 3,467 m^2 (Figure 11-12), the Sino-Singapore Tianjin Eco-City Public House Exhibition Centre integrated energy conservation and emission reduction technologies and solutions such as roof solar PV power generation, chimney-based ventilation system, natural lighting from light guide tubes and GSHP heating and cooling to achieve an overall building energy conservation rate of up to 70%, an unconventional water source utilisation rate of 66.79%, a renewable energy utilisation rate of 100%, and a recyclable building material consumption ratio of 10.34%, realising zero energy consumption and zero emission. It was the first zero-carbon building in Tianjin (Figure 11-13).

Diamond-shaped building structure absorbs sunlight adequately: The entire two-storey Public House Exhibition Centre is shaped like a diamond. Unlike traditional buildings, it is not south-facing, but is oriented 15 degrees towards the south-east. This angle is in line with Tianjin's local sunshine time and intensity, and ensures that solar panels are able to absorb sunlight by taking into account the time of exposure. The roof is covered with solar panels, and even the outer eave that protruded forward in the middle of building was a "base" for solar panels. The solar panels covered an area of 2,600 m^2, generating 240,000 kilowatt hours of electricity per year. The Public House Exhibition Centre consumed about 210,000 kilowatt hours of electricity per year. The intensity of sunlight varied across the day, so there were a lot of power cells underground to store electric energy when the solar panels generate excessive energy, and release electric energy when electric energy was insufficient.

Geothermal energy + ventilation guarantees physical comfort: The central hall of the Public Housing Exhibition Centre has very high ceilings. The façade of the two-storey buildings above the two sides was not made with reinforced steel or concrete walls, but through a creative use of glass windows. This clerestory window ensured natural lighting in the hall and improved building ventilation. There was a chimney-based ventilation system, which connected to outdoor air intake wells through an underground pipe network. Fresh air enters the exhibition centre from the outdoor air intake well and pipe network, and then passes through the clerestory windows and office's indoor windows to allow for internal ventilation. Air-conditioning is not necessary when the outdoor temperature is pleasant, which saves electricity.

Insulation windows: Low-E (low-emission) glass was adopted with an additional layer of film attached, to ensure transparency and better heat insulation. The inclined window design made the sun shine directly on the windowsill. The windowsill on the upper floor is made of a glossy material, which refracts sunlight, and only reflects light rather than heat, maximising the control of indoor temperature loss. No additional heat is absorbed when the air conditioner is turned on in summer, and heat will not dissipate in winter, thus reducing energy consumption.

GSHP heating and cooling system: Capillary network radiant heating was available in the Public House Exhibition Hall. Installing ultra-thin and small-load capillary networks on the roof effectively improved heat transfer and reduced the impact of space transformation on the building.

The luminance of lamps was adjustable automatically based on indoor brightness: There is no lighting or air-conditioning switch or regulator in the whole exhibition centre. An intelligent lighting system is used to adjust the luminance of lamps based on indoor brightness. Whether the light is turned on or not in the office is entirely determined by natural lighting and system setting. Light guide tubes are designed

Figure 11-12: TEC Public House Exhibition Centre

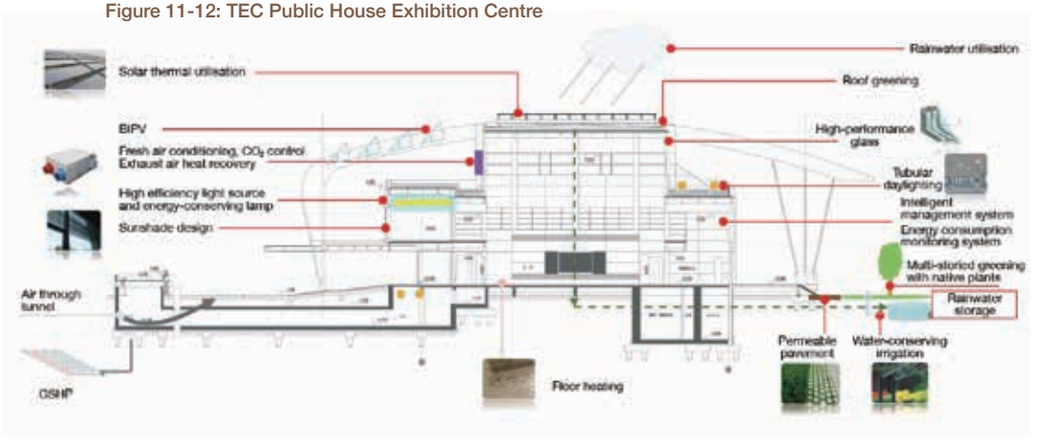


Figure 11-13: Schematic Diagram of Zero-energy Consumption Technology System

to make direct use of natural light. The strong light emitted from the headlights on the roof is not generated by electro-luminescence, but by refraction and reflection of sunlight. Even in the hall with a large space and poor lighting, brightness can be guaranteed.

Zero-energy consumption technology: Installing a solar power generation system (with a total installed capacity of about 292.95 kWh and an annual power generation of about 295.36 MWh) and adopting a series of energy conservation measures contributed to zero-energy consumption. A unified control system was built for centralised monitoring and management of energy consumption of all equipment in the whole building.

Conclusion: Buildings are the core spaces for human activities and major consumers of energies and resources such as water, electricity and materials. To achieve the goal of sustainable development, city managers need to ensure that buildings are energy-efficient. From the very beginning, the eco-city required all buildings to meet green building standards. It introduced a series of standards for green building design, evaluation and operation, which integrated the typical experience of China and Singapore, and created a green building management system that covered the entire building life cycle. In the future, the eco-city needs to continue to explore new green building standards, technologies and solutions to maintain its leadership position. It should further advocate the construction of more highly-rated green buildings, adopt incentive measures to guide and encourage investors in the construction and operation of highly-rated green buildings, and devote greater efforts in helping operators achieve green operation labels. In addition, it should continue to improve green building energy consumption monitoring, operation and maintenance mechanisms to refine the design, construction, acceptance and operation standards for green buildings, actively advance the industrialisation of green building, and engage in international exchange and cooperation to become an internationally influential base for construction, R&D transformation, and display and exchange of green buildings.

Part 4

Liveability and Vitality

This section describes the eco-city's efforts and achievements in public services, economic promotion, technology innovation and building a smart city from the perspective of liveability and vitality on the basis of “Part 3: Green and Low-Carbon”. Together with Part 3, this part captures the essence of the eco-city.

A new city is often in danger of being an “empty city”, “ghost city” and “sleeping city". It is generally faced with the reality of a small initial population, insufficient economic entities, lack of jobs, and incomplete and mutually restricting supporting facilities. In 10 years, the eco-city successfully attracted 100,000 permanent residents and more than 6,000 enterprises to build the foundations of urban vitality. It crossed the threshold in terms of population size to enter a more rapid stage of cluster development, and embarked on a journey of healthy development to avoid the risk of becoming an empty city.

The basic experience of the eco-city included the construction of public supporting facilities to meet the basic needs of residents. The public supporting facilities were developed in advance, before the large influx of new population so as to provide convenient and balanced services in areas such as education, healthcare, food, shopping and leisure. This is the “public service-oriented development strategy”. The strategy is underpinned by the logic of “getting facilities ready in advance rather than drawing people in without the facilities”, and “a city that can attract people to work in it is one that is liveable".

While building a liveable city, the eco-city simultaneously promoted industrial development and technology innovation, and has always considered these areas as priorities when determining the foundation of sustainable urban development. As real estate’s contributions to the regional economy changes from high to low, developments in industry, science and technology must be cultivated preemptively. This includes building industrial parks, incubation bases and other infrastructure, and fostering the industrial development environment and technology innovation climate to form leading industry clusters as soon as possible.

The eco-city at its core, should also be a smart city, and should undertake smart measures to achieve its ecological goals. Based on Singapore’s relevant experience, the eco-city has built public information-based infrastructure in accordance with a service-oriented and unified sharing concept. However, with the acceleration of population growth, the eco-city is also facing a series of urban management problems that cities traditionally encounter. These problems are highly complex, rooted in Chinese culture, and limited to the development stage. They need to be resolved effectively by establishing an institutional mechanism of “utilising both civil and military systems”. The effective solutions formed under the problem-oriented philosophy is experience that can be replicated and scalable.

This part corresponds to the eco-city’s goal of “people living in harmony with the society, and people living in harmony with economic activities”.

Chapter 12

Public Services

Summary

This chapter describes the basic concepts, balanced layout and practical outcomes of the eco-city's public services.

From the very start, the eco-city made the construction of a harmonious society and a liveable city its basic objectives. In line with new urban development trends, the eco-city implemented a "public services-oriented development strategy" in order to prevent the city from becoming a ghost town. The eco-city gave priority to basic public services in its financial input and moderately advanced the development of lifestyle facilities, such as education, health, sports, neighbourhood centres and gardens based on the population growth forecasts.

With a commitment to providing education in partnership with branded schools, the eco-city introduced nine high-quality primary and secondary schools and 12 kindergartens, including Nankai High School, the High School Affiliated to Beijing Normal University, Tianjin Foreign Languages School Affiliated to Tianjin Foreign Studies University, Huaxia Future Primary School of Tianjin Eco-City. This formed an education system that covered kindergarten to high school.

Using Singapore's experience as reference, the eco-city planned and set up an eco-residential system based on eco-cells – eco-neighbourhoods – eco-areas. It provided each neighbourhood with a neighbourhood centre that integrated government and commercial services, and where neighbourhood management, healthcare, commercial, culture and sports, and other facilities were centrally located. These facilities contributed to the integration, standardisation and networking of neighbourhood services, and the formation of a convenient 500 m lifestyle radius.

By referencing Singapore's experience in the planning, construction and management of public housing flats, 20% of the residential projects in the eco-city were public houses. This provided housing security for low- and middle-income groups.

The eco-city established an integrated healthcare service system based on the concept of "family doctor – neighbourhood hospital – general hospital" to ensure that the initial diagnosis is performed by doctors at the neighbourhood level, while treatment is provided at different levels and through bilateral referrals between neighbourhoood and general hospitals.

The eco-city established a "government-neighbourhood interaction and communication mechanism", and created channels and platforms for regular communication between government and enterprises. As a result, a neighbourhood governance mechanism based on collaboration, participation and common interests was formed.

The eco-city encouraged the development of social and public interest organisations, continued to carry out public welfare and environmental protection activities, and vigorously advocated a green lifestyle.

Unlike other new cities, the eco-city attached strong importance to social undertakings from the start. Taking public services as an important foundation for social undertakings, the eco-city provided residents with high-quality public facilities and access to high-quality education, medical services and elderly care services, and liveable housing in order to share the development outcomes with the people.

1. Concept of Public Services Development

To achieve the goal of people living in harmony with society, education, healthcare and neighbourhood services must be ensured. These are the most basic, most important concerns of the people. The eco-city's main social undertaking development concepts include:

Putting the people first: The eco-city planned and promoted developments based on the people's fundamental interests. In order to respect and care for the people, and continue to meet the people's needs and facilitate development in an all-rounded way, the eco-city strived to build a society in which people live in harmony with other people.

Oriented by public services: The eco-city advanced the construction of supporting service facilities moderately to enhance its influence in the region with high-quality public services resources. This helped to attract people to move into the city as soon as possible and prevented it from becoming a "ghost town".

Matching population growth: Taking into consideration the characteristics and needs of the residents in the region, the eco-city configured its public services facilities based on its population size (350,000 people), population structure and rate of employment.

Development from a high starting point: The eco-city leveraged the advantages of national cooperation projects to introduce distinctive and competitive high-quality resources from home and abroad. This helped establish alliances between strong brands and promoted social undertakings from a high starting point.

Open development: The eco-city actively worked with well-known Chinese and foreign educational and medical institutions in the establishment and operation of social undertakings. It encouraged private participation and rapidly formed a brand-oriented and internationalised educational and medical service capacity through strong cooperation and public-private partnerships.

Sharing outcomes: The eco-city prioritised public finance to safeguard and improve the people's livelihood. It insisted on enhancing residents' lives and sharing development outcomes with the people. This ensured that the diversified, multi-level and multi-faceted needs of the people were met and constantly helped the people in their pursuit of a better life. As a result, the residents have a greater sense of gain and the ecological construction outcomes brought greater benefits to the eco-city's residents in a fairer manner.

2. Public Services Planning and Layout

The eco-city positioned itself as an ecological and liveable new city where people live in harmony with other people. It planned and arranged different public services facilities in advance (Figure 12-1) according to the goals and requirements set by the KPIs framework and master plan. On the land reserved and controlled for social undertakings, the eco-city built a lifestyle service system that is accessible within a radius of 500 to 800 m.

Neighbourhood: Focusing on coordinated urban management, social management and neighbourhood services, the eco-city referenced Singapore's "neighbourhood unit" concept and established a three-tier residential model of "eco-cell – eco-neighbourhood – eco-area" in its master plan. The eco-city also created a four-tier public services system featuring the neighbourhood home, neighbourhood centre, urban sub-centre and urban centre. Each eco-neighbourhood was provided with a neighbourhood centre at a central location. There were 10 neighbourhood centres and 10 commercial centres in the Cooperation Zone. A neighbourhood centre covers an area of 15,000 m^2, with a building area of 15,000 to 20,000 m^2.

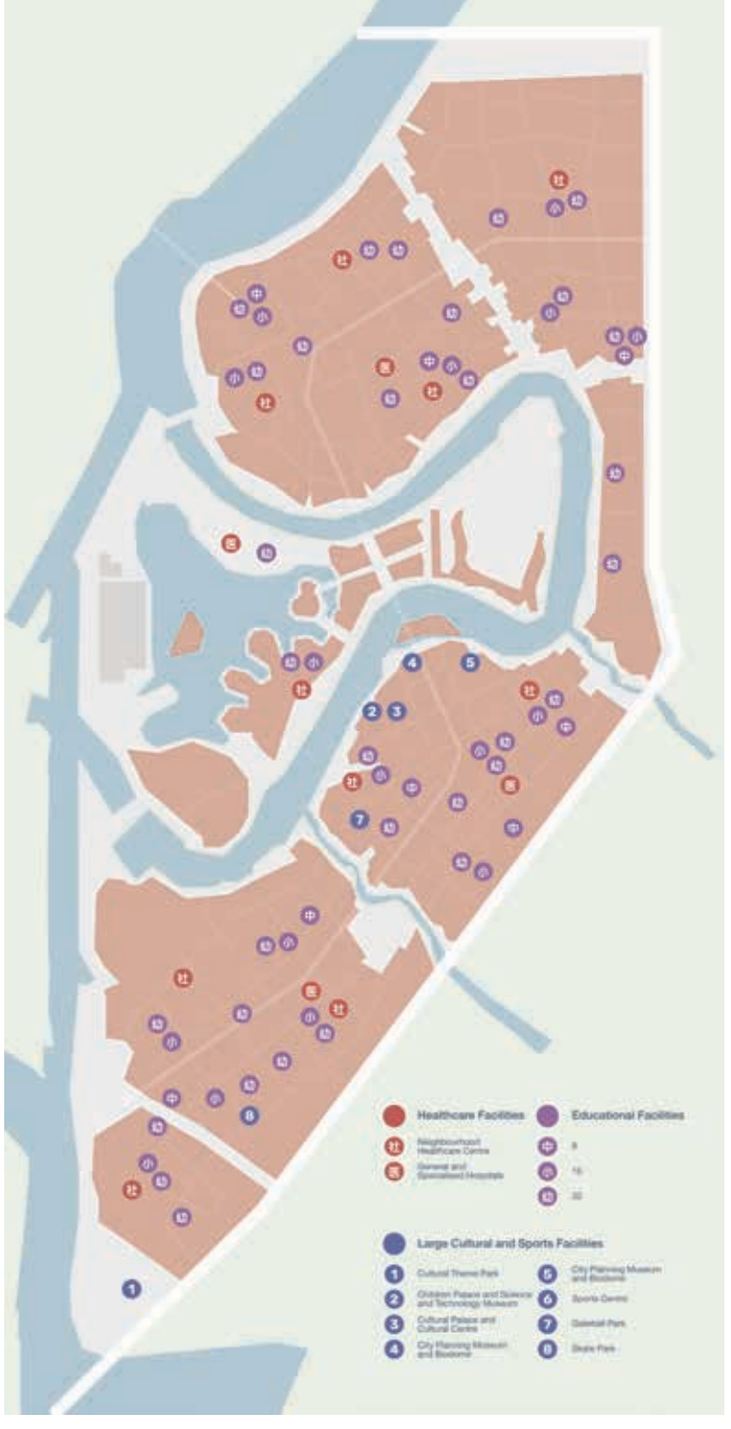


Figure 12-1: Layout of Public Service Facilities in Eco-city

It integrates medical services, cultural and sports activities, office services, neighbourhood management and commercial services, and serves 30,000 people within 500 m. Residents can reach a neighbourhood centre by foot in 10 minutes. “Neighbourhood homes” were constructed as eco-cells. Each “neighbourhood home” covers an area of about 200 m^2 and serves as the neighbourhood committee’s office and a place for neighbourhood residents to relax, entertain and interact. Based on actual needs, they provided special services such as child care and self-service physical examinations. The “neighbourhood homes” were built by developers and provided free of charge.

Education: The layout of the eco-city’s education facilities was planned to provide close access to compulsory education, vocational and higher education through industry-university-research collaboration, and social education with “highlighted features and multi-point coverage”. The kindergartens, primary schools and secondary schools in the entire Sino-Singapore Cooperation Zone have a radius of 400 m, 800 m and 1,500 m respectively. The plan included 32 kindergartens, 19 primary schools and eight secondary schools. By the end of 2017, six primary schools, three secondary schools and 12 kindergartens were built. As a resident who moved from an urban area to the eco-city said: “I used to live in Heping District where houses within half an hour’s walk of schools are called school zone houses, and are exceptionally expensive. Now there is a school just across the road and my house is still very cheap.” The eco-city achieved its mission of ensuring that “schools are near and accessible to everyone”.

Health: Each neighbourhood of the eco-city was provided with a neighbourhood healthcare centre of around1,000 m^2 in space. Large general hospitals were built as regional medical centres to create a two-level service model.

Culture: The eco-city planned to build city-level cultural facilities such as a library and archives, Children’s Palace of Science and Technology, Cultural Palace (Cultural Centre), and Eco-Forum Conference Centre, to create a centralised culture district together with the urban centre and the old Jiyun River course.

Sports: The eco-city planned to build a city-level sports centre and an Olympic park, provide a gymnasium or fitness centre in every area, and construct a neighbourhood sports park in every eco-neighbourhood.

Elderly care: The eco-city planned to build a large elderly care service complex in the central area, an elderly neighbourhood in the initial project area, and day care centres for the elderly in every eco-neighbourhood.

Figure 12-2: TEC Nankai High School

Public house: Based on the indicator of 20% public houses, the corresponding land areas were reserved in the master plan. The land use layout took into full account factors such as urban layout, social security, industrial development and lifestyle needs. The public houses were located in areas with convenient urban transport and built along commercial residences to prevent the area from becoming dirty and disorganised. At the same time, the eco-city explored a way of embedding a certain proportion of indemnificatory housing within commercial housing projects, and implemented an investment model whereby projects were constructed by developers, then repurchased by the government. This promoted an integrative development of public houses and commercial houses.

3. Inclusive and High-quality Education System

Mindful of the goal of providing education that satisfied the people's needs, a collection of renowned academic institutions (“名校云集”) were formed, guided by advanced social development strategies and policies that prioritised the people's welfare. As a result, the eco-city developed a unique educational roadmap.

Joint operation, collection of renowned schools: Since the opening of the first school in 2012, the eco-city has introduced eight well-known preschool education brands including Ivy Academy (Beijing), Hyledar (Shenzhen), 3&3 (Shanghai), Cathay Future (Tianjin), and Great Man (Guangzhou), and founded 12 kindergartens. The total number of children in the area increased from 29 to more than 3,200, representing an increase of over 100 times in five years. In public education, three primary schools and one senior high school, including Tianjin Binhai Foreign Languages School (TBFLS), TEC Nankai High School

Figure 12-3: Huaxia Future Primary School of Tianjin Eco-City

Figure 12-4: Tianjin Eco-city School Affiliated to Beijing Normal University

(Figure 12-2), TEC Nankai Elementary School, Huaxia Future Primary School of Tianjin Eco-City (Figure 12-3), and Tianjin Eco-city School Affiliated to Beijing Normal University (Figure 12-4) were set up through “brand grafting” cooperation. The total number of students increased from 99 to more than 6,200, representing an increase of over 60 times in five years. The total number of faculties and staff increased from 29 to more than 710, an increase of nearly 40 times in five years. In 2017, the total number of teachers and students exceeded 10,000, demonstrating growth at an "eco-city speed".

Collectivised school operation, district-based management:

Education collectivisation is an important approach in realising balanced academic development and resolving the issue of "inaccessible schools". Tapping on the branding of these renowned schools, the eco-city implemented unified management of educational concepts, school management, education and research development, information technology, educational evaluation, and school property management. This ensured the sharing of high-quality educational resources such as management, teachers and equipment.

As the first to introduce branded education resources, the eco-city pioneered the practice of collectivised school operation and district-based management in the TBFLS (Figure 12-5). The TBFLS features one high school department and three primary school departments. These schools shared the same leadership group, and maintained unified management, teacher resources, teaching and research, teaching evaluation and hardware configuration. This effectively curbed the rise of “school-zone houses” which had good social effects. In 2016, to promote the diversified educational development in the area, the eco-city boldly entered into a partnership with well-known private educational institutions

Middle School Department of TBFLS

Primary School Department I of TBFLS

Primary School Department II of TBFLS

Primary School Department III of TBFLS

Figure 12-5: Collectivised School Operation of TBFLS in the Eco-city

in Tianjin. As a result, the eco-city pioneered the "introduction of private education to public education", and brought in a high-quality arts and sports education resource like "Huaxia Future Primary School of Tianjin Eco-City". In the same year, TEC Nankai High School opened its doors, and TEC Nankai Elementary School was set up in 2017. The Nankai brand began to flourish, creating a competitive environment for the development of high quality educational resources. In terms of preschool education, brands such as Ivy Academy (two kindergartens), Hyledar (three kindergartens, Figure 12-6), and 3&3 (two kindergartens) emerged and operated under a franchise model.

School operation system with separate "governance, operation and evaluation": To promote the healthy development of education, the eco-city pioneered a new school operation model featuring separate "governance, operation and evaluation". "Governance" encompasses conducting overall planning to improve the service system. The eco-city established a series of systems covering education investment, operation preparation, teacher recruitment, enrolment policies, professional evaluation, policies that benefit the people, and logistical security, and strived to build a refined and services-oriented education department. "Operation" entails running schools independently and tasking experts to govern the schools. In response to the reform requirements of public institutions, the eco-city took the lead in successfully implementing the principal accountability system under the leadership of the council. This gave principals greater autonomy in running schools. As a result, the operational mechanism of self- development and self-discipline began to take shape. At present, the TBFLS, as a pilot unit for the construction of corporate governance structure in the first batch of institutions in Tianjin on the record of the State Commission Office of Public Sectors Reform, has already achieved governance by experts, and many other regions have learnt from this model. "Evaluation" means entrusting professional evaluation agencies to conduct comprehensive and scientific evaluation of the schools. The eco-city paid for services to monitor and evaluate the school operational standards and educational quality. In 2016, a third-party evaluation of the kindergartens was successfully carried out for pre-school education. The evaluation covered 80 elements in four areas. The development of pre-school education in the area was thus promoted by independent professional evaluation.

First-class hardware facilities: With the goal of "leading kindergartens in the city, leading primary schools in China, and first-class secondary schools in the world", the schools in the eco-city were equipped with all kinds of educational and teaching facilities. The primary schools boast British-style buildings and feature a classic Western atmosphere. Ecological environmental protection technologies

Hyledar Kindergarten

Hyledar Meixin Kindergarten

Hyledar Meiyi Kindergarten

Figure 12-6: Collectivised School Operation of Hyledar International Kindergartens in the Eco-city

such as solar water heating and GSHP air-conditioning were adopted to truly achieve energy conservation. The eco-city pioneered the use of scenario classrooms for biology, history, science and pottery (Figure 12-7) in Tianjin to broaden students' horizons. This practice has been replicated and promoted in many areas of the city. The secondary schools boast post-modern buildings and a high-class and elegant style. An interactive electronic whiteboard teaching system was adopted and information technology products were used in classrooms to inject more life into lessons and improve teaching efficiency. Some of the kindergarten buildings are magical and sweet, while others are elegant and modern.

Figure 12-7: Scenario Classrooms

Sino-Singapore educational exchange: The eco-city formed a normalised mechanism for teacher-student exchange visits between China and Singapore. In 2016, nearly 90 teachers and students from River Valley High School (RVHS), CHIJ Saint Nicholas Girls' School, and Dunman High School visited the eco-city. They shared and exchanged their experiences with schools such as the TBFLS and TEC Nankai High School in environmental protection, morals, sports and aesthetics education, operation of student councils and organisation of major events. In mid-July 2016, 10 teacher and student representatives from the TBFLS attended the Forum of Young Leaders organised by RVHS, further strengthening friendly relationships between schools.

4. Comprehensive Healthcare Service System

The healthcare system of the eco-city was continuously improved. There were nine healthcare institutions. A contractual family doctor service was implemented and an electronic doctor platform was developed.

Two-level health care service system: Based on the population size and structural characteristics of the area, the eco-city established a two-level healthcare service system of "general hospital – neighbourhood hospital".

By introducing excellent medical resources, the eco-city built a high-level and international tertiary Grade A general hospital and several specialised hospitals with distinctive features that meet the needs of its residents (Figure 12-8). Sino-Singapore Eco-city Hospital of Tianjin Medical University came into operation on 28 September 2016. The private tertiary Renhe Tiancheng Hospital with neurology and neurosurgery departments will start operation in early 2019. The TEC Branch of Binhai New Area Women and Children's Hospital is under construction and is expected to begin operations in 2021.

Figure 12-8: China-Singapore Tianjin Eco-City Hospital of Tianjin Medical University

Figure 12-9: First Community Health Service Centre of China-Singapore Tianjin Eco-City

Each eco-neighbourhood was provided with a neighbourhood healthcare centre (Figure 12-9). To fully implement family doctor services, the eco-city offered its residents with family doctors based on a ratio of one doctor per 1,000 residents. It integrated basic medical services and public health services, established resident health records in a unified way, and provided prevention, healthcare, treatment, rehabilitation, family planning and health education services. Moreover, it pioneered an integrated neighbourhood health service management in 2013 to include the healthcare services of institutions, schools and enterprises into the unified management of neighbourhood healthcare centres. The eco-city actively developed a health supporting service system to provide residents with comprehensive, full-cycle healthcare services. It strictly followed the duty pledge on Management By Objectives in family planning, and was ranked as one of the top functions among new areas for two consecutive years by learning from mature and advanced experiences and practices.

Exploring the reform of public hospitals: The eco-city has continuously improved the management system and mechanism of the healthcare service system. It introduced the Rules for Director Responsibility System under the Leadership of the Council of Sino-Singapore Eco-city Hospital of Tianjin Medical University, defined the orientation of the neighbourhood healthcare centre as a public platform to fulfil the government's basic medical and health responsibilities and its status as a legal entity, made clear the relationship between Sino-Singapore Eco-city Hospital and neighbourhood healthcare centres, and engaged in the construction of a medical

consortium. It abolished the internal management of general hospitals at the administrative level, implemented the director responsibility system under the leadership of the council comprising public health administration and co-operators, changed the traditional profit-making model where "a hospital subsidises its medical services with overly expensive drug prescriptions" in public hospitals, and formed an efficient financial compensation mechanism based on "government purchase of services".

Implementing the concept of "comprehensive health": By strategically placing healthcare as a development priority, the eco-city formulated healthy city evaluation indicators and included more indicators that reflected the pursuit of happy life in its KPIs framework. These include elderly-oriented facilities, childless elderly care, volunteer services, bone marrow and organ donation, and other evaluation indicators. It accelerated the formation of healthy lifestyles, and continuously improved the quality of healthcare services to make the healthcare sector a highlight of the eco-city. The eco-city promoted healthy lifestyles, strengthened the construction of a supportive environment, extensively carried out nationwide fitness campaigns and monitored residents' health literacy. To optimise medical and health services, it enhanced the construction of key disciplines and talent recruitment in general hospitals and urged hospitals to continue to improve their service standards and outreach capacity. It encouraged and injected social capital to run hospitals so as to meet the needs of residents for more diversified healthcare services. To deepen smart healthcare, the eco-city accelerated the construction of a "healthy eco-city", an evaluation information system, and formulated policies and specifications on data application by grade, classification and area. At the same time, the eco-city worked hard to ensure that all government departments consider healthcare as a key factor in the formulation of public policies, thereby forming a health alliance within the whole society. Health promotion activities will be organised through multi-sector cooperation to rectify the adverse effects of political, economic, social and environmental factors on health.

Based on the concept of "everybody takes responsibility for their own health", the eco-city developed "LOHAS", a self-service health management app. It constructed health units such as healthy neighbourhoods, canteens, schools and families to truly motivate all residents to participate in the construction of a healthy eco-city.

Advancing elderly care services: In accordance with the unified standard of Tianjin, the eco-city built and operated a day care centre for the elderly in the Second Neighbourhood to service the elderly in the area. The Second Neighbourhood Day Care Centre for the Elderly officially started operations in 2017. It has been widely praised by the elderly residents for its comfortable environment, excellent services and affordable prices. Zhongfu Tianhe Smart Elderly Care Service Demonstration Zone will be completed and put to use as scheduled. The eco-city planned to establish and standardise its elderly care service standard and operation model to foster and strengthen the "silver economy".

Carrying out nationwide fitness campaigns: Nationwide fitness campaigns were carried out in cooperation with neighbourhood administrations and culture and sports departments. Working with the Education and Sports Commission of the Binhai New Area, the eco-city provided its six neighbourhoods with more than 500,000 RMB of fitness facilities. In response to the National Games, it organised the activity "Celebrating the National Games, Walking To Better Health". It carried out nationwide fitness campaigns extensively, and strengthened cooperation with Singapore in the central area to build a world-class, open-style stadium. The eco-city will become a model for a healthy city with the construction of two to three new neighbourhood sports parks. With the opportunity presented by the eco-city's 10th anniversary, it successfully held the Sino-Singapore Tianjin Eco-city Marathon 2018, "Eco Run", and co-organised the 2018 China Model Airplane Open (Tianjin).

5. Community Management and Service System

Borrowing from the experience of Singapore's People's Association, the General Blueprint for Communities of TEC was prepared with the community development vision, three-year action plan and annual implementation themes and projects. With the aid of Singapore's Ministry of National Development, the Social Affairs Bureau of the eco-city organised several visits of local resident delegations to Singapore for community exchanges, with the achievements and insights gleaned from these exchanges compiled and published for mutual sharing. Under the General Blueprint, the eco-city planned a three-level service system for the convenience and benefit of the people. In 2016, the community centre-based new model of community governance and services won the Fifth Administrative Management Innovation Award of Tianjin Municipality.

Practise and improve community centre services. The eco-community is a key level in the three-tier living model and corresponds to the community centres, which are the main providers of community services. Its geographical scope and population scale are different from traditional community committees or sub-district offices. It embodies the concepts of environmental protection, low-carbon living and "one-stop" convenient service which have been promoted since the establishment of the eco-city. By the end of 2017,

the eco-city had developed three community centres (Figure 12-10, Figure 12-11 and Figure 12-12). First, these community service centres were characterised by unified planning, controlled land occupation and advanced development based on the influx of population. Second, the service radius was estimated based on the upper limit of people's travel times and the space was planned according to the size of the population served. Third, these community centres were oriented as integrated community commercial centres based on the concept of "big community and big group", which was different from the "street-business" model of traditional communities. Fourth, these community centres were given 12 essential functions: bank, supermarket, post office, restaurant, laundry, barber shop, drug store, stationer, maintenance shop, community activity centre, vegetable market and basic-level health centre. Fifth, commercial and public-benefiting services were dynamically combined in these community centres. Finally, standardised and brand-oriented development and operation mechanisms were applied. Professional companies were engaged in uniform development and construction as well as in market-based operation and management of non-public facilities, with the establishment of unified identification, management and information systems.

Figure 12-11: Second Community Centre of China-Singapore Tianjin Eco-City

Figure 12-10: First Community Centre of China-Singapore Tianjin Eco-City

Figure 12-12: Third Community Centre of China-Singapore Tianjin Eco-City

Proactively promote community-level joint governance, construction and sharing. The overall plan for "innovative social governance" was fully implemented. The plan had been advocated since the 19th National Congress of the Communist Party of China to establish a community governance system featuring joint governance, construction and sharing in three aspects. First, functional units of the TEC Administrative Committee regularly set up on-the-spot offices at community centres to accept and handle administrative affairs, and an "electronic resident affairs centre" was set up to handle routine affairs online. Second, efforts were made to improve the social welfare and security systems, with livelihood assurance efforts proceeding in an all-round manner from poverty relief to minimum lifestyle security, favourable treatments and pensions, welfare for the disabled and the elderly, etc. Third, the "government-community interaction" mechanism was an innovation, with a long-term mechanism established for "face-to-face" communication between the Administrative Committee and residents. Three feedback channels for local residents were set up — a neighbourhood committee, resident liaison office and the online "popular sentiment system" — to solve issues in three ways: mediation between the people, administrative execution and legal proceedings (Figure 12-13).

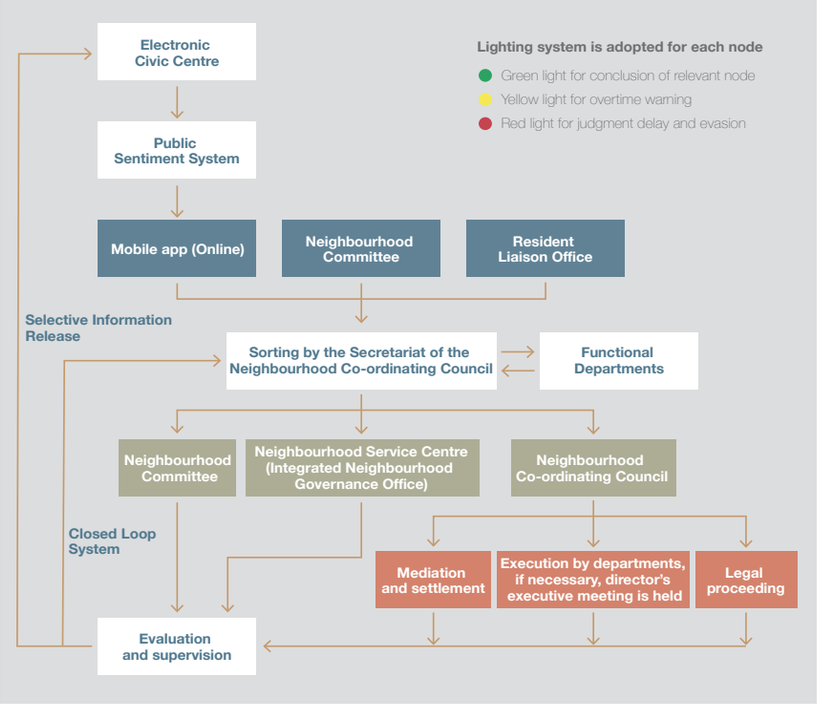


Figure 12-13: System for community dispute mediation on the principles of prevention, mediation and assurance

The purpose was to enable basic-level self-governance units to mediate minor problems as well as highlight the role of the Administrative Committee in coordinating resources and implementing collaborative management.

Vigorously cultivate innovative development of social organisations. The eco-city was unremittingly innovative with community services and patterns of community activities to create a distinctive brand of community services. Certain social services were undertaken by the society with the support of the government, while social organisations were encouraged to exhibit their professionalism and innovation. A community service pattern featuring "one organisation, one feature, one project and one brand" was envisaged by cultivating community leaders and coordinating resources from the government and communities. The eco-city successively set up 97 social organisations in two categories: those subject to official registration and those subject to community registration, including the Huisheng Social Worker Community, Green Home Ecological Culture Association, Volunteer Association, Lehuohui Association, Sound of Land Social Education Centre, 3S Club, Zhongfu Leling Service Community, Gaojiabaozi Cymbal Performance Group, Yufeng Aviation Club and various community activity teams. These social organisations energised community development. Zhongfu Leling Service Community was the first community elderly nursing service organisation in Binhai New Area. It offered services such as community sports, psychological condolence, living aid and other one-stop elderly care services. Public welfare investments led by social organisations were carried out with the theme of "converging the energy and going further". These focused on professional social services, services for women and child care, aid for the elderly and vulnerable groups, social organisation services and the promotion of urban healthcare services. These activities continued to attract professional social work teams to take part in social development.

Continuously enhancing the construction of spiritual civilisation at the community level. The eco-city has always placed a strong emphasis on the development of spiritual civilisation and the building of a civilised urban area. Priority was given to the cultivation of professional social workers, social organisations and community leaders, who were given the roles of explorers and practitioners in organising different community activities, inspiring local residents to improve themselves and ignite their passion for life, and promoting the concepts of a green lifestyle and harmonious living among the people. The Women's Home, Home of the Youths and Off-Campus Psychological Guidance Centre for Juveniles were established at community service centres. Efforts were made to create "civilised apartments" within the 208 community

building blocks, with the aim of ensuring "a special theme for each block". Among them, six communities were assessed as “Communities of Peace, Beauty and Environmental-Friendliness” by the governments of Binhai New Area and Tianjin Municipality. The TEC Volunteer Association led local residents to actively participate in community development. Several public welfare services were established, including the “Neighbourhood Garden”, “Love for TEC”, “Health Power Station” and “Mental Care for the Elderly”. Social resources were brought together to inject fun into daily life and create a neighbourhood where residents help themselves and one another. Events such as “Community Festival”, "Neighbours' Day", resident classes, "Volunteers in Action", "Relay for Love", lifestyle markets and civilised household competitions were held regularly to encourage residents to take part in community development. These cultural activities significantly improved the residents' sense of belonging, happiness and security. At the eco-city, traditional Chinese values were promoted while unethical and dishonest acts were criticised to create an integrity and credibility system for the residents with the aim of nurturing common values.

“Garbage dump” transformed into a “Neighbourhood Garden”

1. Project background

The northeastern corner of Kunyuyuan Housing Estate in the eco-city was once used as a landfill. There was little greenery in the area and the unhygienic conditions were worrying. Unauthorised cultivation was also rampant, making this area a “scar” to the community. Through discussions among members of the Owners' Committee and with the approval of the owners' assembly, a charity garden was proposed for the purpose of improving the community environment and creating a sharing platform for residents who like to grow vegetables. The “Neighbourhood Garden” project came at a time when the eco-city had just started its efforts on the development of community service brand projects.

2. Project implementation

(1) Meetings, promotion and mobilisation: The Owners' Committee of Kunyuyuan Housing Estate organised several meetings between the representatives of owners and property management personnel to discuss how to refit the existing “garbage dump” into a garden. Publicity activities were carried out to obtain the understanding and cooperation of the residents. In the end, after several site meetings, coupled with the vigorous support of the Social Affairs Bureau, Community Party Branch, Neighbourhood Committee, property management companies and residents, this landfill took on a new look.

(2) Hardware implementation and team creation: On the basis of rational planning and careful selection, the garden's hardware facilities were completed at the end of August 2016. To guarantee the project's success and promote the concepts of self-management, self-supervision and self-service, the “Service Team for Voluntary Supervision and Management of Greening” was formed with over 30 members.

(3) Garden bearing fruits: Members of the “Neighbourhood Garden” spread soil on the site and grew vegetables such as spinach, coriander, garlic, pak choi, rapeseed, pepper, lettuce, crown daisy, etc. Before winter, project members purchased their own cold-proof plastic film for the thermal insulation of the vegetables, and grew some cold-proof vegetables. Before the winter of 2017, members again purchased seeds, small plastic pots and compound fertilisers on their own and performed soil replacement and fertilisation in the garden. This started another cycle of hard work. Some zealous residents purchased more species such as apple trees, jujube trees and grape seedlings to enrich the garden in anticipation of the view of the grapevine during summer.

3. Project performance

(1) Community environment improvement and satisfaction of residents' needs: The former landfill was a serious eyesore for the community and caused widespread dissatisfaction among the owners. This “chronic disease” was ultimately treated through multi-party cooperation. The landfill has transformed into a "Neighbourhood Garden" and became the highlight of the community. There are more smiles on the faces of the property owners as the environment has improved. The residents' pursuit of a beautiful living environment was realised to a large extent.

(2) **Improving neighbourly relations and community bonds:** At the moment, there are over 30 people taking part in the growing of vegetables in the garden. Most of them are retirees from different households, blocks and areas. Over time, strangers became friends. The "Neighbourhood Garden" started a conversation on plantation experiences and achievements. During festive celebrations, members of the project would invite other residents to share the fruits of their labour. These kind gestures not only improved the relationship between neighbours, but also enhanced community bonds.

(3) **Promoting a sense of ownership and higher level of self-governance by residents:** With the "Neighbourhood Garden" project, community residents changed a formerly undesirable environment into a functional one on their own. This elevated their sense of ownership. The continuous participation in community affairs further improved their awareness and participation in community development.

6. Housing security system

The eco-city borrowed from Singapore's Housing Board experience and economically affordable housing in other parts of China to develop secure housing (public housing) policies in advance. A total of 569 apartments across eight buildings were delivered as Phase 1 of the Public Housing Project in 2013 (Figure 12-14). All the apartments were furnished with furniture and household appliances and were in "move-in" condition. Phase 2 is expected to be delivered in October 2018. Two buildings will be constructed according to Germany's Passive Housing Standard. The energy conservation rate of residential buildings will be improved from the current 75% to 90%.

Figure 12-14: Phase 1 of the Public Housing Project in TEC

Public housing development. Public housing development was based on the concept of marketisation with professional companies engaged in housing development, construction, marketing and maintenance. The TEC Administrative Committee has set up special funds to support early-stage development and later-stage operation of public housing. Rapid withdrawal of public house sales allowed companies to create a virtuous circle of progressive development. Public houses featured many different specifications, including one-, two- and three-bedroom configurations, offering diversified choices for residents. Public houses were constructed based on the principles of high standards, diversity and environmental protection and conservation. Civil and renovation works were integrated together. Energy-saving and environmentally-protective technologies and equipment including solar energy, wall thermal insulation, garbage recycling, etc. were adopted and deployed to achieve a higher level of utilisation of reusable resources. Houses were built strictly according to the delivery standards for furnished houses to reduce construction costs and prevent secondary pollution to the environment.

Purchasing public housing. The eco-city established a special government department to manage public housing affairs. The department issued several policies including the Interim Procedures for Managing Public Housing in China-Singapore Tianjin Eco-City, Guidance for Public Housing Purchase Services, etc. Property prices took into account construction costs, prices of commodity housing at the same location and affordability of target customers, while rents were

determined based on market trend, costs and other relevant factors. To purchase public housing, a joint application must be submitted by a local enterprise and its employee. The public housing administration will strictly review purchase qualifications and publish the review results. Approval for purchase will be granted if no objections are raised after the results are announced. Public houses are traded in a closed-loop manner. Transfer is prohibited if the house has been purchased for less than five years. After the five-year period, the house can only be transferred to a qualified applicant or a specific organisation responsible for the buy-back of public houses. The price of transfer will be decided by the parties involved. Public houses are subject to full online management. The information of each segment from the purchase application to transaction is available for viewing and supervision by the residents. The eco-city designated some public housing for teachers, doctors and blue-collar workers to expand the scope of secure housing.

7. Development of green ideology and culture

The eco-city proactively promoted the development of a green culture in all areas. Green and healthy lifestyles and consumption habits were advocated and bases for green culture education and practices were established to gradually develop a characteristic ecological culture. Great efforts were made to build an economical government. TEC Administrative Committee was given the title of "Pioneer of National-level Economical Public Institutions".

Nurture new residents: As a newly-developed urban zone, the eco-city adhered to a green and ecological orientation and took the nurturing of ideologies in students as the starting point with the implementation of the "Starting with Children" project which aims to nurture new residents. Schools were directed to develop campus courses with the characteristics of the eco-city and devote their efforts to the cultivation of talents with international environmental protection visions and advanced cultural concepts. In January 2017, the development of the ecological education campus course was initiated. Currently, there have been 199 teaching schemes developed and over 10 quality courses. The project has entered into the phase of implementation. In 2016, the eco-city became the first "Social Practice Base for Environmental Education in Middle Schools and Primary Schools of China" in Binhai New Area. One school was nominated as "International Green Flag School" and one kindergarten was nominated as "Tianjin Municipal Environmentally-friendly Kindergarten".

Advocating a green lifestyle: The eco-city has actively introduced policies towards conservation of resources and environmental protection to promote a green lifestyle and actions. Management rules on garbage sorting, policies encouraging green consumption, a parking charging system as well as gradient charging systems for water, power and gas supplies were introduced. The establishment of fiscal and taxation systems to support the development of charity-oriented and public-benefiting organisations was explored. "The Guidance on Travel on Public Traffic" as well as the "Citizen Handbook and Guidance for Green Actions of the Residents" were prepared to encourage low-carbon travel. About 8,000 to 10,000 people get around the city on foot or bicycles. Environmental protection education was continuously carried out to create a universal environmental protection atmosphere. Environmental protection advertisements were delivered at high frequencies, together with the distribution of environmental protection pamphlets and the organisation of green culture-related activities. Positive actions were reported to eliminate occasions of waste. Many publicity events were held, including "Water Conservation Week – Building a Sponge City and Promoting Eco-civilisation" to "Environmental Protection Week – Practising Green Lifestyle and Sharing Clean Water and Blue Sky", "Where to dispose of the garbage?" — A garbage sorting and promotion event, and "Eco-Camp" China-Singapore Environmental Protection Forum. These events led to the creation of three water-conservation enterprises and four water-conservation communities, and attracted the participation of many enterprises and individuals. These activities increased awareness of environmental protection among employees and residents.

Building a financially prudent government: The development of a financially prudent government has remained a major objective for the eco-city. An energy management platform was established to provide timely information about the energy consumption of office buildings and public facilities. Results were regularly published and examined. Contractual energy management was first implemented at public security buildings. Controls were strengthened for key energy consumption points such as air-conditioning systems, lighting boxes of hall backgrounds, night lighting systems, etc. Light sensing systems were adopted in offices and public spaces to reduce power consumption. Informatised office automation systems were widely promoted to realise paperless offices, resulting in office paper consumption savings of 85% and use of recycled paper of over 90%. Controls on daily water consumption were strengthened. All public facilities were installed with water-conservation devices to effectively control water use.

Conclusions:The development of the eco-city was based on a higher level of public services to improve the city's attractiveness. The resolution and elimination of concerns of the people as they moved into the city ensured the eco-city's vitality and prosperity. A reasonable layout allowed local residents to enjoy basic living services in the most convenient manner. Strong financial power allowed high-quality facilities and services. The eco-city has shown, through practice, that high-quality input of public services can significantly enhance urban operations and contributions. Hence, there is merit in providing financial support for public services and creating a positive development cycle. A newly developed city lacking appropriate planning and development mechanism can easily fall into a vicious circle of low-level public services and low-output urban development. It is essential to adhere to the strategy of “public service-driven development” and to ensure “service capability remains ahead of needs” instead of making “needs wait for services”.

After a long period of development, a newly built city may be faced with imbalances in the growth of moving-in populations, population structure, moving-in communities as well as the needs for public services. These bring great challenges for public services and require the local government to invest efforts in overall planning, demand variation forecast, advanced construction, etc., to ensure the shoulder-to-shoulder development of basic public services such as education, health and sports, and marketised services such as business, recreation and entertainment. In this way, the city can stay on track with virtuous, positive and stable development.

In the era of information, the education level of the residents has increased. Those who are familiar with information technologies have higher expectations for public services. The pursuit of a better life will be reflected in a concentrated manner in a newly developed city. It is necessary to encourage the public to take part in social development and community governance. Needs should be understood and responded to rapidly. In addition, the city must remain open, transparent, standardised and regulated to prevent the administrative challenges of unbalanced allocation of public services resources.

Chapter 13

Green Economy

Summary

This chapter describes the efforts and phased outcomes of the eco-city in developing a green economy.

The eco-city tried seizing developmental opportunities by identifying the most suitable key industries. It then worked out the development plans for key industries such as culture and new-generation information technology, and accelerated the creation of a development trend in which the key industries were clustered through policy and environmental support.

Five industrial parks including National Animation Industry Park, National Movie & Industry Park, Science Park, Information Industry Park, and Eco-industry Park were built in succession as carriers for specialised industrial development.

Focusing on the modern services industries, the eco-city strived to foster key sectors such as culture and new-generation information technology. Using a market-oriented model, it moderately advanced the construction of specialised industrial parks and strengthened the development plans for key industries to take the first step towards building a city that is supported by a green economy.

1. Evolution of Industrial Orientation

From the start, the eco-city has constantly tried to identify the appropriate key industries and determine the industrial orientation at each phase of the project in order to find a way to integrate industrial development and project implementation.

A competitive economy is a basic goal of a liveable city. Singapore formally raised the issue of the eco-city's economic activities during the business negotiations with Tianjin city. Singapore proposed that "to strengthen the eco-city's image, it must to develop suitable high-end economic industries, such as financial centres. What's the vision of the Tianjin Municipal People's Government in this regard, and when will it be implemented?" China responded by saying that: "the eco-city project should focus on developing tertiary industry, including five major industries, i.e., cultural and creative industries, service outsourcing industry, eco-environmental protection industry, education and training industry, as well as related service industries such as trading, tourism, exhibitions, finance, and headquarters. The idea of building a financial centre in the eco-city should be studied further. What is for sure is that a financial service industry can be developed in the eco-city." This was the first formal discussion between the two sides on the eco-city's economic development.

It was made clear in the master plan that the eco-city's economic function was to vigorously develop leading industries such as culture and creativity, energy conservation and environmental protection, information technology, services outsourcing, special finance, education and training, green building, MICE (meetings, incentive, convention and exhibitions), sports and recreation, and modern logistics. The eco-city should be an international centre for exchange and exhibition of eco-environmental protection concepts and technologies, where eco-environmental protection technology laboratories and engineering technology centres gather in China. In addition, the eco-city should be an education, training and industrialisation base for advanced, applicable technologies such as eco-environmental protection, and an international eco-cultural tourism, leisure and recreational area.

Since its founding in 2008, the eco-city has upheld the concept of a green economy. By combining the local situation with the orientation

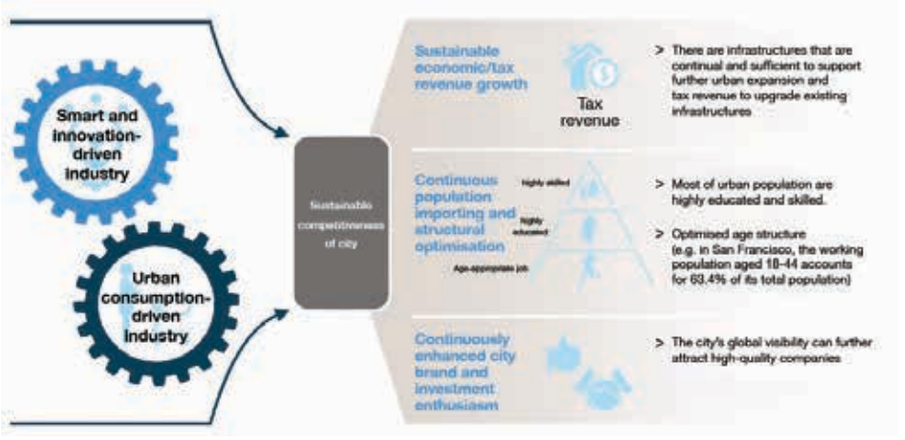


Figure 13-1: Schematic Diagram of the Eco-city's Industrial Development Goal

of industrial development and trends in China and foreign countries, the eco-city performed industrial integration and dislocation with surrounding areas and rationally decided on the industrial development orientation. It chose industries in areas such as culture and creativity, Internet and innovative finance, and introduced a number of well-known enterprises.

Since 2014, the incorporation of the Tourist Area and Fishing Port Area has enabled the development carriers, industrial resources and supporting facilities of the eco-city to expand and be further improved. The eco-city's industrial orientation was also reviewed and refined based on changes to the environment and situation. In 2015, the eco-city tasked Roland Berger, a well-known industry consulting firm, to carry out a new round of industrial planning. The planning was centred on core industries that support the development of the world's eco-cities, and focused on two categories- being smart-driven and consumer-driven. Priority is given to the development of smart and innovative industries driven by technology and urban consumer industries with the ability of attracting population growth. As a result, five key industries including culture and creativity, Internet and high-tech, talent, cold-chain logistics, and coastal tourism were identified (Figure 13-1).

In 2018, the Report on the Work of the People's Government of Binhai New Area made it clear that the eco-city should focus on developing "three major economies". First, a good momentum should be built to cultivate intelligent industries, and accelerate the implementation of industry-leading projects to create a cluster that will drive the development of big data, cloud services, smart facilities and other industries. Second, the cultural industry should be consolidated and upgraded to seize the opportunities of coordinated development provided by the Beijing-Tianjin-Hebei region and ensure the transfer of high-quality resources from the capital in four areas including film, television and animation, book publishing, advertising media, and variety and music. Third, the development of a tourism industry should be accelerated to enrich tourist products and routes with the opportunity of creating a global tourism demonstration zone and building China's first three-level tourist service system.

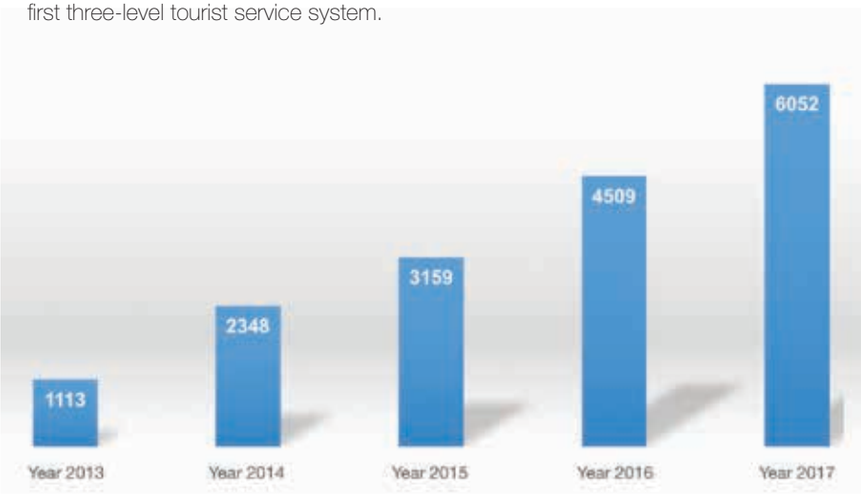


Figure 13-2: Schematic Diagram of the Number of Business Registrations in the Eco-city in the Past Five Years

2. Development History and Outcomes

In accordance with the industrial development orientation and with the commitment to the development path of green and low-carbon industries, the eco-city gradually created the foundation for the cultural and creative, Internet and high-tech, tourism, healthcare service and other modern service industries. By the end of May 2018, the eco-city had more than 6,800 registered enterprises with a registered capital of over 240 billion RMB.

2.1 Cultural and Creative Industries

The cultural and creative industries served as an industry pillar for the eco-city. By the end of May 2018, there were more than 1,200 registered enterprises in this area. Currently, a cluster of three main industries – film, television and animation, and book publishing and

advertising media – has been formed. Among these, Thinkingdom Media was listed in the A-share market of Shanghai Stock Exchange in April 2018. It was the first main board-listed private book enterprise in China and the first Tianjin cultural enterprise to hit the main-board market.

In the development of the film, TV and animation industries, six of the top 10 listed companies in China have invested in the eco-city, including H. Brothers, Bona Film, Enlight Media, and Huace Group. In 2016, the public technology service platform of National Animation Industry Park produced Chinese Animation Culture, the first feature film in China to showcase the development of Chinese animation in an all-round way. The "NEW CHARM Nezha Dolls" designed by the HIVE design platform of National Animation Industry Park were exhibited at the 2016 Davos World Economic Forum in Tianjin. The beta version of Guangying Music, China's first music connect business platform focusing on music trading and music community, was released in the eco-city.

In the development of the book publishing industry, the eco-city was home to many leading private publication and distribution enterprises such as Thinkingdom Media, CS-Booky, Readers, Xiron, and China Literature. In 2015, the TEC Copyright Exchange was founded. It boasted five functions: copyright registration, copyright operation, finance support, business development, and copyright maintenance. At present, more than 10,000 new media copyright resources have been collected. In 2016, the initiative helped enterprises in the area to register more than 300 copyrights.

In the development of the advertising media industry, the eco-city brought together leading Chinese and foreign enterprises such as CTV Golden Bridge, Charm Communication, Blue Focus, Shunfeng Communications, Century Media, and Inly Media. It also boasted diversified advertising formats, including general advertising, movie, TV product placement, Internet advertising and outdoor advertising.

2.2 New-Generation Information Technology Industry

By the end of June 2018, more than 1,600 IT companies were registered in the eco-city, including Internet pioneers such as Meituan, DiDi, Ourpalm, Hero Entertainment, Momo Technology, Dr.Peng, Storm, Renrenche, and Longtu Game.We-Media's incubation base, the first in China to cover the entire industry chain, was founded in the eco-city as well. Among these, Momo Technology paid about 500 million RMB in taxes in 2017 and had a turnover of over 7 billion RMB, making it one of the leading Internet enterprises in Tianjin.

In 2016, the big data industry of the eco-city began to take off. The area saw the gathering of Hylanda, Datatang, DHC, Tencent and other companies in the fields of data-mining and analysis, data storage, database R&D and application, and more than 10 cooperative projects, including Hylanda Incubator, Big Data Talent Training and Certification, Big Data Trading Platform and Big Data Industry Fund, with an estimated output value of up to 10 billion RMB.

The eco-city was also one of the first to venture into the e-sports industry. It built top e-sports venues and introduced a number of well-known Chinese and foreign e-sports competitions to promote the development of the e-sports industry. Moreover, an e-sports complex was built in the National Animation Industry Park to create an online game, e-sports and online celebrity ecosystem, and form a complete industry chain covering game R&D, events operations, e-sports club, events livestream and derivatives development.

2.3 Tourism Industry

The eco-city has unique coastal resources, and the tourism industry became its specialty industry. There were 25 finished, unfinished and new operational tourist projects, forming a regional tourism chain led by Tianjin Binhai Aircraft Carrier Theme Park (Figure 13-3) and Tianjin Fantawild Adventure (Figure 13-4), and supported by Tianjin Aqua Magic (Figure 13-5) and Binhai Liyumen (Figure 13-6). In early 2016, the eco-city was included in the list of the first batch of "National Global Tourism Demonstration Zones" announced by the China National Tourism Administration. In 2017, the scenic spots in the area welcomed more than four million visitors. In 2018, the first TEC International Tourism Festival was successfully held, and the National Maritime Museum, Macau Cultural Park, and Yi'ou Park will open for trial operation

TEC National Animation Industry Park attracted more than 2,800 registered enterprises

As a cultural industry park co-constructed by the Ministry of Culture and Tourism of China and Tianjin Municipal People's Government, the TEC National Animation Industry Park has been actively cultivating and supporting the production of original animation, television and film products to achieve both social and economic benefits. By the end of 2017, there were more than 2,800 registered enterprises in the National Animation Industry Park.

During the summer holidays of 2017, Da Hu Fa, an animated film co-produced by Nice Boat Animation and Enlight Media was released to the acclaim of the industry and fans. This film featured a traditional Chinese ink painting style and was completely original. It emerged as a top animated film produced in China with a score of 8.5 according to authoritative agencies. This film with a unique style not only earned 87 million RMB, but was also nominated for Best Animated Feature Film at the 54th Golden Horse Awards in China.

There are many more similar enterprises that are devoted to original animation and film-making in the National Animation Industry Park. Large film and television companies such as H. Brothers, Enlight Media, Bona Film, YOHO, and Tangren Media also registered businesses at the park. Many popular animation, film and TV series were made at the National Animation Industry Park. Data showed that the public technology service platform of National Animation Industry Park alone has serviced more than 400 works, including last year's hits such as The Mystic Nine, Ice Fantasy, Noble Aspirations, The Legend of Qin, as well as the animated films Throne of Elves, Bobby the Hedgehog, etc.

The National Animation Industry Park provided corresponding support and assistance for enterprises at different stages. In addition to providing free office space, it also supplied equipment such as graphics tablets and workstations in the early stages to support start-ups. It also offered many industrial services to mature enterprises to help them quickly build their business, such as helping to acquire the Permit to Produce and Distribute Radio and Television Programmes or the Permit for Movie Production (for one film only). In addition, the park also helped with the registration of Internet broadcasting platforms such as iQIYI, LeEco, and Ku6.com. Besides, the National Animation Industry Park also attracted many game companies such as Skymoons, CMGE, Longtu Game, and Hero Entertainment. It served as a bridge between film and television enterprises and game companies to facilitate mutually beneficial and win-win outcomes.

TEC E-sports Centre to Come into Service in June

Nowadays, e-sports, which integrate technology, sports, entertainment and social media, and goes beyond gaming, has taken the world by storm. The International Olympic Committee has officially listed e-sports as a sport and has begun to include it in the Olympic Games. "E-sports" integrates entertainment, games, live streaming and many other fields. It has formed a mutually beneficial and win-win relationship with many industries and is of great economic and cultural value.

Some experts analysed that the huge development potential of e-sports made it another hotspot for investment, and the next five years will be the "golden five years" of the Chinese e-sports market.

At present, the eco-city has attracted many game enterprises such as Hero Entertainment, Ourgame, Ourpalm, and Longtu Game, laying a solid foundation for developing the e-sports industry.

To make use of its own industrial advantages and seize the industrial development opportunities, the eco-city has already entered into partnerships with the well-known e-sports enterprise alliance in China. They are working together to build a professional e-sports venue with nearly 10,000 m^2 in space. The E-sports Centre is scheduled to be completed and come into service in June 2018. It will be the top e-sports venue in North China and will introduce at least 20 high-level tournaments each year. By introducing tournaments, the upstream and downstream industrial resources such as teams, agency companies, and live streaming platforms will settle at the eco-city and the e-sports industry chain will gradually improved.

subsequently. The "Smart Eco-tourism" app and tourism big data platform that integrated food, lodging, transportation, travel, shopping and entertainment was successfully developed and marketed. Currently, the eco-city is speeding up the construction of a multifunctional tourist distribution centre, and preparing for the tourist train transportation system to connect tourists to scenic spots and connect scenic spots to the government, so as to provide tourists with quality services.

Figure 13-3: Tianjin Binhai Aircraft Carrier Theme Park

Figure 13-4: Tianjin Fantawild Adventure

Figure 13-5: Tianjin Aqua Magic

Figure 13-6: Binhai Liyumen

2.4 Other Modern Service Industries

For the financial industry, by the end of June 2018, there were more than 600 registered businesses in the eco-city, with a registered capital of nearly 100 billion RMB. Investment-oriented financial enterprises developed rapidly, gradually forming the development trend where "traditional funding serves as support, venture capital expands channels, and real finance gathers popularity". The eco-city saw the gathering of leading enterprises such as CDH Investments, Orient Capital,

Tsinghua Holdings, Boyu Capital, SSCM, Primavera Capital, Lions Capital, PICC Capital, CITIC Capital, NOAH, Wanda, ZhenFund, CCB International Culture, BlueRun Ventures and Redpoint Ventures.

As for the health services sector, the bio-pharmaceutical industry became another key industry in the eco-city, bringing together a number of excellent Chinese and foreign biopharmaceutical companies such as Dynamiker Biotechnology (Tianjin) Co., Ltd., Jecho Biopharmaceuticals Co., Ltd., Nanopep Biotech Corporation and Xinuo Biomedical Co., Ltd. In the meantime, for the integrated development of the healthcare industry, a number of high-quality projects such as Binhai Women's and Children's Hospital, Sino-Fortune & Tianhe Smart Senior Community, Renhe Tiancheng Hospital were founded in the eco-city. Moreover, a world-class medical rehabilitation centre will be introduced to further attract high-quality medical resources in order to build a healthy eco-city, where the bioscience and healthcare industries can complement each other and develop in an integrated manner.

3. Construction of Industrial Parks

Under the principle of appropriate advancement and professional service, the eco-city planned and built five industrial parks including the National Animation Industry Park, National Movie & Industry Park, Science Park, Information Industry Park, and Eco-industry Park. These serve as an agglomeration for new-pattern industries and a growth engine for the eco-city. After nearly 10 years of cultivation, each park possesses a certain level of industry and endogenous development capability, gathering a number of listed leading enterprises that meet the development demands of a green industry.

National Animation Industry Park

The National Animation Industry Park covers an area of 1 km^2 and a building area of 770,000 m^2. It is a major cooperative project between the Ministry of Culture and Tourism of the PRC and Tianjin Municipal People's Government and also the first national comprehensive demonstration park for the animation industry. It was provided with an advanced public technology service platform (Figure 13-7) and achieved the connection with supercomputer "Tianhe-I". It also has the world's largest and fastest animation rendering cluster that provides technical and equipment support for enterprises inside and outside the park. More than 800 well-known cultural enterprises such as H. Brothers, Bona Film, Enlight Media, Yellow Mountain Studios, U Young, Vasoon Animation, Mr. Cartoon, Cloudary, Xiron, Thinkingdom Media, and Readers have successively settled in the National Animation Industry Park.

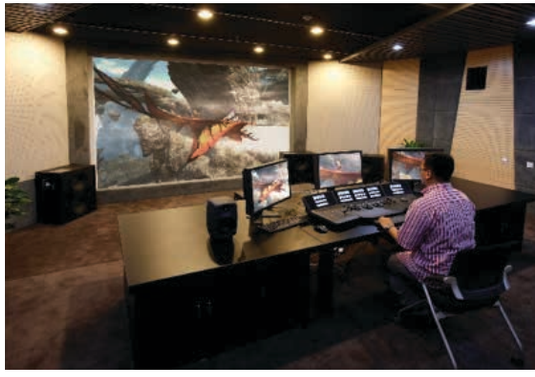


Figure 13-7: Comprehensive Demonstration Public Technology Service Platform of National Animation Industry Park

Four core sectors were formed – film, television and animation, book publishing, and Internet and advertising media – and their advantages in terms of industrial cluster were very prominent.

National Movie & Industry Park

The National Movie & Industry Park was co-constructed by the National Radio and Television Administration and Tianjin city. It covers an area of 1 km^2 and aims to be China's first 3D films and television industry base with independent intellectual property rights, international influence and competitiveness. It integrates film and TV creativity, film and TV production, film and TV technology R&D, film and TV product trading, film and TV derivatives production, and high-tech 3D film and TV experience. Tianjin Fantawild Adventure, the first fourth-generation high-tech theme park in the Beijing-Tianjin-Hebei region invested in by Shenzhen Huaqiang Holdings Limited, was officially opened. It came into service in July 2014 (Figure 13-8), attracting more than one million visitors every year to good economic and social benefits.

Science Park

The Science Park mainly attracts three industrial clusters including electronic information, bioscience, and green industry. It boasts a planning area of 0.27 km^2 and a building area of 400,000 m^2. Currently, many well-known enterprises such as the Institute for Electronics and Information Technology in Tianjin, Tsinghua University, State Grid (Tianjin) Integrated Energy Service, Momo Technology, Hylanda Incubator, Tianjin Housing Group Green Building Research Centre, Beike Taida Investment Development Co., Ltd. and Longtu Game have settled here (Figure 13-9).

Figure 13-8: Tianjin Fantawild Adventure

Figure 13-9: Science Park

Information Industry Park

Focusing on the intelligent industry, the Information Industry Park is committed to becoming an intelligent and humanised comprehensive development platform for the electronic information industry of the 21st century and a first-class information technology R&D, training, export and consulting service base in China (Figure 13-10). It boasts a planning area of 0.7 km^2 and a building area of 800,000 m^2. Currently, core carriers such as TEC Smart Centre (Figure 13-11) have been basically completed.

Eco-industry Park

The Eco-industry Park is located to the north of the eco-city and has a planning area of 1.5 km^2. It follows the Evaluation Standard for Green Building and applies eco-technologies such as using energy-conserving materials and solar energy technology. The park aims to be a production base in the environment industry. At present, it has attracted projects such as Nanopep Biomedicine, GTE-Global Environmental Protection Technology, and BBS Automation Base (See Figure 13-12).

4. Building Business Environment

A good business environment lays the foundation for sustainable development. According to the World Bank's Doing Business report, Singapore was one of the “Best Countries for Business” for 10 consecutive years from 2007 to 2016. Using Singapore as a benchmark, the eco-city proactively improved its business environment, reduced administrative barriers, and enhanced the transparency of government departments in an attempt to build an international, and market-oriented business environment operating within the Rule of Law.

Figure 13-10: Design Rendering of Information Industry Park

Figure 13-11:
TEC Smart Centre

Figure 13-12: Eco-industry Park

International Investment-attracting Platform

The eco-city took full advantage of the Sino-Singapore cooperation to fully integrate resources and build a unique comprehensive investment platform and supporting service system to promote industrial development. The ECAC, TECID and its subsidiaries, SSTECID, and International Enterprise Singapore participated in the process of attracting investment, seeking to integrate Singapore's international vision with the strengths of localised operations, thereby attracting investments from China and the world.

Singapore's Experience in Developing a Business Environment

1. Developing headquarters and centres

The Singapore government spared no effort in developing a headquarters sector, and offered targeted, preferential policies to attract multinational corporations to set up their headquarters in the country. In Singapore, multinational corporations can easily exchange, trade and build partnerships with each other, so more and more Asian corporations are choosing Singapore as a platform to enter the global market. Data shows that there are currently about 26,000 international corporations in Singapore, and one third of the "Fortune 500" corporations have set up their Asian headquarters in Singapore.

Known for its integrity, quality, reliability, law enforcement, efficiency and rigorous intellectual property laws and enforcement policies, Singapore is actively developing a knowledge-based economy and has made remarkable achievements in technology R&D. Singapore is the fourth largest international financial hub in the world after New York, London, and Hong Kong. Its foreign exchange turnover, cross-border loans and OTC (over-the-counter) derivative transactions ranked fourth, 10th and 13th in the world respectively.

2. Free trade and investment atmosphere

Registering a company: Singapore is basically a tariff-free country with the highest level of free-trade in the world. With a strategic geographical location and pro-business policy, it provides many convenient and preferential policies for enterprises and investors. The procedures for registering a company and overseas branch are quite simple in Singapore. You can register online by visiting the business file system (Bizfile) of the Accounting and Corporate Regulatory Authority (ACRA). Furthermore, Singapore has signed 42 Investment Guarantee Agreements (IGA) to help protect investments in other countries and regions made by companies registered in Singapore in order to reduce non-commercial risks.

Ideal commercial facilities: Whether it is located in the central area of the business district or in the surrounding area of the city, in a luxury office building or a flatted factory block, companies enjoy access to a full range of infrastructure in Singapore.

Staff recruitment: Singapore has significant advantages in human resources. It has not only cultivated a strong local talent recruitment team, but also vigorously attracts top talents from overseas. Singapore is committed to talent training and infrastructure construction to build a vibrant talent ecosystem. Candidates can learn about recruitment and training through the SME Portal website. Moreover, the Economic Development Board (EDB) has worked with a number of companies to provide job-seekers with diverse training programmes.

3. Preferential tax policy

Many have talked about Singapore's low tax rates, which attracted many foreign investors. It is also quite competitive among developed countries. Meanwhile, the Inland Revenue Authority of Singapore (IRAS) also actively monitors the implementation of its tax system.

Individual income tax: The amount of individual income tax payable varies with the taxpayer (resident taxpayer or non-resident taxpayer) and income level. Singapore implements a progressive tax rate system. In addition to the deduction and exemption, the individual income tax rate remains between 0% and 22%.

Corporate tax: All expenditure or profits invested in Singapore are subject to income tax unless they are specifically exempted under the Income Tax Act. These exemptions include dividends on shares, and trust funds and interest on fixed deposits. Both local businesses and foreign enterprises must pay taxes on income earned in Singapore and overseas income received in Singapore in accordance with law.

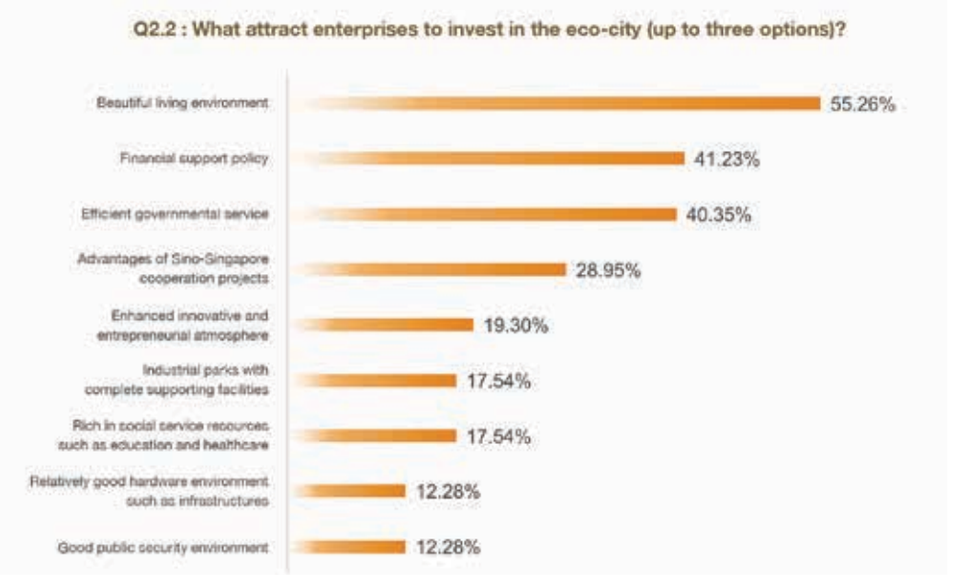


Figure 13-13: Investigation and Analysis of Main Factors Affecting the Attractiveness of Investment Environment in Eco-city

All-round Enterprise Services

The investment-attracting teams of the eco-city worked together to provide seamless services to potential investors by implementing the trinity of “administration”, “investment attraction” and “service”. Through the “project manager responsibility system” and “first inquirer accountability system”, every enterprise that approached the eco-city enjoyed the rights and privileges of a “taxpayer”. The city acts like a “nanny” to these enterprises by providing a comprehensive range of support and services. The city seeks to understand the specific needs of each enterprise so as to provide customised solution and fine-tune government support. The enterprises will be monitored so that timely assistances can be offered to help break any operational bottlenecks and one-stop services provided to improve their operating efficiency. At the same time, the eco-city also organise various trade and marketing activities. According to the Investment Climate Survey of the eco-city in 2016, the enterprises interviewed fully affirmed the investment climate and believed that the beautiful living environment, financial support policies and efficient government services were the three main factors that attract enterprises to invest in the eco-city (Figure 13-13).

Policy Support

Both China and Singapore have continuously established and improved industrial policy systems in terms of financial support, support guarantees and industrial environment. Singapore introduced measures such as the Tianjin Eco-city Assistance Programme (TAP) to encourage Singaporean companies to set up branches in the eco-city and support the training of Chinese domestic talents for their employment in the eco-city. The State Administration of Foreign Exchange designated the eco-city as a pilot area of "willingness exchange settlement system under capital account". The Ministry of Culture and Tourism of China and Tianjin city worked together to build the "National Animation Industry Park". The "National Movie & Industry Park" by the National Radio and Television Administration settled in the eco-city. The ECAC has also established and continuously improved the investment-attracting policies and systems, including formulating industrial development promotion measures and industrial promotion policies for animation, new energy and business and other industries. It provided preferential policies in terms of finance, office housing and human resources for financial, creative and service outsourcing industries, and gave policy support for the enterprises in terms of office buildings, transportation and public houses.

Global Cooperation

Efforts were made to seek comprehensive cooperation with internationally renowned institutions to promote industrial development. The eco-city entered into business partnerships with embassies and consulates of more than 10 countries including Singapore, the United States, France, Japan, Canada, Sweden, and Denmark, and actively participated in business activities and exchanges organised by embassies and consulates of other countries. It held several special promotion activities together with Singapore SME, Singapore Chinese Business Association, Japan Research Institute, and SME Support Japan, to further enhance the eco-city's international visibility. On this basis, it actively built relationships with internationally renowned eco-regions such as Freiburg in Germany, Abu Dhabi in the United Arab Emirates, Malmo in Sweden, and organised studies and exchanges with them in the fields of development, construction and industrial development.

Conclusion: Although the eco-city developed its economy from scratch, it adopted the "investment selection" model from the very start. It focused on developing low-energy, low-emission, sustainable knowledge-intensive or capital-intensive industries, and resolutely rejected high-energy, high-emission and polluting enterprises, and abandoned projects with low input-output ratio and land use efficiency. There is often a gap between government planning and industrial development. Fortunately, the cultural and new-generation information technology industry sectors that the eco-city chose to set foot in were in line with the general trend of industrial development. They have become the two industries with the greatest aggregation effect in the eco-city, avoiding the problem of developing a key industry that does not match its own capabilities and external opportunities. However, it is not easy to cultivate and form a well-known cluster of a key industry in short time, which may take 20 or 30 years. Priority should be given to the matching of short-, medium-, and long-term development goals. The eco-city will study industrial developments and the supporting needs of specific industries in depth, and make good short-, medium- and long-term development plans to stay on track. These plans will be reviewed regularly to ensure sustained investment and contributions. The eco-city will respect the development trends of the respective industries, especially from previous practical experience to avoid making a decision subjectively. It will focus on the cumulative benefits of investment to avoid having to frequently revise its plan due to the lack of apparent short-term gains, and make efforts in realising the "fist" effect of the industrial supporting environment, avoiding "hit-or-miss" industry investments.

Chapter 14

Technology Innovation

Summary

This chapter describes the efforts and outcomes of the eco-city in developing science and technology.

Science and technology constitute a primary productive force. The development of a new city requires a group of institutions and enterprises for R&D transfer and commercialisation. The consolidation of scientific research will ensure sustainable competitiveness.

To boost development through policies, carriers, cooperation and coordination, the eco-city introduced talent recruitment and technology innovation policies, set up industrial incubators, established a technology transfer and commercialisation platform together with universities and institutes, and founded angel and investment funds. These attracted a number of scientific research institutions and talents to the area.

By the end of 2017, the eco-city had brought in 10,577 technological talents, accounting for about 72% of total employment. There were 13 postdoctoral programmes, bringing in and training a total of 29 postdoctoral fellows. 15 enterprises were included in the list of the "1,000-enterprise &10,000-talent Programme" in Tianjin. The specialised incubators such as Thinkbig Incubator for Cultural and Creative Industry, TusStar Incubator, Beihang StarsUp Technology, Hylanda Full-Process Service Incubator were built in the area as well.

Innovation is the primary engine of development and the strategic support to the construction of a modern economy. In line with the orientation of "a platform for R&D, innovation, application and extension of eco-environmental technology, and a modern high-tech ecotype industry" endowed by the two governments, the eco-city actively supported the R&D and application of advanced practical technologies in the areas of environmental governance, green building and green energy. To develop the science and technology industry, the eco-city introduced a series of supporting policies, built a number of incubators, and set up a "government-industry-university-research-user" platform for technology transfer and commercialisation together with universities and institutes. By the end of 2017, there were 463 technology-based SMEs, 15 "Little Giant" technology enterprises, and 44 national high-tech enterprises.

1. Strengthening Support for Technology Innovation

China's President Xi Jinping stressed that "whoever has first-class innovative talents and first-class scientists can gain an advantage in the technology innovation" and that "we should firmly establish the strategic positioning of talents to guide development, take a full range of measures to attract talents, and strive to consolidate the talent foundation for innovative development". As a new city, it was imperative for the eco-city to attract talents on a large scale.

Promulgating talent introduction policy: Based on the needs of key industries and talents development, the eco-city formulated the *Interim Provisions of Sino-Singapore Tianjin Eco-city on the Introduction, Cultivation, and Reward of Talents, Opinions about Preferential Policy of Sino-Singapore Tianjin Eco-city on Introducing Urgently-needed Talents, Interim Measures of Sino-Singapore Tianjin Eco-city for the Administration of Postdoctoral Programme,* and *Interim Measures of Sino-Singapore Tianjin Eco-city for the Administration of Special Funds for Talent Development.* In addition, it introduced policies on housing subsidies, rent subsidies, household registration of talents, education for their children and employment for their spouses, and initially established a talent policy system based on "basic talent policy + professional talent policy". By the end of 2017, the eco-city introduced 10,577 technological talents, accounting for about 72% of the total employment.

Establishing a university-enterprise cooperation mechanism: Efforts were made to drive postdoctoral programmes to establish a university-enterprise cooperation platform with universities in order to intensify the inflow of talent. Dynamiker Biotechnology (Tianjin) Co., Ltd. set up an expert workstation and a postdoctoral programme. It worked with Nankai University to establish a "joint development base for talent training", which was awarded the "Practice Base for Foreign Students". By the end of 2017, there were 13 postdoctoral programmes in the eco-city, introducing and training a total of 29 postdoctoral fellows. 15 enterprises were included in the list of the "1,000-enterprises & 10,000-talent Programme" in Tianjin. 14 enterprises were included in the list of compliance enterprises in "introducing and cultivating high-end talents" during the transformation of 10,000 SMEs in Tianjin.

Introducing measures for technology support: *The Interim Measures of Sino-Singapore Tianjin Eco-city for the Promotion of Technology Innovation* was promulgated, and 19 policies were formulated to enhance the independent innovation capability and quality of enterprises, improve the planning and quality of technology-based enterprises, and create an innovative and entrepreneurial climate. These included incentive policies for technology-based SMEs, "Little Giant" technology enterprises, and high-tech enterprises; establishing a national fund for technology transfer and commercialisation; supporting enterprises and scientific research institutions to cooperate in building technology R&D platforms, key laboratories and engineering centres; implementing intellectual property awards; and intensifying the support for scientific and technology innovation activities.

Strengthening financial credit support: The eco-city offered financial support to "Little Giant" enterprises and potential "Little Giant" enterprises with growth opportunities for their R&D projects in science and technology, and funded key enterprises of the focus industries in the eco-city to assist in the planning of technological development and optimisation of the corporate governance structure so as to promote healthy development and facilitate the cultivation of core competitiveness. Inheriting the sub-fund of the National Fund for Technology Transfer and Commercialisation, the eco-city set up a national-level fund for technology transfer and commercialisation at a total scale of 285 million RMB. In accordance with the requirements of Binhai New Area, the eco-city pushed for the establishment of the Qingyan Venture Capital Fund for the Institute for Electronics and Information Technology in Tianjin, Tsinghua University, in Binhai New Area, with a total scale of 241 million RMB. Tianjin Eco-city State-owned Assets Management Co., Ltd. has shares in two industrial investment funds: "Tianjin Tianchuang Yingxin Venture Investment", a sub-fund of the National Fund for Technology Transfer and Commercialisation, focusing on the investment in enterprises in the national and regional project database for technology transfer and commercialisation; and "JAIC (Tianjin) Venture Capital", focusing on the investment in high-tech, high-growth SMEs in the areas of clean energy, energy conservation and environmental protection, healthcare and mobile Internet.

2. Fostering Featured Innovation Carriers

On the basis of the research on innovation carrier planning, the eco-city drew reference from successful experiences of technology innovation in mature areas of China and foreign countries to determine the development direction of the innovation carriers around key industries, and reserved development space to avoid homogeneous competition. The innovation carriers for industries including culture and creativity, Internet technology, hardware R&D, and big data were built.

Thinkbig Incubator for Cultural and Creative Industries: This incubator features an integration of culture and technology. It positions itself as a "national cultural and creative co-working space", and focuses on micro film, film, TV and animation, game, industrial design and intelligent hardware. With an investment of more than 80 million RMB in the public technology service platform for animation, film and TV, it has cultivated a number of excellent enterprises such as Nice Boat Animation, which produced works such as Da Hu Fa, a top-grossing Chinese animated film in 2017. The eco-city attracted more than 100 enterprises, and provided sub-incubation platforms such as a micro film industry base, animation creative space, U17 cartoonist village and a design and entrepreneurial accelerator (Figure 14-1).

Figure 14-1: Thinkbig Incubator for Cultural and Creative Industry

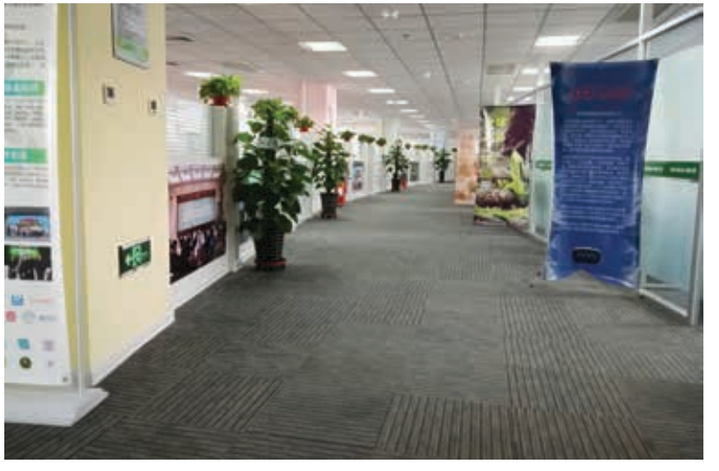


Figure 14-2: TusStar Incubator

TusStar: Leveraging Tsinghua University's strong scientific research ability and industrial resources, TusStar Incubator has rich operating experience and investment capability. It is a professional incubator brand that promotes independent innovation in China. Incubating enterprises can benefit from a four-in-one incubation model of "incubation service + entrepreneurship training + angel investment + open platform", and seven-step incubation chain resources from "Tsinghua Dream Class" to "Global Incubation Network". This helped promote independent innovation in the region. TusStar set up its direct investment fund and "micro-equity plan" fund for China in the eco-city, and has invested in a large number of projects with development potential. Among over 100 incubators, TusStar (Tianjin Eco-city) is second only to its Beijing headquarters in terms of achievements (Figure 14-2).

Figure 14-3: Beihang StarsUp Technology

Beihang StarsUp Technology: As a wholly-owned subsidiary of Beihang Investment Co., Ltd., Beihang StarsUp Technology, with high-quality space operation and equity investment as the main driving force, and with the advantage of Beihang University and Beihang Investment, built a service platform for industrial upgrading centred on the three aspects of industry events, scientific research cooperation and resource docking. It entered strategic partnerships with excellent overseas professional incubators from places such as the United States, Europe and Israel, to explore and introduce overseas high-tech projects and advanced technologies. This co-working space features hardware R&D such as new materials and flight control (Figure 14-3).

Hylanda Full-Process Service Incubator: Hylanda Technology Group, with a history of 20 years, is dedicated to open source big data analysis of the Internet using Chinese word segmentation as its core technology. Relying on its own core technology, it successfully incubated and invested in a number of big data companies and formed its own investment and incubation methodology. Through the whole industry chain model of "data + platform + industry application + talent cultivation + business incubation", Hylanda Big Data continues to expand innovative applications around data opening, data transaction, data application and vertical industry incubation. By opening and exchanging data and computing resources, it attracts data technology, talents and funds to the eco-city. It endeavours to build a big data industry ecosystem to facilitate the coordinated development of big data industry in the Beijing-Tianjin-Hebei region. Hylanda not only engages in vertical investment and incubation, but is also exploring a new model for its own development. In September 2016, this incubator received financing of 30 million RMB at a valuation of 300 million RMB. In 2017, the incubator doubled its valuation and received another round of financing of 30 million RMB (Figure 14-4).

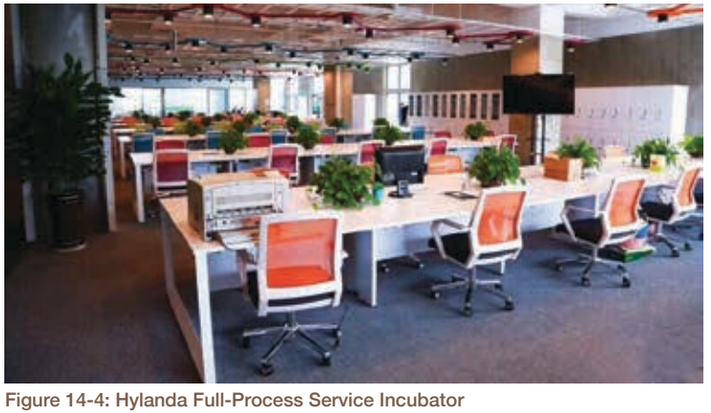


Figure 14-4: Hylanda Full-Process Service Incubator

3. Sino-Singapore Cooperation on Green Building Technology

To fulfil the requirements of 100% green building in the KPIs framework, the ECAC and the MND signed the Memorandum of Understanding between the Eco-city Administrative Committee and the Ministry of National Development on the Cooperative R&D Programme of Green Building-related Technologies (MOU) in 2013. Under this agreement, both sides would make annual investments to set up a special fund to support universities, R&D institutions, enterprises and public institutions of China and Singapore in carrying out R&D of green building technology and to apply research findings to the eco-city. The areas of green buildings and smart city were given top priority to attract new technologies and new achievements in eco-environmental protection and apply them to the eco-city, making the eco-city a practitioner and leader of eco-technology and promoting the eco-city's role as a demonstrative model.

By the end of 2017, the Sino-Singapore Cooperation Project on Green Building Technology had been launched in four phases, involving a number of universities and research institutes such as the National University of Singapore, Nanyang Technological University, China Architecture Design & Research Group, Tianjin University, Tianjin Chengjian University, Tianjin University Planning Institute, Tianjin Eco-city Green Building Research Institute, as well as R&D enterprises such as Surbana International Consultants Co., Ltd., Green Koncept, and Bluepath City Consulting. The technology R&D projects including urban microclimate and heat island effect research, energy station operating and dispatching system, water conservation of green building, green building indicator library, passive housing application demonstration, building integrated PV, green building fresh air system integration demonstration, intelligent environment-friendly urban management, Eco-pass, ecological planning, green building design, and sponge city were carried out.

The urban design guidelines to improve the impact of a microclimate became an important basis for urban planning. The energy system dispatching platform developed in the energy station project can be applied in an optimal dispatching platform that analyses the dynamic demand-supply relationship between energy and load. This helped in the monitoring and allocation of energy resources and optimising economic operation. The green building design optimisation system software offered guidance for early technology selection of projects applying for multi-system certification of Chinese national standards, the eco-city's local standards, and the Green Mark. The water conservation project made available key technologies such as water quality guarantee, water conservation, system optimisation, and management measures for green buildings of the eco-city, as well as many important technological achievements and related technical reports such as water-conserving and water consumption standards, incentive policy system for water conservation of green building, and the green building water-conserving technology review method in the phase of the construction design. Water-conserving design guidelines, technical guidelines for water quality, guarantee of green building water supply and implementation guidelines for sponge city construction were prepared.

4. "Government-industry-university-research-user" Technology Platform

The eco-city combined "government, industry, university, research and user" in the field of science and technology to integrate resources so as to make greater use of them. It worked with influential universities and research institutes to build technology platforms. The government provided policy support and material guarantees, enterprises provided funds and manufacturing technology, universities provided technology R&D teams, research institutes carried out technology transfer and commercialisation, and users put forward their needs. They give full play to their respective advantages to form a promotion mechanism for technology transfer and commercialisation. Under this concept, the eco-city introduced and supported the establishment of the Institute for Electronics and Information Technology in Tianjin, Tsinghua University and Beihang Intelligent Driving Institute in Tianjin.

Against the backdrop of the Chinese government's Beijing-Tianjin-Hebei integrated and coordinated development strategy, the People's Government of Binhai New Area worked with Tsinghua University to establish the Institute for Electronics and Information Technology (IEIT) in the eco-city in 2015. Supported by the Department of Electronic Engineering, Tsinghua University, the IEIT focuses on technology and product R&D, technology transfer and commercialisation, and high-tech business incubation in the field of electronic information. It plans to build processes and test platforms such as a comprehensive test on electronic information, comprehensive test on electromagnetic waves, optoelectronic integrated chip technology, and big data cloud computing. The institute aims to explore a sustainable and positively-cycled mechanism and operation model for high-tech technology transfer and commercialisation, attract high-level innovation and entrepreneurial talents, build an advanced experimental platform for electronics and information technology, and incubate high-tech technology with a social impact. This will help promote national technology innovation and industrial development in the field of

electronics and information technology. Since its establishment, the IEIT has made breakthroughs in technology transfer and commercialisation, platform construction and financial innovation. 16 enterprises were registered in various fields such as optoelectronic chips and artificial intelligence. A number of high-level experimental platforms such as an optoelectronic chip technology centre, integrated circuit test platform, and artificial intelligence cloud platform centre have been built and gradually operationalised in corporate forms. With the support of the People's Government of Binhai New Area, the Qingyan Fund was established with a scale of 241 million RMB. "HKS Education Fund Limited" has invested 50 million RMB to set up "Qing Innovation and Venture Fund", which specialises in the incubation of IEIT's technologies. The IEIT and Tsinghua Tongfang jointly launched a special fund of 125 million RMB to support the R&D of cutting-edge technologies. A fund group was gradually established to help technology transfer and commercialisation. In 2017, the IEIT was approved to set up postdoctoral programmes. In the same year, the IEIT and the eco-city co-founded "Sci-tech Park of the Institute for Electronics and Information Technology in Tianjin, Tsinghua University". With the commitment to the concept of building a new industrial city based on "industry-university-research-government", the Sci-tech Park positioned itself to establish a complete ecological chain from scientific research to technology transfer and commercialisation, to promote the industrialisation of electronics and information technology.

Beihang Intelligent Driving Institute in Tianjin is the only national association of China in intelligent technology, Chinese Association for Artificial Intelligence, CAAI (headed by China Association for Science and Technology). Relying on the professional technology and talent advantages of the Intelligent Driving Committee under the CAAI, School of Transportation Science and Engineering BUAA, Tianjin University, and China Automotive Technology and Research Centre, as well as the ECAC's resource advantages, the first comprehensive transportation intelligent driving institute was co-founded in China. The institute strives to be a technology innovation base, industrial service base, talent training base and business incubation base in the field of intelligent driving in China. It tests and verifies key technologies, promotes the construction of industry standardisation, speeds up the establishment of policies and regulations, engages in demonstration operations, and promotes public education. The institute is headed by experts from China's global experts recruitment programme. By combining institutes with platform companies, scientific research, technology transfer and commercialisation were carried out in the intelligent driving market. In the meantime, an industrial investment fund was established around the Intelligent Driving Institute to support new projects of intelligent driving technology.

These two institutes not only serve the two universities, but more importantly, they build a bridge between scientific research of universities and market demand and cultivate their own technology enterprises around electronic information and intelligent driving in the eco-city. By supporting them in the building of a series of experimental R&D and test platforms, the eco-city eventually became the "absorber" of the cutting-edge technology enterprises in these two fields, thus promoting the development of related industries.

Technology innovation activities were actively organised to create an atmosphere of technology innovation. The eco-city and China Mobile jointly launched a pilot project for a new generation of mobile communication technology (5G). It actively hosted a series of drone activities during the 2nd World Intelligence Congress, for instance, the World Intelligent Drone Industry Development Forum (Figure 14-5), World Intelligent Drone Exhibition (Figure 14-6), World Intelligence Drone Racing (Figure 14-7), and World Intelligent Drone Carnival (Figure 14-8). Moreover, it successfully held the China-US Young Maker Competition, which attracted 257 teams from all over the world (Figure 14-9).

Figure 14-5: World Intelligent Drone Industry Development Forum

Figure 14-6: World Intelligent Drone Exhibition

Figure 14-7: World Intelligence Drone Racing

Figure 14-8: World Intelligent Drone Carnival

Figure 14-9: China-US Young Maker Competition

The eco-city created the organisation model of "government-industry-university-research-user". Through joint contribution, Tianjin Eco-city State-owned Asset Management Co., Ltd. and related companies co-founded the research institutions such as Tianjin Eco-city Green Building Research Institute, Sino-Singapore Tianjin Eco-city Environment & Green Construction Testing Centre Co., Ltd., and China Eco-city Academy. With the help of the eco-city's construction theories and practices, the R&D of theory, technology and standards in green construction, energy conservation and environmental protection, and eco-city research have been carried out to form research findings that are practicable and scalable.

Conclusion: Developing a technology industry and cluster technology resources from scratch are the common challenges faced by new urban developments. The eco-city, driven by its own construction demands, worked with Singapore to set up support funds for R&D on green building technology, and formed a group of practicable green building technologies. To resolve the problem of environmental pollution control, it formed a complete set of technologies and schemes for polluted site treatment. To implement the requirements of the Chinese government for innovation and entrepreneurship, it built a number of featured industry incubators together with professional institutions, and introduced a number of startups. To gather talents, it established science parks, research institutions and independently operated enterprises jointly with universities and institutes. To seize the opportunity for coordinated development of the Beijing-Tianjin-Hebei region, it brought in universities and institutes in a targeted manner to accelerate the formation of local research capabilities. Driven by the need for fund matching, it set up government guidance funds and numerous private equity funds. These comprehensive efforts have provided better conditions for fostering regional technology climate and clustering technology resources.

Chapter 15

Urban Governance

Summary

This chapter describes the practices and achievements of the eco-city in comprehensive urban governance and the construction of a smart city.

The eco-city established a daily law enforcement system that combines "comprehensive law enforcement + professional law enforcement". In response to typical problems, it further set up joint law enforcement and focused on administration mechanisms.

Deciding the level of urban operation and maintenance that should be achieved, and what cost criteria should be used, are common problems that plague many cities. The eco-city established 10 standards in six areas for the operation and maintenance of urban infrastructure to initially realise standardised allocation, delicacy management, normalised operation and long-term maintenance.

The eco-city set up a clear responsibility system for safety production to define the main responsibilities of the government, industry and enterprises, and constructed a "double prevention mechanism" for urban risk classification prevention and control and hidden danger identification. It pioneered the planning and building of a safety experience hall to strengthen education on safety awareness for the people.

Informatisation is an important means of resolving urban governance and development. The eco-city is committed to building a world-leading smart city. It has built "unified sharing" infrastructure such as a communication pipe network, data centre and video surveillance, and key projects such as an urban data aggregation platform and urban operation and maintenance centre.

At the beginning of development, a new city is generally faced with the "ghost town" crisis. As the population steps beyond the threshold of accelerated development, a series of urban governance problems follows. The eco-city is moving from a period which merely focuses on construction to a period in which both construction and management must be emphasised. Leveraging the forces of marketisation, standardisation and informationisation, the eco-city carried out proactive and effective exploration and practices in urban governance, and strived to build a social governance system based on "organisation and leadership, government responsibility, social coordination, public engagement and guarantee of ruling by law".

1. Comprehensive Urban Law Enforcement Pattern

Law enforcement system: In accordance with the requirements of Tianjin City for relatively centralised law enforcement, the eco-city adopted a comprehensive urban law enforcement model to form an urban management structure which combines comprehensive law enforcement with divisional management and industrial management, and professional law enforcement with social management. Comprehensive law enforcement covers various areas such as municipal infrastructure, landscaping, energy, water, public transportation, city appearance and environmental sanitation. Professional law enforcement includes areas such as industry and commerce, construction and the environment. Driven by the needs of law enforcement, the eco-city set up a comprehensive law enforcement brigade. Under the principle of "setting up teams by region and grouping by discipline", law enforcement squadrons were divided by areas and law enforcement teams were divided by roads, neighbourhoods and other disciplines to further improve the effectiveness of law enforcement management and achieve full coverage of comprehensive law enforcement services. Based on a digital urban management platform, the eco-city established a horizontal communication mechanism, forming a coordinated linkage between the comprehensive law enforcement brigade and related functional departments and industry organisations such as construction, urban management, property, owners, neighbourhood, public security, industry and commerce, and security. In addition, it implemented joint law enforcement against hot and difficult issues in urban management.

Three-level patrol: The eco-city established a three-level patrol mechanism of "patrol by digital platform, self-inspection by operation and maintenance units, and supervision by urban management bureau", to achieve full coverage of comprehensive law enforcement management by grid. It adjusted and divided management grids scientifically and dynamically

according to regional construction progress, population flow, road network density and other factors, and implemented fixed posts, fixed personnel, fixed responsibility, and fixed area for each management grid to ensure that the grids are functional and optimised.

Focused governance: In view of the key and difficult issues in urban management, combined with major creation activities such as a national health city, and national civilised city, focused governance projects were established to cover six governance functions, i.e. slag leakage control, illegal construction control, roadside stall business control, control of areas around construction sites, posters and graffiti control and advertising boards control. Priority was given to the investigation and punishment of illegal construction, including establishing and bettering the mechanism of dismantling illegal construction, strengthening the communication with administrative departments such as planning and construction, improving the coordination and linkage mechanism for illegal construction investigation and punishment, proactively and properly resolving the remaining problems, promptly investigating and dealing with unfinished and new illegal construction to resolutely curbing the momentum of illegal construction. Through focused governance, the eco-city endeavoured to create a landmark area for environmental improvement and law enforcement management.

2. Urban Operation and Management Model

Functional integration: Following the idea of "comprehensive urban management, refined service and full coverage", the eco-city integrated operation and maintenance management functions including municipal greening, energy management, water management, traffic management, city appearance and environmental sanitation, and comprehensive law enforcement, and rationalised the mechanisms and systems to achieve the separation of construction and management. This created an urban management system that integrates "service, management and law enforcement".

Collaboration between government and social organisations: Following the concept of collaboration, participation and common interests, the eco-city established various channels for residents to participate in urban governance by means of government authorisation, franchising and purchasing services. This formed a new model in which enterprises and residents are involved in urban construction and management.

For enterprises, according to the *Regulations for Administration of the Sino-Singapore Tianjin Eco-city* and related agreements, the TECID obtained the franchise of 18 operational items including energy, communication, water, environmental sanitation and transportation, and undertook the investment, construction and operation functions of non-operational items including municipal roads and bridges, pump stations, greening and public buildings. On this basis, the ECAC entrusted the TECID to operate and manage the above-mentioned infrastructure and public facilities through government purchase of services and financial subsidies, forming a new market-oriented and contractual model for operation and management of urban infrastructure and public facilities.

For residents, a digital urban management platform was established to make available the channels for residents to give feedback on urban management issues. Through this platform, the residents describe the problems they find in the system, and then the urban management departments relay these issues to the relevant authorities to handle and promptly respond to the residents with the results. To promote the management model of neighbourhood self-governance, a mechanism of "neighbourhood-based, tiered arrangements, and joint management" was built. By means of contacting the neighbourhood and regularly participating in the neighbourhood residents' coordination meetings, the urban management moved from being "single-centre" to "multi-centre", forming an urban management mechanism with government leadership and wide social involvement.

Operation and maintenance standards: To define the management objectives of infrastructure and supporting projects, standardise maintenance management procedures, and achieve the standardised allocation, refined management and normalised operation of urban infrastructure, the eco-city developed a standardisation system for urban infrastructure management. This included a total of 10 standard system documents in six areas, covering the operation and maintenance standards of "standard roads, ordinary roads, maintenance roads, standard bridges, ordinary bridges, standard parks, ordinary parks, standard terminals, standard lines and standard water surface". The refined management guided by standardised construction solidified a large number of daily, trivial and repetitive urban management objects or services to promote management improvement with standardised construction, promote supporting facilities improvement with standardised construction, and promote assessment and supervision with standardised construction.

3. Urban Safety Management

Improving the responsibility system for safety production: In order to promote the implemention of safety management, the eco-city identified the local management responsibility, industry's supervision responsibility and enterprises' entity responsibility one by one, and established an urban safety management responsibility system. The safety supervision departments of production and business units in industries (fields) such as construction, business, tourism, warehousing, manufacturing and "nine small places, i.e., primary schools/kindergartens, small hospitals, small shops, small dining places, small hotels, small entertainment places, small Internet cafes, small beauty and bathing places, and small production and processing enterprises", were specified, achieving "full coverage" of safety supervision. Emphasis was placed on the enterprises' entity responsibility, and enterprises were urged to perform their duties according to law, so as to control safety incidents from the source.

Building a double prevention mechanism for risks: The eco-city built a double prevention mechanism for urban risk "classification prevention and control" and "hidden danger identification" to comprehensively improve its level of urban risk management and control. On the basis of comprehensively investigating the production and business units of various industries to identify their main risks, the eco-city established an urban risk classification prevention and control system. In addition, it formed an urban risk assessment model, a risk database and a dynamic risk grade distribution map to ensure risk identification and dynamic management and control. Efforts were made to promote the hidden danger investigation system, formulate a list of hidden danger investigation and management, refine the items, contents and frequency of hidden danger investigation, and promote all employees of enterprises to participate in the investigation of hidden dangers.

Endeavouring to improve the safety awareness of all the people: The eco-city completed the preliminary study of the comprehensive safety experience hall, and proposed to set up education modules such as home safety, construction, special equipment, fire control and dangerous chemicals, to enhance the sense of experience and participation through real scene experience, virtual reality experience, and accident warning education, thus enhancing the safety awareness and emergency response capability. Efforts were made to promote QR codes for global safety tips. These QR codes are available in crowded places and risk points such as tourist attractions, commercial outlets and workplaces, so that relevant personnel can obtain safety tips, operating procedures and response measures before they are exposed to the risks. Focused actions of "one enterprise, one policy" were carried out for education and training, and safety production education and training programmes were formulated according to the characteristics of enterprises to enhance the pertinence and effectiveness of training.

4. Constructing Smart Cities

The eco-city kept exploring, innovating and practising in the field of smart cities, and pioneered the concept of a "pulsating city" of perception, communication, insight and experience. Under the principle of unified sharing, it constructed hardware infrastructure and public service platforms.

Overall planning: Based on the construction experience of top international smart cities, the eco-city developed a smart city development strategy and implementation plan. In 2008, the Intelligent City Planning for Sino-Singapore Tianjin Eco-city was formulated.In 2012, the Action Plan for Smart City 2012-2015 was developed. In 2013, the eco-city was successfully included in the list of the first batch of pilot units for the creation of smart cities in China. In 2015, the Pulsating City Master Plan 2015-2020 was prepared with reference to Singapore's experience in constructing a smart nation. In early 2018, the preparation of the planning for a new smart city was launched as an important basis for smart city construction in the next five years. The eco-city also worked out the communication infrastructure construction planning and intelligent transportation planning. Following the smart city plan, the eco-city organised the construction of infrastructure and public system projects in a unified manner, realising resource sharing and saving construction funds.

Hardware infrastructure: The eco-city, under the principle of "unified construction, resource sharing, centralised maintenance and intensive management", advanced the construction of hardware infrastructure, avoiding waste of resources caused by repetitive construction. First, a unified communication pipe network project was constructed, which carried a variety of services such as a residential communication network, government and enterprise communication network, cable TV network, urban integrated service network and administrative management network. This avoided repeated construction by various service operators. By the end of 2017, 29,052 residential optical cables, 1,067 km of communication pipelines, 548 km of optical cables, two core computer rooms, and 28 wireless base stations were completed. Second, a city-class green data centre was constructed. The centre, which met the standard for a national Class A computer room in China, laid a solid foundation for the eco-city to implement cloud

Figure 15-1: Public Utility Operation and Maintenance Centre (Figure 15-1)

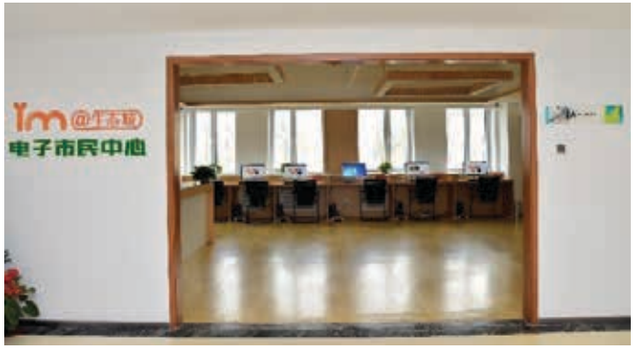


Figure 15-2: The Second Neighbourhood E-Citizens Centre

services and develop the big data industry. Third, a public service platform for video surveillance was constructed. The eco-city pioneered a “video surveillance sharing service platform” which allows a system to serve many fields such as urban security, urban management, safety supervision, municipal operation, social services and public travel.

Software services system: The eco-city brought into play the unique advantages of a new city such as having a small burden, good system and new technology to break the data barriers of segmentation, and build, operate and maintain public data software platform intensively. First, an urban data aggregation platform based on unified geographic information brought together 55 kinds of data in construction, economy, environment, energy, urban management, urban operation and maintenance, and integrated 14 sets of annual series image data, nine sets of real scenario data, two sets of oblique photogrammetry data and more than 20 types of professional layers, achieving full coverage of the eco-city. The preliminary data analysis and information mining formed a data analysis model that could reflect the pulse of the city in urban traffic, environment, energy and urban management in a timely manner. Second, the Public Utility Operation and Maintenance Centre (Figure 15-1) was built. The centre integrated the operation data of 16 disciplines including roads, bridges, water supply and gas, and synchronously updates them, thus forming an intelligent management system that integrates all-inclusive information-based management, full-time operation monitoring, and all-round real-time scheduling of municipal public utilities. The construction model of this centre has been recognised by the MOHURD and recommended to other provinces and cities in China. Third, the Sino-Singapore Tianjin Eco-city E-Citizens Centre (Figure 15-2) was constructed with reference to the experience of Singapore’s E-Citizens Centre to provide the public with a one-stop online service platform for “medical, food, lifestyle, travel, entertainment and education services”. Fourth, an Internet approval platform was built, by which 45 key issues could be dealt with online, and the staff could receive, inquire and handle services through various terminals such as SMS, websites and hotlines without leaving the office. Fifth, a unified user login platform was built with reference to Singapore’s "smart nation" Singpass system. The platform realised the functions of aggregation and integration of user information, sharing and interaction of business systems, and resource allocation of public platforms.

Conclusion: Urban management is profoundly complex and arduous, and requires strong institutional guarantees. Almost every city encounters problems such as illegal construction, commercialisation of housing, unlicensed business activities, group house renting, roadside stall businesses and construction disturbances. These problems often involve different functional departments and concerning a variety of laws and regulations. Faced with different illegal objects, they are constrained to varying degrees by appropriateness of law enforcement entities, the adequacy of law enforcement basis, the standardisation of law enforcement procedures, the adequacy of law enforcement force, and the fear of group visits and stability. Among these, some problems involve many areas. The masses believe that the law does not punish numerous offenders, therefore, governance is time-consuming, expensive and unsatisfactory. Some problems are likely to return, making the efforts fruitless. In practical work, human relations often get in the way. As a new city, the eco-city took “arresting the source, establishing rules and intervening early” as its guiding ideology and adopted a range of innovative measures. For the illegal construction of commercial housing, it put emphasis on design review from the source to reduce the possibility of construction as much as possible, and prohibited the transaction of illegally constructed houses from the transaction link. These were implemented to good effect. In addition, it introduced a series of standards for the operation and maintenance of urban infrastructure, which provides an open and transparent basis for daily maintenance, construction operations, supervision and assessment, and fund settlement. Urban safety is about prevention and scientific handling. By adapting to the basic laws and main problems of urban safety construction, and focusing on defining responsibilities, developing experience education, and cultivating safety awareness, the eco-city proactively explored new measures to improve its ability in urban risk control and emergency response to accidents. Relying on the advantages of new areas and in light of the concept of unified sharing, the eco-city broke barriers and constructed unified information-based software and hardware infrastructure to create favourable conditions for urban governance and also gain cost-savings. In the future, the eco-city will seek to learn even more from the construction experience of Singapore’s “Smart Nation”, to provide unified, convenient and safe application services to the government, enterprises and residents in order to enhance the level of urban intelligence with practical applications.

Part 5

Integration and vision

This section briefly introduces the general trend of coping with climate change and the promotion of sustainable development by the international community. It summarises the new development vision and focuses of globally representative cities, and analyses various phenomenon, including the rise of China's construction of an ecological civilisation, the rapidly increasing number of "eco-cities", as well as the new expectations, tasks and challenges that lay ahead in the development of the eco-city. The purpose is to accurately identify the direction and focus of future development of the eco-city, based on accurate perceptions of the progress in global urban sustainable development and in the context of China's construction of an ecological civilisation.

Looking ahead, the eco-city will become a benchmark for continuous development worldwide, an example of ecological civilisation construction, a city of innovation for green development mechanisms and a cradle for developing eco-mindsets and culture, as well as a green, liveable, harmonious, flexible, humane and smart city that is attractive, competitive and lively.

Chapter 16

Development Trends

Summary

This chapter describes the global picture of tackling climate change and promoting sustainable development, as well as China's overall deployment to push forward the construction of an ecological civilisation.

With global responses to climate change entering a new phase, serious challenges remain in mitigating, and adapting to, such a global phenomenon. *The Paris Agreement* set out the overall objective of global response to climate change after 2020, which has clearly defined the adoption of "National Independent Contribution Programme". The UN's *2030 Agenda for Sustainable Development* established a new vision for development and proposed 17 goals and 169 targets covering three major areas - economy, society and environment.

Many well-known cities in the European Union, North America and Asia have put forward their future development visions and sustainable development plans, and listed the key areas for development.

A historic, transformational and global change has taken place in China's efforts to promote eco-environmental protection. The 18th National Congress of the Communist Party of China incorporated the construction of ecological civilisation into China's Socialism with Chinese Charateristics's "Five-in-one" and "Four Comprehensives" strategies. The Report of the 19th National Congress pointed out that "the construction of ecological civilisation is a millennium plan for the sustainable development of the Chinese nation", stressing the need to establish the concept of "clear waters and lush mountains are invaluable assets", to adhere to the basic national policy of saving resources and protecting the environment, and to treat the eco-environment like our own lives. The National Conference on Environmental Protection held in May 2018 clarified the "Six Principles" and "Five Tasks" that must be followed in the new era to promote the construction of ecological civilisation.

Everything will be difficult if you do it alone, but easy with the help of others: With the global response to climate change in a grim situation, exploring sustainable development and building ecological cities has become the unanimous choices of countries all over the world. Many countries and cities have laid out their visions of future development and the main directions of their efforts, which present a pattern of achieving equally satisfactory results through different approaches.

1. Trend of Global Sustainable Development

Sustainable development can be traced back to the World Conservation Strategy jointly published by the International Union for Conservation of Nature (IUCN), United Nations Environment Programme (UNEP) and World Wildlife Fund (WWF) in 1980. In 1987, the World Commissionon Environment and Development (WCED) released a report titled "Our Common Future", which took "sustainable development" as the basic programme and defined it as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs".

Mitigating and adapting to global climate change remain critical

The question of how to tackle climate change is a long-term, complex and arduous global issue. Since the establishment of the UN Framework Convention on Climate Change (UNFCCC) in 1992, the global response to climate change has, on the whole, been characterised by periodic and undulating progress. At the UN Climate Change Conference in December 2015, *The Paris Agreement* which was of milestone significance was concluded. It set out the overall objective of global response to climate change after 2020, i.e. "to control the average temperature rise to a level below 2°C, and strive to achieve a control target of 1.5°C temperature rise. The world needs to achieve peak greenhouse gas emissions as soon as possible and a balance between greenhouse gas emission sources and absorption sinks (net zero emissions) by the second half of this century". *The Agreement* clearly specified the adoption of the "National Independent Contribution Programme", and defined the targets of financial assistance for each country, i.e. developed countries would provide USD100 billion annually to help developing countries after 2020. It also set up the "Global Stocktake Mechanism" for the first time.

In 2002, ICLEI-Local Governments for Sustainability put forward the concept of "resilience" at the UN World Summit on Sustainable Development. In 2012, UNISDR launched a resilient network of Asian cities to tackle climate change. In 2013, the Rockefeller Foundation started the project of "100 Resilient Cities in the World". At present, the concept and strategy of resilient cities have been widely used in practical areas such as coping with climate change and managing urban disaster risks.

The agenda for sustainable development sketches out a new vision

In September 2015, the UN convened the Third Conference on Housing and Sustainable Urban Development ("Habitat III"), at which the *2030 Agenda for Sustainable Development* was formally reviewed and approved. A total of 17 goals and 169 targets were proposed, covering three main areas - economy, society and environment (Figure 16-1). These goals were also known as the Sustainable Development Goals (SDGs). This is another programmatic document on international development after the Millennium Development Goals (MDGs). Compared with the MDGs, SDGs are more universal and open with higher quality.

Countries are exploring new paths for sustainable development

At present, the implementation of the *Agenda for Sustainable Development* is the core work in the field of international development, and this will last for a long period into the future. In recent years, countries have made explorations and innovations (Table 16-1). The European Union has spared no effort in promoting low-carbon emission reduction and tackling climate change. It has not only introduced a number of policies, which are supplemented by fiscal, taxation, fund, appraisal and other incentives, but also urged European countries to adopt localised measures

Figure 16-1: United Nations Sustainable Development Goals

Table 16-1: Overview of global sustainable development cities

Distribution	Eco-city practice	Population size	Practice point
Europe	Reykjavik, Iceland	12,000 residents	Development and utilisation of new energy
	Malmo, Switzerland	285,000 residents	Comprehensive eco-city construction
	Zilina, Slovakia	85,000 residents	Eco-community construction
	Hanham Hall, UK	170-220 households	Eco-community construction
	Logrono Montecorvo, Spain	3,000 households	Eco-community construction
	Freiburg	200,000 residents	Comprehensive eco-city construction
	BedZED, UK	82 households+ 20 small-sized enterprises	Eco-community construction
	St. Davids, UK	1,800 households	Comprehensive eco-city construction
	Glumslov, Sweden	2,000 residents	Ecological buildings
	Erlangen, Germany	100,000 residents	Comprehensive eco-city construction
	Kalundborg, Denmark	3,500 households	Symbiotic industrial zone
	Oslo, Norway	520,000 residents	Comprehensive eco-city construction
	Hammarby Sjostad, Sweden	35,000 residents	Ecological new town construction
	Ferrara, Italy	130,000 residents	Comprehensive eco-city construction
Asia	Toyama, Japan	1.12 million residents	Comprehensive eco-city construction
	Yokohama, Japan	3.63 million residents	Comprehensive eco-city construction
	Gwang Gyo, Korea	77,000 residents	Ecological new town construction
	Icheon, Korea	320,000 residents	Ecological new town construction
	Minamata, Japan	40,000 residents	Comprehensive eco-city construction
	Tajimi, Japan	100,000 residents	Comprehensive eco-city construction
	Kitakyushu, Japan	1.06 million residents	Comprehensive eco-city construction
	Obihiro, Japan	162,000 residents	Comprehensive eco-city construction
America	Arcosanti pilot town, U.S.A	5,000	Ecological new town construction
	Portland, U.S.A	Over 500,000	Comprehensive eco-city construction
	Aerial Treasure Island, San Francisco, U.S.A	13,500 residents	Eco-community construction
	Sonoma Mountain Village, California, U.S.A	2,000 households	Eco-community construction
	Curitiba, Brazil	1.8 million residents	Comprehensive eco-city construction
	Destiny Florida, U.S.A	--	Development of new energy technology
	Bahia de Caraquez, Ecuador	30,000 residents	Comprehensive eco-city construction
	EcoVillage at Ithaca, North America	60 households	Eco-community construction
Oceania	White Bay Eco-city, Sydney, Australia	12,000-22,000 residents	Ecological new town construction
	Waitakere, New Zealand	200,000 residents	Comprehensive eco-city construction
Africa	Ivory Park Eco-community, Johannesburg, South Africa	Existing 30 households; 60 residents planned	Eco-community construction

Data source: Yang Peifeng and Chen Huiwen, List of Current Foreign Eco-city Construction Practices

for implementation. Organised by the European Commission, European Green Capital is one of the most exemplary awards. Starting from 2010, a European city will be identified each year as the most environmentally-friendly, ecological, green and liveable city. Specific indicators for assessment include: air quality, climate change, mitigation and adaptation, ecological innovation and sustainable employment, energy efficiency, green urban areas for sustainable land use, comprehensive environmental governance, local transportation, natural and biological diversity, noise environmental quality, waste management, wastewater treatment and water supply management. This event has been held for eight editions, and every award-winner is a model of a low-carbon, ecological city, including Stockholm, Sweden (2010), Hamburg, Germany (2011), Vitoria-Gasteiz, Spain (2012), Nantes, France (2013), Copenhagen, Denmark (2014), Bristol, UK (2015), Essen, Germany (2017), Nijmegen, the Netherlands (2018) and Oslo, Norway (2019).

North America, with its vast and sparsely populated land, has a different urbanisation model from that of Europe, but it has also produced a number of excellent liveable cities. Vancouver, Canada, is recognised as the most outstanding city in sustainable development in North America and even the world. In 2009, the government of Vancouver released a strategic report titled Vancouver 2020: A Bright Green Future. The report put forward 10 long-term goals in the three areas of "green economy and green jobs", "greener communities" and "human health", aiming to build Vancouver into the most environmentally-friendly, healthy and liveable eco-city in the world. As the product for specific implementation of this vision document, the Greenest City Action Plan 2020 was formulated in 2012. The Plan pointed out that "Vancouver can both maintain its growth and prosperity, and become a green capital: a global leader in tackling climate change". It established the goals for three systems (Zero Carbon Emission, Zero Waste and Healthy Ecosystem) and 10 core areas (green economy, environmental leadership, green building, green transportation, zero waste, accessibility of natural environment, reduction of ecological footprint, clean water, clean air and local food), and also developed an Immediate Action Plan (for 2011 to 2014), which broke down the goals and relevant indicators for specific implementation of the programme. The progress of each planning goal would be assessed each year, and an annual assessment document on "implementation update" would be prepared and made public in a timely manner.

Melbourne, Australia, also known for its liveable environment, issued the Plan Melbourne – Metropolitan Planning Strategy 2050 in 2014. The planning process and content were more "flexible, sustainable and adaptable" to better address future uncertainties. Plan 2050 estimated that Melbourne's total population in the long term would reach 7.7 million. The Plan also put forward guiding suggestions on the eight directions of development, including urban pattern, ecological protection and restoration of natural environment, expansion of food production capacity, reduction of noise pollution and improvement of air quality, management of flexible water circulation system, protection of critical water and sewerage infrastructure assets, encouragement of the development of clean energy, waste management and resource recovery.

International metropolises face more complex challenges, which are different from those of slow-paced liveable cities such as Vancouver and Melbourne. The government of New York released a new master plan titled One New York: The Plan for a Strong and Just City in 2015. With the goal of "building a greener and greater New York, the Plan established 10 tasks covering housing and communities, parks and public spaces, brownfield, water quality, water supply, transportation, energy, air quality, solid waste and climate change, and set out the new visions of becoming "a growing, thriving city, a just and equitable city, a sustainable city and a resilient city". The plan aimed to build a just and equitable society while maintaining economic prosperity in the long-term development of the city, to be more responsible for the health and well-being of all citizens, to enhance the capacity for sustainable development and to be more resilient to all kinds of disasters and risks.

Compared with European and American cities, eastern Asian cities have a higher population density, heavier burden of economic development and more intensive energy consumption. Therefore, to realise sustainable development, it is necessary to explore a unique path that is suitable for their respective situations. In 2016, Singapore revised the Sustainable Singapore Blueprint 2009 in accordance with its emission reduction targets and economic and social development, and proposed the goal of building "a liveable and warm home, a vibrant and sustainable city, and a positive and friendly community". To prepare for the 2020 Summer Olympics and improve the ecological quality of the city, Tokyo issued Creating the Future: The Long-term Vision for Tokyo plan, setting forth the goal of building "the best city in the world", which is oriented to be "a city of the future".

2. Trend of Sustainable Development in China

The construction of ecological civilisation rising to an unprecedented level

The Report of the 19th National Congress of the Communist Party of China pointed out that "the construction of ecological civilisation is a millennium plan for the sustainable development of the Chinese nation". As early as 2003, Xi Jinping, the then-secretary of Zhejiang Provincial Party Committee, published an article in the Qiushi magazine, in which he put forward the important conclusion that “civilisation will flourish when ecology prospers, and civilization will decline when ecology declines”. The 18th National Congress of the Communist Party of China incorporated the construction of ecological civilisation into China's Socialism with Chinese Charateristics's "Five-in-one" strategy, in which “Beautiful China” was taken as the grand goal of ecological civilisation construction for the first time. It also put forward the “Four Tasks” of ecological civilisation construction in the future, namely, optimising the development pattern of national land space, promoting resource conservation in an all-round way, strengthening the efforts to protect the natural ecosystem and environment, and enhancing the construction of systems promoting ecological progress. The 19th National Congress of the Communist Party of China (CPC) incorporated the idea that "lucid waters and lush mountains are invaluable assets" into the Report of the 19th National Congress and the Constitution of the CPC.

The National Conference on Ecological and Environmental Protection held in May 2018 marked a historic turning point in China's promotion of ecological and environmental protection. Standing at the top of development of the CPC and China's national undertakings, President Xi Jinping clarified the following "six principles" that must be adhered to in the new era to promote the construction of an ecological civilisation: ensuring harmony between human and nature; lucid waters and lush mountains are invaluable assets; sound ecological environment is the most inclusive benefit to people's well-being; mountains, rivers, forests, farmlands, lakes, and grasslands are a life community; protecting the environment requires the best institutional arrangements and the strictest rule of law; and working together on global ecological civilisation construction. The important conclusions of the "six principles" constitute a closely knit and organically unified ideology. They profoundly reveal the relationship between economic development and ecological and environmental protection, and deepen the understanding of economic and social development laws and natural ecological laws. This pointed out the way for China to take the road of civilised development which entails production growth, affluent life and a sound ecosystem. The conference also clearly proposed the acceleration of construction of an ecological civilisation system, including: ecological culture system, ecological economic system, target responsibility system, ecological civilisation system and ecological security system.

A new stage in tackling climate change

As a responsible developing country, China views development as its top priority and implements the sustainable development agenda as an important aspect of fulfilling its international responsibilities through the comprehensive implementation of the relevant works.

As early as 2014, China issued China’s National Plan on Climate Change (2014 to 2020), which proposed the guiding ideology, target requirements, policy orientation, key tasks and safeguard measures for China to respond to climate change. It integrated the requirements of mitigating and adapting climate change into all aspects and the overall process of economic and social development, with a view to accelerating the construction of a green low-carbon development model with Chinese characteristics.

In 2015, the Chinese government submitted the Intended Nationally Determined Contributions (INDCs) to make arrangements for strengthening mitigation and adaptation actions after 2020. The specific targets include: striving to reach the peak greenhouse gas emissions as early as possible by around 2030; achieving a 60-65% reduction in greenhouse gas emissions per unit of GDP by 2030 compared with 2005; non-fossil energy accounting for about 20% of primary energy consumption; forest reserves increasing by about 4.5 billion m^3 compared with 2005; continuing to actively adapt to climate change, forming mechanisms and capabilities to effectively resist climate change risks in agriculture, forestry, water resources and other key areas and cities, coastal areas, and ecologically fragile areas, and gradually improving the system of forecasting, early warning and disaster prevention and mitigation. In addition, China established the "Alliance of Peaking Pioneer Cities of China" with the aim of strengthening the experience-sharing of low-carbon development and emission reduction between cities, promoting excellent practices at home and abroad, and playing an exemplary role to drive other cities to accelerate the green and low-carbon transformation and upgrading. Eventually, this will lead to the goal of greenhouse gas emissions peaking by around 2030.

In 2016, China released China's Position on the Implementation of the 2030 Agenda for Sustainable Development and China's National Plan on Implementation of the 2030 Agenda for Sustainable Development. It reviewed China's achievements and experiences in implementing the Millennium Development Goals, analysed the opportunities and challenges in implementation of the sustainable development agenda, and clarified the guiding ideology, general principles and implementation path of China's implementation of the work. In 2017, the Chinese Ministry of Foreign Affairs released the first China's Progress Report on Implementation of the 2030 Agenda for Sustainable Development. Through a wealth of examples and data, the report systematically reviewed China's progress, challenges and subsequent work plan in the implementation of 17 sustainable development goals since September 2015. It provided a timely organisation and evaluation of the implementation of the sustainable development agenda, and provided useful lessons for implementation in other countries.

China's environmental protection enters a crucial period

Since the 1st National Conference on Environmental Protection held in 1973, the various national conferences on environmental protection have made different arrangements. During the 18th National Congress of the CPC, President Xi Jinping emphasised that "lucid waters and lush mountains are invaluable assets", and "sound ecological environment is the most inclusive benefit to people's well-being". Environmental protection has become a precondition in urban planning and construction, and the performance appraisal system of "one-vote negation concerning environmental protection" is being implemented throughout the country.

With the continuous implementation of the institutional reform of the Chinese government, the responsibility for tackling climate change and emission reduction has been included in the newly established Ministry of Ecology and Environment of China, making clearer the institutional mechanisms and implementation paths of China's environmental protection work. The latest National Conference on Ecological and Environmental Protection, held in March 2018, made comprehensive arrangements for strengthening ecological environmental protection and pollution prevention and control, and urged the whole party, country and society to work together to push China's ecological civilisation construction to a new level. In June 2018, the State Council promulgated the *Opinions on Strengthening Ecological Environment Protection and Resolutely Fighting Pollution Prevention and Control*. It determined that by 2020, the overall quality of the ecological environment would be improved, the total discharge of major pollutants would be greatly reduced, environmental risks would be effectively controlled, and the level of ecological environmental protection would be compatible with the goal of building a well-off society in a holistic way. Focusing on key areas and highlighting weak links, the "Opinions" clearly requires victories in three major defence wars (blue sky, clear water and pure land defence war) and seven major landmark wars (blue sky defence war, diesel truck pollution control, water source protection, black and odorous water treatment, Yangtze River protection and restoration, Bohai Sea comprehensive management, and agricultural and rural pollution control). This marks the beginning of the national fight against environmental pollution.

Green cities are forming a pattern of competitive development

In response to the requirements of ecological civilisation construction and green development, the State Council, various ministries and commissions have successively issued policies and measures to encourage green urban developments. In 2015, the Central Urban Work Conference was held again 37 years after the last meeting. The conference stressed that it was necessary to comply with the new situation of urban work, the new requirements for reform and development and the new expectations of the people. It was also necessary to adhere to the people-centred development ideology, and clarify the guiding ideology, overall thinking and key tasks for doing a good job in urban work, specifically including: respecting the law of urban development; coordinating three major structures of space, scale and industry to improve the overall importance of urban work; coordinating the three major links of planning, construction and management to improve the systemic nature of urban work; coordinating three major driving forces of reform, technology and culture to improve the sustainability of urban development; coordinating the three major layouts of production, life and ecology to improve the liveability of urban development; coordinating the three major subjects of government, society and citizens to enhance the enthusiasm of all parties to promote urban development.

Multiple ministries in China have taken the lead, or worked together, to promote the pilot demonstration of urban green development. In 1992, China started the selection of national garden city creation. In 2011, China started to implement the low-carbon ecological pilot city (town) construction. In 2012, China approved the first batch of eight "National Green Ecological Urban Areas", including TEC. According

to incomplete statistics, by the end of 2017, there were 11 ecological garden cities (Ministry of Construction), 16 green ecological urban areas (Ministry of Construction), seven green low-carbon key small towns (Ministry of Finance and Ministry of Construction), six low-carbon pilot provinces (NDRC), 81 low-carbon pilot cities (NDRC), 55 low-carbon industrial parks (NDRC), 28 climate adaptation pilot cities (NDRC), 100 ecological civilisation construction demonstration zones (NDRC and six other ministries and commissions), and several upgraded low-carbon community pilots (NDRC).

China has implemented a major strategic plan for the coordinated development of Beijing-Tianjin-Hebei region, relieving Beijing of its non-capital functions and constructing of the Xiong'an New Area. Xiong'an New Area is one of the most iconic, comprehensive and exemplary strategic projects. It is oriented to be a centralised district to take over Beijing's non-capital functions. It is positioned as "a green ecological and liveable new urban area, an innovation-driven leading district, a demonstration zone of coordinated development and a pioneer zone of open development". President Xi Jinping stressed: "The Xiong'an New Area should be constructed in accordance with the requirements of ecological civilisation construction and the principle of ecological priority and green development, and be developed into an ecological benchmark featuring rationally distributed buildings, low carbon and better natural ecology. Lucid waters and lush mountains are invaluable assets. It is necessary to reasonably determine the scale of the Xiong'an New Area, improve the ecological function, highlight the "scientific, ecological, livable and intelligent" development direction, create an excellent living environment, and build an eco-city with blue sky and green water and compact development of multiple groups, with a view to realising a beautiful ecological space, a liveable living space, an intensive and efficient production space, ensuring harmony between human and nature, and building a beautiful home to restore a blue sky to the people."

3. The situation and tasks faced by the eco-city

Following the general trend of sustainable development in the international community and China, combining the objectives of "three harmonies" and “three abilities" and "providing a demonstration for sustainable development of other cities" determined by China and Singapore, and in combination with a series of requirements put forward by Tianjin City and Binhai New Area, the task of demonstrating and promoting sustainable development in the eco-city was a formidable one.

During the visit to Tianjin in May 2013, President Xi Jinping put forward the important requirements of "focusing on improving the development quality and efficiency, ensuring and improving people's livelihood, strengthening and improving the party's leadership, and accelerating the creation of beautiful Tianjin". The "Three Focuses" have profoundly clarified the direction, overall importance and fundamental problems of Tianjin's development. They placed great importance, heavy responsibilities and high hopes on Tianjin's development, and provided a fundamental guide and action plan. During his visit to the eco-city, Xi Jinping stressed that "it is necessary to take into account both the advanced, high-end positioning and replicability and scalability, and deliver a convincing response in terms of the harmony between people, between people and economic activities, and between people and the environment. This will serve as a demonstration for building a resource-conserving and environmentally-friendly society."

The Implementation Plan for the Construction of National Green Development Demonstration Zone approved in 2014 clearly stated: "By 2020, TEC will be developed into a national green development demonstration zone, with its main indicators reaching domestic leading levels. As a result, the eco-city will become a demonstration of green development in China, a window for China to showcase the achievements of green development to the international community, and a platform for external exchanges".

The coordinated development strategy of Beijing-Tianjin-Hebei is changing from a blueprint to a reality, and the key tasks of transportation, ecology and industry have been comprehensively promoted. A framework for traffic integration with the high-speed rail and expressways as the backbone has gradually formed. The regional ecological environment has improved significantly with preliminary effects in ecological fields such as pollution control and emission control, sewage treatment and greening, inter-regional prevention and control. Beijing's non-capital functions and industries have been transferred to Tianjin and Hebei in an orderly manner, showing good development momentum. Against the backdrop of coordinated development of Beijing-Tianjin-Hebei, Tianjin's orientation has been adjusted to: a national advanced manufacturing R&D base, a northern international shipping core area, a financial innovation and operation demonstration zone, and a pioneer of reform and opening-up. In 2017, Binhai New Area established a new goal of building a prosperous, liveable and new smart city.

Under these circumstances, the eco-city needs to thoroughly implement the ecological civilisation concepts put forward by President Xi Jinping, and take the lead in the exploration and practice in the five aspects of ecological culture system, ecological economic system, target responsibility system, ecological civilisation system and ecological security system, so as to comprehensively enhance the construction level and pilot demonstration value. The eco-city also needs to actively integrate into the coordinated development of Beijing-Tianjin-Hebei, identify its position in Tianjin City and the Binhai New Area, and effectively implement the mission of "three harmonies". These will provide a good response in terms of harmony between people, between people and economic activities, and between people and the environment. In addition, the eco-city also needs to focus on the outstanding problems that prevail in the city, adopt innovative and even subversive thinking, adhere to the ultimate thinking, and take refined measures to form a batch of achievements in systems, policies, standards, measures and programmes. On this basis, it is necessary to first replicate the experience in the Binhai New Area and Tianjin City, and then cooperate deeply with the Beijing-Tianjin-Hebei region and countries along the "Belt and Road" to implement the mission requirements of the "three abilities".

Chapter 17

Future Vision

Summary

This chapter describes the vision and strategic initiatives for the future development of the eco-city.

Looking ahead, the eco-city has established its vision, orientation, principles and strategies for development by going with the tide of sustainable development of the international community, implementing China's overall plan for ecological civilisation construction, and formulating a "roadmap" and "strong point" of its own by borrowing from the experience of pioneer cities adapted to its own situation.

Vision: to become a benchmark for sustainable development worldwide.

Orientation: to become an example of ecological civilisation construction, city of innovation for green development mechanisms and cradle for developing ecological concepts and culture.

Principles: giving priority to ecology, being people-oriented and driven by innovation, marketisation, and being led by a problem-solving approach and pursuit of excellence.

Strategies: creating an innovative system, strengthening green features, expanding openness and cooperation, promoting harmony and sharing, advancing win-win coordination and realising replicability and scalability.

The orientation and vision of the eco-city are consistent, sustained and unambiguous, i.e. to explore growth opportunities based on urban sustainable development, accumulate relevant experience, provide solutions and play a leading role as a model for other cities.

1. Vision

The vision of development of the eco-city is "to become a benchmark for sustainable development worldwide", meaning that the eco-city will develop strongly to be internationally influential in terms of sustainable development and the aspiration of its goals.

This vision reflects three characteristics: demonstration, internationalisation and continuity:

Demonstration: this characteristic is proposed based on the specific requirement of China's President Xi Jinping during his visit to the eco-city in May 2013, i.e. to take into account the advanced and high-end positioning, as well as replicability and scalability, with a convincing response in terms of the harmony between people, between people and economic activities and between people and the environment, so as to provide a typical model for constructing a resource-conserving and environmentally-friendly society. It emphasises the exemplary and demonstrative role in the field of sustainable development. In addition, it also complies with the requirement of "providing a model for sustainable development of other cities" in the *Framework Agreement*.

Internationalisation: it is clearly stated in the *Implementation Plan for Sino-Singapore Tianjin Eco-city National Green Development Demonstration Zone* that was issued on 3 October 2014 that the eco-city will become a window for China to showcase its achievements in green development to the international society and be a platform for external exchange. In December 2016, the State Council issued the Development Plan of China's Innovation Demonstration Zone for the Implementation of the 2030 Agenda for Sustainable Development, stipulating the accumulation of sustainable development experience via typical demonstration and the promotion of the UN's agenda on sustainable development by 2030. As an integrated and unprecedented urban development trial project between China and Singapore in exploring sustainable development and coping with climate change, the eco-city will thoroughly implement the country's overall planning for ecological civilisation construction. It will become an example of executing the *2030 Agenda for Sustainable Development*, play a leading and demonstrative role in the field of sustainable development, win wide international acclaim and show its global vision and international influence.

Continuity: this characteristic comes down to a continuation of the requirement of "providing a model for sustainable development of other cities" jointly proposed by China and Singapore. The intrinsic requirement for sustainable development is environmental protection, which coincides with the approval for developing the eco-city into a national green development demonstration zone of the State Council. Meanwhile, the statement of "sustainable development" is aligned with international practice.

2. Orientation

In 2014, the State Council approved the *Implementation Plan*, in which the following development orientations were specified: an example of ecological civilisation construction, city of innovation for green development mechanism and cradle for developing ecological concepts and culture.

An example of ecological civilisation construction: optimising the pattern of spatial development and comprehensively promoting conservation of resources, enhancing protection for an ecological system and environment as well as exploring a new model of development in terms of rational protection, optimal development, effective utilisation and sustainable development.

A city of innovation for green development mechanism: courageously exploring and attempting to break mechanical and systematic barriers in green development, properly handling the relations between the government and the market, establishing industrial, investment, price, tax, financial, environmental protection and assessment systems for promoting green development and developing a long-term mechanism for green development.

A cradle for developing eco-mindsets and culture: strengthening basic study, experimentation and theorisation of green concepts and culture, continuously enriching the applications of green development and improving the originality of green ideology, technology and culture, enhancing education, training and international exchange on green culture, urging the government, enterprises and individuals to establish standards for performance assessment, production assessment and consumption based on green development so as to actively contribute to improving the soft power in the country's green culture.

This development orientation reflects authority, scientific basis and advancement.

Authority: on October 3, 2014, the State Council approved the *Implementation Plan*, in which the above development orientations were clearly stipulated. This is the only occasion when these orientations are stipulated in a national document. The *Implementation Plan* is an overall plan that systematically promotes the construction of ecological civilisation and the practice of green development throughout the country. It is led by the National Development and Reform Commission (NDRC), based on repeated demonstration by experts and scholars and submitted to the State Council for approval with advice sought from a dozen national ministries and commissions.

Scientific basis: this development orientation emphasises that the eco-city will practise, innovate and take the lead in ecological civilisation construction, green development system building and green concept and culture cultivation. It will generally focus on playing a leading role in ecological civilisation construction and providing strong support in the cultivation of systems and culture via innovative practices. This is a systematic, complete and focused strategic arrangement.

Advancement: this development orientation is in line with the "Five-in-One" strategy established and emphasised during the 18th and the 19th National Congress of the CPC. It fully reflects the strategic orientation of "cultural development and ecological civilisation construction" which was further highlighted since the 18th National Congress of the CPC. In addition, it also conforms to the requirement of "accelerating the creation of an ecological civilisation system" proposed at the recent National Conference on Environmental Protection. It is in complete compliance with the requirement of "accelerating the establishment and improvement of an eco-culture system based on ecological values and concepts, having an eco-economic system centred on industrial ecologicalisation and ecological industrialisation, having an objective responsibility system which focuses on improving the quality of ecological environment, having an ecological civilisation system guaranteed by proper governance and modernised governing capabilities as well as an eco-safety system based on a virtuous cycle of an ecological system and effective prevention and control of environmental risks".

3. Principles

The eco-city will adhere to the following principles based on a decade of practical experience and the tasks to be achieved in the future:

(1) Giving priority to ecology: Reflecting the concept of ecological civilisation and treating ecological governance and environmental protection as the basic prerequisites to promote coordinated development of the economy, society and environment.

(2) Being people-orientated: Embodying the ideology of “for the people” and sharing the outcomes of urban development with the people.

(3) Driven by innovation: Solving problems with innovative ideas and methods, providing effective solutions and generating the effect of demonstration.

(4) Marketisation: Giving full play to the decisive role of market mechanisms by encouraging social capital to take part in the eco-city's development so as to improve both development standard and efficiency.

(5) Led by problem-solving: Making overall arrangements regarding typical problems in urban planning, development and management; providing effective solutions based on practical tests.

(6) Pursuit of excellence: Persist in refining and being thorough, studying further and deeper; maintaining a leading role and improving the demonstration effect.

4. Strategies

Six development strategies were established for the eco-city, mapping out the basic route to achieving the objectives and stepping into the future according to the new development concepts of “innovation, coordination, green, openness and sharing”. These strategies are based on the original intention of “developing an eco-city which is practicable, replicable and scalable” and taking into account the vision, orientation and development principles of the eco-city.

Create an innovative system: Accelerate the creation of a complete innovative eco-system by borrowing from experience in system construction from pioneers in this field. Create a proper environment which encourages and supports innovation. Gather institutions and personnel that want to, and are capable of, innovation to generate a momentum for innovation. Lay down short-, medium- and long-term innovation plans. Specify key areas and directions of breakthrough. Achieve outcomes continuously in theoretical, systematic, technological, enterprise-level and schematic innovation.

Strengthen green features: Continuously enhance and improve environmental protection, resource utilisation, energy conservation and emission reduction according to core requirements for an eco-city and by thoroughly implementing all indicators for development. Create a clean and pleasing eco-environment. Make an effort to gather, conserve and recycle land, water, energy and waste. Vigorously promote energy consumption reduction in the fields of green building, green traffic, etc. Maintain efforts in these fields and continue to improve. Strengthen green development outcomes and highlight ecological features of the eco-city with systematic solutions.

Expand openness and cooperation: Grasp the historic opportunities afforded by the further opening up of China to the outside world. Take advantage of Sino-Singapore cooperation and preferential policies for Tianjin Free Trade Zone to obtain pilot preferential policies towards expanding the openness to foreign-funded service industries so as to attract international enterprises and institutions to settle down in the eco-city. Deepen Sino-Singapore cooperation. Focus on key fields and advantageous industries. Set down action plans for introducing international resources via cooperation with Singapore. Try to create a marketised, legalised and internationalised business environment acting on international conventions and enhance the international image of the eco-city.

Promote harmony and sharing: Conduct a thorough implemention of the "people-centered" concept. Ensure that developments are for the people, by the people and shared with the people. Continue to implement the strategy of “public service-driven development” to become a “liveable city” that is well-known nationally. Maintain the financial inputs into education, medical care, sports, culture and parks. Accelerate the development of large-sized associated facilities including commercial complexes, sports complexes, etc. Further develop strengths and make up for shortcomings to provide the people with a stronger sense of gain and happiness with comprehensive, high-quality, convenient and practical public services.

Promote win-win coordination: Establish the concept of coordinated and joint development. Implement specific requirements on coordinated development in indicators. Promote the proper interconnection and virtuous interaction of the eco-city with its neighbouring areas to achieve mutual support and benefit. Promote growth in key industries to make them bigger and stronger. Avoid homogeneous competition with neighbouring areas. Strive towards dislocation development. Accelerate the development of external rail traffic and highway networks to improve inter-region traffic capability and strengthen the foundation for coordinated development based on closely joined traffic systems. Tightly grasp the strategic opportunity provided by the coordinated development of the Beijing-Tianjin-Hebei Region and introduce non-core functional resources from the capital as quickly as possible.

Realise reproduction and popularisation: Summarise the experience of constructing the eco-city and embed them into systems, standards and plans for development and construction to generate “knowledge” which is scalable, flexible and practicable. Set up an international sustainable development exchange centre which is led by the government and subject to market operations to support the reproduction and promotion of the eco-city. Actively take part in developing standards for international sustainable development cities, propose standards for the sustainable development of medium and small cities, and set up marketisation standard certification service institutions to improve the international influences of the eco-city. Grasp the golden opportunities from the Belt and Road Initiative, the Strategy for Coordinated Development of the Beijing-Tianjin-Hebei Region and the development of the Xiong’an New Area. Actively cooperate with neighbouring areas and provide services to develop cooperative channels while expanding the eco-city's businesses and sharing successful experiences.

5. Outlook

What will the eco-city of the future be like? Figuratively, it is a process of stepping from “light green” to “dark green”. Specifically, it should be a foreseeable and reachable prospect that contains the most basic, practical and refined elements.

Fresh air: Blue skies and white clouds with no fog or haze, allowing people to breathe freely and comfortably.

Clean water: Crystal clear water bodies and beautiful landscape, portable tap water.

Noise: A quiet environment with low to no noise, allowing people to enjoy the peace and relax their minds.

Biodiversity: A Stable spectrum of life that coexist in harmony. Natural breeding of local animals and plants.

Green travel: All-direction rail traffic and slow-traffic system. Voluntary travel by bus, bicycle and foot.

Green building: More high-class green buildings. Allow the people to truly experience the advantages of green buildings.

Energy utilisation: Highly efficient renewable energy utilisation systems that reduce the use of fossil fuels and decrease carbon emission.

Water treatment: Improved rainwater collection and sewage treatment systems, higher water quality and wider application of treated water.

Less garbage: Save resources, reduce and sort garbage, with voluntary practising of the green living style.

Green economy: Clustered development of industries with high technologies, low consumptions and no pollution to generate development momentum.

Local employment: Providing more attractive employment opportunities

Open public space: Close urban and community parks allowing people to play and relax.

Community harmony: Harmonious neighbourhoods and joint governance. Sense of belonging, and regard for it.

Sense of safety: Social justice and equality. Make people feel at ease and relaxed.

Flexible infrastructure: Capable of coping with floods, strong winds, storms, fires and earthquakes.

Convenient public services: Hierarchical service facilities which are accessible by foot.

Affordable housing: Competitive housing quality and prices leading to sustained attraction of new migrants.

Smartness: Wide application of advanced technologies, ensuring visual, convenient and efficient urban management and public services.

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Imagine the future of the city: Here, people are the most important element and people-centred care is apparent everywhere. The air is clean, the water is crystal clear and the natural environment is pleasant, allowing people to be happy and relaxed. Within the city, resource consumption and carbon emissions are less, highlighting its ecological features. This city provides high-quality and accessible public services, where the people can freely enjoy a comfortable and satisfactory urban lifestyle. In this city, innovation is everywhere, bringing along enormous vitality. In this city, advanced technologies are extensively applied, giving the city a strong sense of modernity and relevance. In summary, this is a humane, green, liveable, lively, harmonious and smart city. It is an ideal home for people to live in.

Maybe to you, these visions of the future are basic. That's right: It requires ideological transformation and persistent efforts, which are not as easy as you may think, to do something basic extremely well. When these visions are realised, it will no longer be just a typical eco-city template. It will become a true eco-city, which is the original intention of China and Singapore. The “seed” has sprouted, flowered and borne fruit for a decade. We have reason to believe that this will produce more plentiful and beautiful fruits in the future.

Annex

Abbreviations

TEC (Tianjin Eco-city, or Sino-Singapore Tianjin Eco-City): Sino-Singapore Tianjin Eco-city
ECAC: Eco-City Administrative Committee
MOHURD: Ministry of Housing and Urban-Rural Development of the People's Republic of China
Joint Venture: Sino-Singapore Tianjin Eco-City Investment and Development Co., Ltd
Investment Company: Tianjin Eco-City Investment and Development Co., Ltd
TEC JSC: Tianjin Eco-city Joint Steering Committee
TEC JWC: Tianjin Eco-city Joint Working Committee
Framework Agreement: Framework Agreement on the Development of an Eco-city in the People's Republic of China between Governements of the PRC and the Republic of Singapore
Supplementary Agreement: Supplementary Agreement on the Framework Agreement on the Development of an Eco-City in the People's Republic of China between Governments of the PRC and the Republic of Singapore
Supplementary Agreement II: Supplementary Agreement II on the Framework Agreement on the Development of an Eco-City in the People's Republic of China between Governments of the PRC and the Republic of Singapore<
Commercial Agreement: Commercial Agreement on Sino-Singapore Tianjin Eco-city in Tianjin Municipality, the People's Republic of China, with Eco-City Administrative Committee as Party A and Sino-Singapore Tianjin Eco-City Investment and Development Co., Ltd as Party B
Joint Venture Contract: Joint Venture Contract between Tianjin Eco-City Investment and Development Co., Ltd and Singapore Tianjin Eco-city Investment Holding Co., Ltd/Sino-Singapore Tianjin Eco-City Investment and Development Co., Ltd
Administrative Provisions: Administrative Provisions of Sino-Singapore Tianjin Eco-city
"Three Strategic Positioning": To become a demonstration model of ecological civilisation construction, city of innovation for green development mechanism and cradle for developing eco-mindsets and culture.
"Three harmonies and three abilities": "Refer to people living in harmony with other people (including both current and future generations); people living in harmony with economic activities; and people living in harmony with the people"
Overall Planning: 2008-2020 Overall Planning of Sino-Singapore Tianjin Eco-city
KPIs Framework: KPIs Framework of Sino-Singapore Tianjin Eco-city
Implementation Plan: Implementation Plan for Sino-Singapore Tianjin Eco-city National Green Development Demonstration Zone
"Cooperation Zone": Within 30km^2 of Sino-Singapore Tianjin Eco-city
"Management Zone": The Costal Tourism Zone and the Centre Fishing Port included into the jurisdiction of TEC at the beginning of 2014, which is about 118km^2.

Postscript

Sometimes, something that looks simple is also the most difficult because all the fine details will add up to something that is bigger than the sum of its parts. Telling the story of how the TEC transformed from a wasteland to an eco-city is something that appears simple, but is definitely not easy. This book condenses the wisdom and efforts of Chinese and Singaporean colleagues.

The successful publication of this book was the result of the care and support of all parties. Compilation committees and consulting groups of both sides provided valuable opinions for this book. The compilation group on China Eco-City Academy spared no pains from converting its research into the first draft of this book. Colleagues of the Eco-City Project Office and the Centre for Liveable Cities proactively discussed and proposed revisions. Colleagues of functional departments of the Eco-City Administrative Committee, the Investment Company and the Joint Venture provided us with an abundance of materials and took part in discussions and revisions. They contributed greatly to the foundation of this book. Core members of the Compilation Group made significant contributions to the compilation, proofreading, revision, improvement and publication. The Centre for Liveable Cities translated and published the English version of this book. Wang Jianmin, a local photographer, and Hong Fuxiang, a teacher from TEC Huaxia Future School, provided photos that added colour to this book. Peng Zhengyang did the final compilation of this book. Tianjin People's Publishing House revised the entire book precisely within a short time, contributing greatly to the publication of this book during the eco-city's 10th anniversary. Thanks are also due to all other colleagues and friends for their care and support for this publication.

This book, with the targeted audiences of urban decision-makers, managers and researchers, aims to present a practical case of a newly built eco-city in a systematic and highlighted manner. It is not a theoretical work and lacks the accurate, professional and fastidious examination of chapter arrangement, theoretical framework of literal expression and connotation analysis. As decided by compilation groups on both sides, considering the preferences of global readers and to keep this book succinct, it does not contain contents related to the party that are extensive and important, and will be separately summarised and published. Your understanding is kindly appreciated.

Hopefully, this book will benefit the decision-makers, managers, researchers and those interested in the development of eco-cities. Mistakes are inevitable due to the limited capability of the compilers and lack of time. Your opinions are highly appreciated and this book will be further revised and completed in subsequent editions.

The achievements of milestones of the past, and the eco-city itself, will always continue to develop further. In a certain sense, the publication of this book not only summarises the past, but also reminds us to stay true to, and keep in mind, our mission and always to be ready to start from a new beginning. For ecological civilisation construction, today's success will be rewarded in the future. We sincerely hope that more colleagues working on eco-city development will join us in building a beautiful home for mankind.

Compilation Committee
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