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APEC Low-Carbon Model Town Development Model and Tool Kit Study

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APEC Low-Carbon Model Town Development Model and Tool Kit Study (LCMT-DMTK)

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1 Overview of Low Carbon Town

The concept of Low Carbon City originates in Low Carbon Economy, which was put forward in the context of coping with the global climate change and advocating less greenhouse gases emission during human production and living activities. In 2003, the government of United Kingdom published its "Energy White Paper" entitled "Our Energy Future: Creating a Low Carbon Economy", in which the concept of Low Carbon Economy was first put forward. The White Paper pointed out that Low Carbon Economy means to achieve more economic output by less natural resources consumption and environmental pollution, in order to create approaches and opportunities for a higher living standard and better living conditions, and to provide new business opportunities and more job opportunities for the development, application and output of advanced technologies. Low Carbon Economy gives consideration to both "Low Carbon" and "Economy", of which Low Carbon is a model that humans respond to the climate change to realize sustainable economic and social development. Low Carbon means we must reduce or even stop depending on carbon-based fuel to the greatest extent and realize energy utilization transition and economic transition in the pursuit of economic development; Economy, means we need to maintain a stable and sustainable economic development on the basis and in the course of energy utilization transition, however this concept should not exclude the maximum of development, output, and long-term economic growth.

As the major sites of human activities, cities consume a large amount of fossil energy and discharge 75% of the total global greenhouse gases emission and 80% of its contamination. In the course of accelerating urbanization, the faster the city expands, the weaker it will be since frequent climatic disasters will threaten the normal production and living activities of urban residents. Thus the city is not only victim of many significant environmental problems, but also, for its powerful resource distribution ability and influence, the most important platform of low carbon economy development.

According to the definition given by the World Wide Fund for Nature (WWF), Low Carbon City refers to a low level of resource consumption and carbon dioxide emission on the premise of high-speed economic development.

The definition given by the Climate Group indicates that Low Carbon City means to carry out Low Carbon Economy in the city, and to achieve a lower or even zero carbon dioxide emission. It is also generally believed that to build a Low Carbon City is to develop Low Carbon Economy with city as its carrier, to implement the concept of green traffic and green buildings, to change consumption ideology of the local residents, and to innovate low-carbon technologies, thereby reducing greenhouse gases emission to the greatest extent.

Other researches show that Low Carbon City is built under the objective of a low carbon society, with Low Carbon Economy as its development model and direction, and in which citizens are holding a low-carbon lifestyle. To develop a Low Carbon City aims to achieve an urban construction model and means of social development that will contribute to reduce carbon emission, on the premise of a constant improvement of living quality, by transforming the original economic development model, consumption ideology as well as the lifestyle of local residents.

A Low Carbon City, by means of developing Low Carbon Economy, innovating low carbon technologies and changing lifestyles, aims to reduce greenhouse gases emission to the greatest extent, to completely get rid of previous social economic operation mode that depend greatly on mass production, mass consumption and mass emission, and to form a economic system featured by structure optimization, cyclic utilization, and energy efficiency, as well as a healthy, economical, and low carbon lifestyle and consumption model, so as to realize a clean, efficient, low carbon and sustainable development of the city.

Low Carbon City contains the following four aspects: first, it requires a lower level of energy consumption and carbon dioxide emission, and carbon sources should be kept less than carbon sinks (carbon source is the process, activity or mechanism through which carbon dioxide is emitted into the air; carbon sink refers to the process, activity or mechanism that is used to clear up carbon dioxide). Second, it requires a low-carbon ideology and lifestyle of the citizens. Third, it emphasizes that enterprises should maintain a low-carbon production mode to increase energy efficiency and to reduce carbon emissions. Fourth, government should keep low-carbon society as its

objective, and provide policy and system guarantees to the construction of a Low Carbon City.

2 The Development Process of APEC Low Carbon Town

In June 2010, the project of developing Low Carbon Model Towns within the district of APEC was launched during the Ninth APEC Energy Ministers' Conference held in Fukui, Japan, and Yujiapu Central Business District of Tianjin was nominated as the first Low Carbon Model Town.

In November 2010, APEC Economic Leaders' Meeting was held in Yokohama. After giving full discussion of the wishes and approaches to integrate Asian-Pacific region to a higher degree in 21st century, centered on the topic of "Change and Action", they put forward the growth strategy of building a low-carbon society, promoting low-carbon policies and developing low-carbon industry. President Hu Jintao delivered a speech titled "Deepen Mutually Beneficial Cooperation and Promote Common Development", and initiated "to strengthen the cooperation of low-carbon demonstration projects in cities and towns, to promote energy conservation and emission reduction and to enhance cooperation in energy efficiency ". Later, APEC passed the Low Carbon Town Projects of Yujiapu Central Business District of China, SAMUI Island in Surat Thani Province of Thailand, Da Nang City of Viet Nam and San Borja, Lima of Peru.

Besides, other Member Economies of APEC have been carrying out practices in building Low Carbon Cities.

2.1 Australia

2.1.1 Adelaide

As the capital city of South Australia, Adelaide locates in the south of Australia with a population of 1 million. Adelaide is known for its large and numerous parks, bluestone buildings and relaxed lifestyle, and it is also Australia' fourth largest city with advanced automobile and electrical appliance industries. The city is planned and constructed concentratedly with many perfectly preserved old buildings in the urban area; and its

downtown is surrounded by parks or green spaces that are accessible on foot. The Second International Ecological City Seminar was held there in 1992. The Urban Ecology Australia devotes to changing dwelling districts into a ecological city—a community of vitality, justice, ecological sustainability and economical feasibility. Founded in 1991, this organization was recognized by the United Nations as a nonprofit and nongovernmental organization. The Ecological City Project of Adelaide has benefited greatly from the efforts of Urban Ecology Australia.

Fig. 1 Adelaide City

Source: http://cn.southaustralia.com/regions/adelaide-city.aspx

The Urban Ecology Australia believes that an ecological city should guarantee the residents a high quality of life by using the minimum of natural resources. They have achieved the objective of an ecological city from the following five aspects:

Use local materials, energy, air and water to achieve the best effect.

Blend the natural ecosystem into urban areas; introduce local wild fauna and flora and promote urban public space.

（1）Use vegetation to control urban micro-climate – to stabilize temperature and humidity.

（2）Create a joyful social environment to strengthen community life and social relationships.

（3）Support cultural innovation to enable people to prosper and develop their creative potentials and use new technologies to improve the habitability of buildings.

（4）Furthermore, they have proposed tailored principles in designing ecological city based on different elements of the city:

（5）City Structure: Rampant low density cities should be transformed to middle-high density urban residential areas network that is separated by green space and with limited size, making it possible for most citizens to walk or bike to workplace within commuting distance.

（1）Buildings: Buildings of an ecological city should make full use of the sunshine, wind and rainfall to meet the energy and water demands of the residents. Multi-layer residences are generally used to maintain green space to maximum extent.

（2）Biological Diversity: An ecological city should have corridors as natural habitats, so as to foster biodiversity and make sure that residents have a close contact with the nature and acquire pleasure form it.

（3）Transportation: Most food and other products of an ecological city should be from the inner city or neighboring areas to reduce transportation costs. Enabling most people to go to work on foot or by bicycle to minimize the demand of motor vehicles. Abundant public transportation connects to regional centers to meet the demand of further distance. The sharing of local cars will allow residents to use them when necessary.

（4）Industry: The products of an ecological city should be able to reuse, reproduce and recycle. During the production, attentions should be paid to the recycle of secondary products and the mobility of Minimum Viable Products.

（5）Economy: The economy of an ecological city should be labor-intensive instead of material, energy and water intensive, to maintain enough workload and minimize material consumption.

Fig. 2 The park of Adelaide

Source: http://www.australia.cn/destination/south-australia/adelaide/

With 29 parks, Adelaide is now among one of Australia's most environmentally friendly cities. Many other hotels have been following the example of Hilton to join the Green Action Plan and to advocate water saving and recycling.

Fig. 3 Activities in Adelaide

Source: http://www.australia.cn/destination/south-australia/adelaide/

As for activities, WOMADelaide is a completely green gala for the famous Clipsal 500 Adelaide and Santos Tour Down Under, both are low-carbon races. Global Green Challenge (formerly known as the World Solar Challenge) was held to lead the trend of "low carbon". A more important part in the project were the earthworms since Adelaide

Convention Center used 800 thousand earthworms to change the food debris into manure.

Adelaide is a city of bicycles, the Adelaide Bike Center possesses more than 500 bikes that are distributed to three sites for rent. One will be allowed to use the bicycle, helmet and lock freely all day long after showing his credentials (driver's license, passport or student ID card) at any site and completing the forms. What's more, Tindo is the first bus using solar energy in the world which runs between central and north Adelaide and is equipped with air conditioner and wireless network.

Fig. 4 The natural scenery in Adelaide

Source: http://www.australia.cn/destination/south-australia/adelaide/

In terms of recycling, the 140-year-old Adelaide Central Market can nowadays recycle more than 85% of its own garbage. The Parliament House, the South Australian Museum, the Art Gallery of South Australia and the Adelaide Central Bus Station are all equipped with solar panels on the roof. Other green projects including the rebuilding of Adelaide Zoo are mainly some hydraulic and recycling projects. Houses, apartment communities and students' dormitories are also among Adelaide's renovation projects of "green living".

2.1.2 Halifax

Halifax eco-city is located in the original industrial zone in Halifax Street in the city of Adelaide, Australia. With a covered area of 24 hectares, it is a mixed community with 350-400 households that is connected with the existing city life and facilities. Major buildings are dwellings in the community, which is equipped with facilities for business and community service.

As the first case of ecological city project, Halifax eco-city was mainly designed by architect Paul F Downton and political and ecological activist Cherie Hoyle together with other people. This project covers not only the physical environment containing communities and buildings, but also social and economic structure. It posed challenge to the traditional business development model by initiating the ecological development pattern of “community-driven development”. In February 1994, Halifax eco-city project won the “International Ecological City Award”; and in June 1996, this project was evaluated as the best practical example in the “City Forum” during the Second Conference of UN-HABITAT held in Istanbul.

Halifax eco-city has a square planning grid with the neighboring apartments encircle a square courtyard, while all courtyards are surrounded in various ways in order to avoid repetition. In addition, they are occasionally interspersed with circular elements to present different themes. Rammed earth is among the major raw materials in constructing the buildings while cob walls have developed the Rammed earth construction technology; they are standing on the earth, and finally return to the earth. This design, which can support the floor, the roof, and accumulate heat, in addition, this design can also absorb and insulate sound, and contribute to a harmonious neighborhood relationship within the compact city, can be used for hundreds of years.

Buildings in Halifax eco-city vary from 2 to 5 stories with gardens and gazebos on the roof which are suitable for leisure and rest and can also be planted with fruit trees or vegetables to promote communication among neighbors. The roof gardens of the whole area are equipped with more than 1000 solar collectors which could provide energy for heating, cooling and charging. The spatial pattern of the buildings changes from being open to closed appropriately according to the spontaneity and preference of modern people, making it an evolutionary architecture in vibrant atmosphere. Such

ecological buildings adopt energy-saving construction materials that are non-poisonous and non-allergic to our bodies, emit less greenhouse gases, which in the meantime can avoid the use of rare woods.

People yearn for a healthy and balanced environment when it comes to the finance, society and culture while they also pursue tolerance, equality and participation, thus the city should belong to the citizens living there. City planners are making efforts to change the fact that traditional commercial development put more emphasis on how to take full advantage of the field to build as many houses as possible. Because of the obvious contrast in principles and values, traditional commercial development in Halifax is faced with lots of challenges from ecological development. (See Table 1)

Tab. 1 The comparison of traditional development mode and ecological development mode

Type	Traditional <interest-driven>	ecological <community-driven>
Goal	acquire maximum profit	satisfy the community
Approaches	land speculation, communities developed from private interest	land cultivation, community authorization
Sources of fund	arbitrary——mostly profitable banks	ethical investment and local exchange trade system——capitals will be returned back to communities
Sources of materials	any sources that are “convenient”——market-driven and capital-intensive	prudent chosen——healthy, environmentally friendly, local and labor-intensive
Politics	exclusive, corrupt, expedient and self-centered	tolerant, moral, open and ecology-centered
Economy	The nature should serve the human beings and the economy.	The economy should serve the community and the ecology.

Halifax has put forward 12 planning principles aimed at the development of ecological city:

（1）Restore degraded lands: In the development of human settlements, pay attention to the recovery of the ecological health and potentials of the land.

（2）Adapt to the biota: Respect, value and adapt to the relevant parameters (ecological factors) of the biota, development mode should be adapted with the landscape, the natural form of land as well as its limit.

（3）Balanced development: Balance the ecological relations between the development intensity and the bearing capacity of land, and to protect all the existing ecological characteristics.

（4）Avoid urban sprawl: Draw a permanent natural green belt, relatively improve the development density of human settlements or exploit at a development density within ecological limit.

（5）Optimize energy utility: Realize low energy consumption, and the use of renewable energy, local energy products and resources recycling technologies.

（6）Be conducive to the economy: Support and promote appropriate economic activities.

（7）Provide health and safety: Make use of appropriate materials and space to provide a safe, healthy pla）ce for living, working and entertainment, under the condition of sustainable ecological environment.

（8）Encourage community building: Create wide-ranging and diverse social and community activities.

（9）Promote social equality: Economic and management structures should reflect principles for social equality.

（10）Respect the history: Significant historical heritage and facilities should be reserved to the uttermost.

（11）Enrich the cultural landscape: Keep and promote cultural diversity, and ecological awareness should run through the development of human settlements, construction and maintenance.

（12）Improve the biosphere: Improve the biosphere through the repair, supplement and improvement of atmosphere, water, soil, energy, biomass, food, biodiversity, habitats, ecological corridors and waste to reduce the ecological impact of urbanization.

Tab. 2 The ecological list of Halifax eco-city

		-10	-7	-5	-2	+2	+50	+75	+10	
	Departure of sustainability	0	5	0	5	5			0	Tendency to sustainability
Air	pollution									purification
Water	contamination									purification/ circulation
Soil	degradation									restore
Energy	unrenewable									renewable
Biomass	decrease									Increase/ stabilize
Food	consumption									produce
Biodiversity	decrease									increase
Habitat	destruction									create
Eco-corridor	decrease									increase
Waste	generate									recycle
General effect						+2	+10	+30	+30	

Halifax proposed 21 specific operation strategies based on the above principles:

（1）Ecological development potentials: Ecological development should start from the potential analysis of ecological land, which means to make an evaluation of its potentials. Urban development should be adapted to the potential pattern of land utilization established on the basis of ecological principles, so that the city's ecological development can play a positive role in improving the overall ecological health.

（2）Utilize existing technologies: Ecological development should use simple, effective and appropriate technologies rather than foreign or unnecessary ones that are usually complicated and energy-intensive.

（3）The integration of buildings and sites: To integrate the buildings and sites following esthetic standards, but most importantly, following the ecological functions standards. Buildings should be completely combined with the landscapes and plants. The integration of buildings and sites reflects both the economic and ecological features of the buildings. The most important relations of any building lies in the coordination with its surrounding environment rather than simply take up the space.

（4）Green buildings: A healthy building should be beneficial to the environment in its materials, structure, design and process of construction, etc.

（5）Micro-climate: Each building affects the micro-climate of its location, and cities influence the climate of the region. Ecological development requires that building environment should follow the changes of micro-climate or provide a shelter to meet the requirements of local residents.

（6）Close-range planning: Effective planning can reduce energy consumption to the minimum. In terms of traffic, this objective can be achieved by reducing traffics and shortening the distance to the destinations. Close-range planning should firstly meet the needs of walkers, and advocate the new standards of returning back from machines to human beings.

（8）Static traffic: When considering using cars, vans or trucks, static traffic should be taken into consideration together with the design and layout of traffic. Driveways should be restricted so that private cars are not allowed to use the driveways to reach all other buildings except emergency vehicles; Parking Spaces should be reduced to the minimum size with multiple functions, such as collecting rainwater.

（9）Self-construction: Self-construction is an important part during ecological exploration mainly for 2 reasons: Firstly, people have the rights to decide whether to replace their labor by any currency so that the poor, the unemployed can still contribute to the urban development. This principle is particularly suitable for developing economies or developed economies undergoing economic recession. Secondly, it is impossible for ecological system to maintain unchangeable, ecological exploration should allow every citizen to make proper adjustment in their “backyards”.

（10）Recycling materials: Encourage appropriate use of recycling materials to reduce waste and unnecessary energy consumption. Buildings should make use of recycled materials so that all or part of its components can be easily recycled. Building materials should be selected to fit their functions and life cycles.

（11）Regional resources: Building materials and components should mainly be taken from the local resources so as to reduce energy consumption and waste materials on the basis of overall system analysis. This objective will help to promote the development of regional economy.

（12）Water sources and water ecology: Exploited water sources should be taken from river basin of the region. The previous water circulation pattern should be maintained adapted to the surrounding areas after the artificial environment has been built.

（13）Power supply: Ecological development seeks a self-sufficient energy supply. Therefore, some human activities that require large amount of energy can be supplied by more centralized energy sources such as desert solar power plants. Basic energy should come from renewable energy sources, for which although it is necessary to use fossil fuel supplement in the short or medium term, this kind of energy supply should be easily transformed to renewable energy structure, such as gas transforming to methane or hydrogen. Energy use should be based on thermal efficiency, so gas is best used for heating and cooking instead of generating electricity.

（14）Waste: Nothing in nature can be seen as waste. All system resources, energies and materials used in the ecological development are designed to produce little or no waste.

（15）Planting: Planting should be a priority during ecological development with priority of native vegetation as well as certain ecological regulation targets.

（16）Food: To improve the productivity of city landscape as much as possible, and to increase food production such as vegetables and fruits.

（17）Art: Art should be combined with the construction and operation of the ecological development sites. It should be a part of the buildings and physical environment, and a part of the citizens' life like the air they breathe and the water they drink.

（18）Industry: Industries with its purpose of production, procedure and products conforming to the general objectives of ecological development are allowable; industries concerning military technologies are not permitted, not including space technologies.

（19）Education and skills training: Education and skills training are needed through the whole procedure and operation of ecological development.

（20）Sales management and the relations with community: The sale of ecological development should be ethical with conformation to its general objectives and

management should cater to the needs of communities. Continuous community links between the initiators and professionals should be combined with the ecological development. All sales, management activities and relations with community should be ethical and equal.

（21）Community: Demands of the communities promote ecological development while ecological development in turn meets the needs of communities. Communities are required to carry out self management.

（22）Funding: Sources of funding of ecological development should be ethical, and exclude financial support from mining activities for example. Ideally, all the funds should be from local investment.

2.2 China

Urbanization is the way China must take to develop, and how to achieve a low-carbon, intelligent and sustainable urbanization is an important issue calling for China's continued exploration. Back in 2010 and 2011 , Chinese leaders actively proposed to develop low-carbon model towns when they were attending the APEC Economic Leaders' Meeting. In 2012, the National Energy Administration submitted a Report on APEC Low-Carbon Model Town – Development in China during the 20th APEC Economic Leaders' Meeting. In 2014, China hosted the 22nd APEC Economic Leaders' Meeting, during which it launched Low Carbon Model Town World Campaign all over the economy. Representative towns were picked as test cases to develop a database for the low-carbon town project and to promote the campaign through project cooperation.

2.3 Yujiapu

Yujiapu, a financial district located in the CBD area of Tianjin Binhai New Area, has been designated to be one of the low-carbon model towns from the very beginning of its foundation. From the pilot program in the area, China will create a path with regional characteristics for low-carbon development and provide advanced low-carbon concepts and experiences for low-carbon town development both home and abroad.

Fig. 5 Yuiapu

Fig. 6 Yujiapu financial district

During the 9th APEC Energy Ministerial Meeting in June, 2010, Yujiapu financial district was identified as the first case of APEC low-carbon model towns. In June of 2011 , 120 experts and officials from 21 APEC member economies passed the Concept Design for Yujiapu as a Low-carbon Town after a field inspection. Later in September, the industry, layout, construction, energy, transport, resource regeneration and Key Performance Index (KPI) passed the examination of the experts from respective APEC

member economies, which were also referred to as “Five Plus One Elements”. First, use of low-carbon energy: manifest high efficiency and low consumption of the energy; second, low-carbon transport: advocate walking and railway transport underground in cities with narrow street blocks and dense road network; third, low-carbon buildings: fully implement of the Chinese national standard on green building and energy certification of buildings; fourth, public services: Build a new social service system at the core of intelligent city; fifth, low-carbon system management: Establish a management system at the town-level, including carbon footprint verification, regional carbon information platform, carbon trading, industry standards for admittance into the area , government subsidies and incentives, etc. The ONE element of the Five Plus One Elements is a highlight, which means to showcase technology and pilot facilities and equipment which can be presented as demonstration application case in the area.

Fig. 7 Buildings in Yujiapu

All buildings in Yujiapu are designed up to the Chinese standards for green buildings and in accordance with the indication system and key elements of low-carbon town. Some of the buildings also followed the American LEED standards for green buildings. That makes a 100% coverage of green buildings and 70% of high-star rated green buildings in the target area.

Fig. 8 Green building in Yujiapu

In terms of transport, Yujiapu advocates public transport and walking and designed two horizontal and two vertical subway lines as well as an intercity high-speed railway connecting Beijing and Tianjin to provide convenient and smooth public transportation system for the district. Meanwhile, wide underground space and business streets are also designed to achieve seamless connection between buildings and housing clusters in terms of public transport, work and shopping and to maximize travel convenience. In this way, less fossil fuel is consumed due to less use of vehicles and an integrated low-carbon transport system is provided to the district.

In terms of energy , a report on Regional Energy Research and Employment Analysis is compiled based on a comprehensive study of Yujiapu program in terms of the city design, traffic planning, use of wind and solar energy and geothermy, renewable water resources, garbage disposal, cooling and heating system as well as green power grid. The report intends to explore an intensive low-carbon technology and set a reasonable target for carbon emission reduction. In terms of optimizing regional energy supply and use, in-depth study of regional energy structure, and cooling and heating system is conducted. Several energy centers are designed in the urban open space and parkland taking into account of the layout of underground parking lots and using low-carbon resources such as waste heat from power plants, electricity during off-peak hours and ice thermal storage technology. The traditional machine room for cooling and heating in each building is replaced, and energy and land

resources are intensively utilized to the maximum extent so as to provide green resources to the financial district.

In the construction process, a study of low-carbon construction technology is carried out, and guidelines are formulated to guide the construction in the purpose of improving low-carbon awareness of the construction personnel and reducing carbon emissions during the construction.

2.3.1 Yanqi Lake Convention Center

Yanqi Lake International Convention Center was the main venue for APEC 2014. Low-carbon eco-friendly technologies including passive energy-saving design, natural ventilation and natural lighting are extensively used in the center.

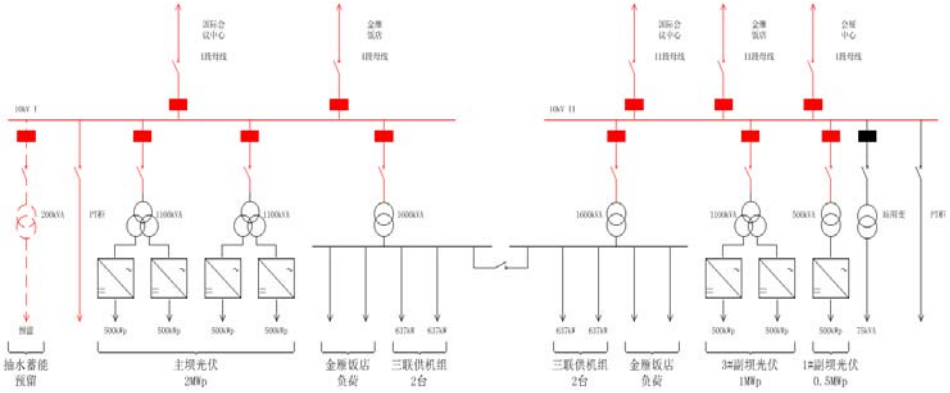

Fig. 9 Energy Saving design

As regards to energy, solar photovoltaic plants are constructed on the dam of Yanqi Lake reservoir. Solar water heating system, geothermal heat pump system and smart micro grid are set up in each building to provide combined cooling, heating and power with the technology of generating power from gas fire and get heating and cooling energy from the waste heat. Large numbers of charging piles are set up so as to promote the use of electric vehicles. On-site sewage treatment system is constructed for rainwater collection and reuse, and disposal of kitchen waste.

Fig. 10 Eco-system of the region

Low-carbon technologies and solutions have been put forward at the planning phase for construction. The original eco-system of the entire region has been retained to a large extent thanks to the precondition of keeping trees during planning and designing. Segmentation of the area from pipelines is largely avoided thanks to central heating and large-scale pipeline arrangement from distributed energy systems. The original topography is also made good use. The north slope of the main venue is about 9 meters higher than the south. Acting according to the circumstances, the designers made the north ground floor on the same horizontal line with the south second floor, and parking lot and kitchen at the north basement. In this way, energy consumption of the parking lot and kitchen is lower, ventilation of the whole building better and the landform largely retained.

Fig. 11 Low-carbon operation and maintenance

Optimizing the design of the construction team and low-carbon operation and maintenance are reinforced during construction. As for building the circular roof with a radius of 120 m, the original plan was putting it up after having finished the pillars. Later it was adjusted to lifting up the whole building to the target position after having finished it on the ground, which greatly reduced energy consumption during construction.

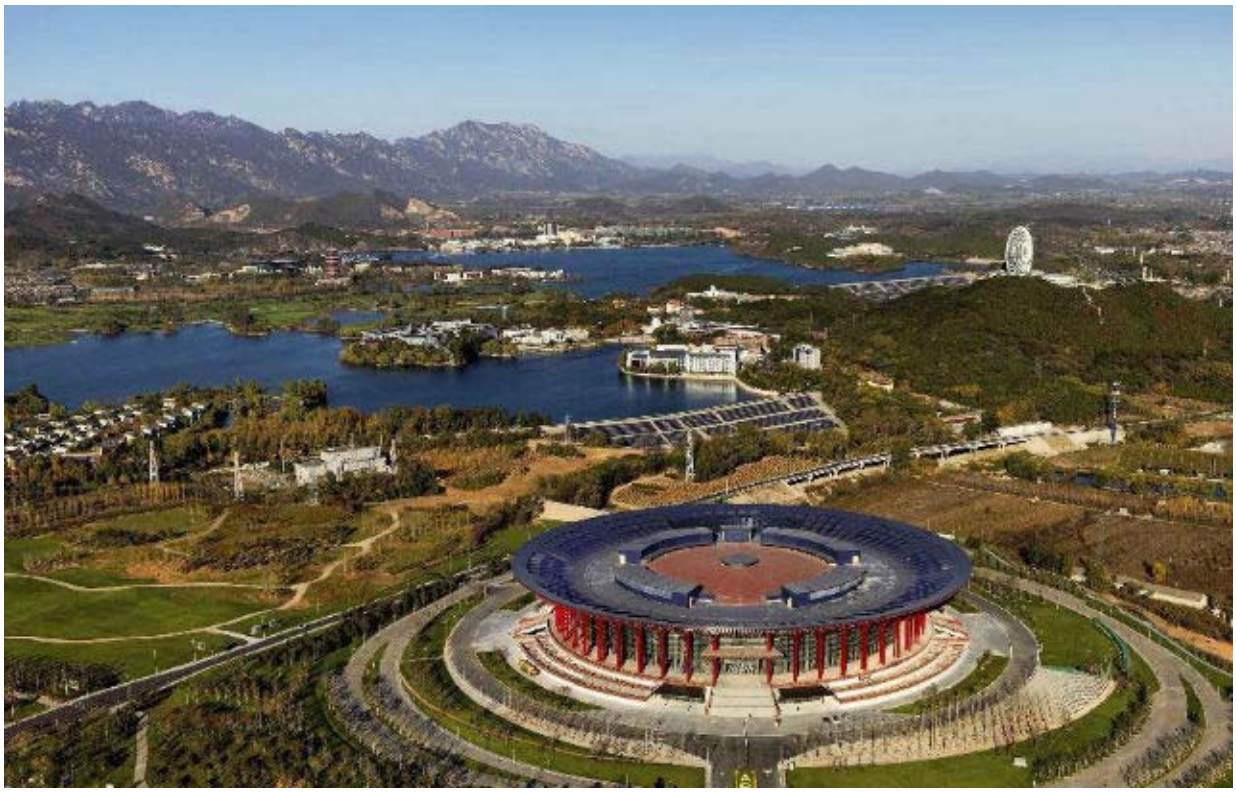

Fig. 12 Yanqi Lake

Great emphasis is attached to the carbon neutrality of the Yanqi Lake convention center, and third-party international organizations are invited to conduct an overall investigation and calculation of carbon emission. The forecasted carbon emission is 3,800 tons of carbon dioxide, about 47.7 g per square meter of the floor area.

Fig. 13 The construction in Yanqi Lake

Fig. 14 The project planning chart

Fig. 15 The photos of Yanqi Lake

Fig. 16 The map of Yanqi Lake

2.3.2 Shanghai

In the process of turning into a low-carbon city, Shanghai attaches great importance to the energy consumption of buildings. It chooses office buildings, hotels and shopping malls as pilot cases to conduct energy auditing and disclose energy consumption in the purpose of increasing energy efficiency of large buildings. Property management personnel in public buildings will also be trained to improve their ability of energy-saving operation. In order to reduce carbon emissions and achieve sustainable development, “low-carbon economy pilot zone” is to be established in Lingang New Town in Nanhui District and Chongming Island in Shanghai so as to promote low-carbon economy. The late-mover advantage of Lingang New Town and Chongming Island will be fully used to establish and complete the policy framework for low-carbon development. Comprehensive practice zones including low-carbon communities, business centers and industrial parks will be built in both areas to promote integrated application of low-carbon technology and development of low-carbon economy, and to explore new way for Shanghai to turn itself into a low-carbon city. The Shanghai World Expo Park has made a very good exploration in low-carbon development.

In 2001, the Chongming Island was defined to be an eco-island and strategic space for future development of Shanghai in the city planning. After three years organized selections and rounds of international bidding, ARUP and Shanghai Urban Planning and Design Research Institute collectively formulated Detailed Regulatory Planning in Dongtan, which explicitly expressed that the goal of making Dongtan the world’s first sustainable eco-city is to turn it into an eco-city first. The planned floor area for Dongtan Eco-city is about 86 square kilometers and the start area 6.5 square kilometers with a population of about 80,000. The eco-city is scheduled to be completed by 2040. Dongtan eco-city is comprised of three sections: international wetland park of 24 square kilometers, eco-agriculture park of 27 square kilometers and eco-towns of 35 square kilometers.

Shanghai attached great importance to improving energy efficiency and employing renewable resources when preparing for the World Expo. All the energy used in Dongtan, Chongming Island is from renewable resources such as wind power.

Learning from its neighboring downtown area, Dongtan is seeking to reduce water consumption per capita 43% and waste landfill 83% and realize zero carbon emission from transportation. Dongtan eco-city is promising to become the world's first carbon neutral zone (with zero carbon dioxide emissions). In this eco-city, heat and electricity will directly come from wind power, biomass energy, garbage power and solar photovoltaic panels on the top of urban buildings. The tallest building in the city only has 8 floors, and it's built with environmentally friendly technology. The lawn and plants on its roof is the natural heat shield for the eco-city and also a storage to collect rainwater to irrigate. Emission of carbon dioxide from the area built at the first phase is expected to be reduced by 350,000 tons annually, and people will be traveling by walk, bicycle, fuel-cell bus and water taxi. Exclusive pavement for pedestrians and lanes for bicycles will be built. The longest walking distance to bus stops nearby will take less than 7 minutes. Carbon dioxide emissions will be reduced by 400,000 tons per year in this way. System to collect, process and reuse water has been established in downtown area, and 80% of solid waste has been recycled. The most eminent feature of Dongtan eco-city is that it's going to build an eco-system of low-carbon and low consumption of water and energy. Dongtan is going to set an example of how to develop in the future for China or even for East Asia – an example of how to keep sustainable development in cities in post-industrial age, and an example of how to pursue a life of best quality.

2.3.3 Baoding

As a pilot city under the World Wildlife Fund (WWF) program, Baoding in Hebei Province, China proposed a strategic concept of "Baoding, China Power Valley" in 2006. It attempts to build an industrial and enterprise cluster relying on the new energy and energy equipment industry in the national hi-tech zone in the city. Seven industrial parks covering industrial chain of wind power, solar PV, and energy conservation will be further developed and industrial systems including photo electricity, wind power, biomass power, stored power and power transmission are to be nurtured. Meanwhile, endeavors are going to be made in terms of R&D, personnel training, business service and industrial manufacture to make a complete industrial chain.

In December 2008, Baoding municipal government announced the Tentative Opinions on Building Low-Carbon Cities, and drafted the Outline of Program for Developing Baoding as a Low-Carbon City (2008-2020). Baoding came up with two phased goals for its low-carbon development roadmap, setting the target for carbon emission reduction and proportion of the added-value of new energy industries in the industries above a designated scale by the year 2010 and 2020. In 2010, carbon dioxide emission per thousand capita was 25% lower than 2005, and the added value of new energy industry accounted for 18% of that of industries above a designated scale. By 2020, carbon dioxide emission is expected to be 35% lower than 2010, and the proportion of the added value of new energy industry to reach 25%.

In order to accelerate the development of new energy and energy equipment manufacturing industry, six industries consisting of solar photovoltaic power generation, wind power, low power consumption, energy storage, power transmission and electric power automation need to further improved. And a supporting industrial system for low-carbon city should be established to build China Power Valley. Low-carbon awareness of organizations at each level and of citizens should be awakened through activities of all forms, and low-carbon way of living and city construction should be promoted as well. Moreover, energy reservation and low carbon emission should be advocated in enterprises, countryside, buildings, urban transportation and trade. Six key projects are comprised of “China Power Valley”, “Solar City”, urban ecological environment construction, low-carbon running demonstration of office buildings, low-carbon community demonstration and integrated low-carbon urban transportation system.

Tab. 3 Six key projects

key projects	main content
“China Power Valley”	To build an international manufacturing site in about ten years for new energy and energy equipment with industrial parks covering solar photovoltaic power generation, wind power, power conservation, stored energy, power electronic device, power transmission and electric power automation.
“Solar City”	To realize overall utilization of solar energy in manufacturing industry and

	daily life in the city in about three years.
Urban Ecological Environment Construction	To strive to realize concentrated heating in urban area so as to get rid of scattered coal-fired boilers in three years and to provide central heating to satellite towns. To accelerate the construction of urban water system and renovate moat and floodwalls; also to take Green Action in order to realize per capita green area of 13.5 square meters, greening ratio 40% and green coverage 43% , levees on the moat and development transformation; implementation of the " shade action " , 2015 , the per capita green area reached 13.5 square meters , green rate of 40 %, green coverage rate reached 43 %.
Low-Carbon Running of Office Buildings	To accelerate low-carbon running of office buildings of governments at all levels by replacing energy-saving light bulbs, installing solar lighting system, promoting e-government system, using less night lighting and air conditioner and establishing a system for energy demand and use in office buildings.
Low Carbon Community Demonstration	To actively promote low-carbon community planning, construction technology and community management. To carry out low-carbon community pilot demonstration project and get down to design before 2010. And to endeavor to realize the scale of low-carbon community 50% bigger than that of current ones before 2015.
Integrated Low-Carbon Urban Transport System Integration Project	With regard to urban planning, a rational distribution of working and living area, public facilities and commercial establishments in both main urban area and satellite towns is needed to reduce unnecessary traffic demand. At the same time, construction of fast public transportation networks between urban clusters should be stepped up. By 2015, a rapid transit system and fast public transportation network in urban area and between urban area and satellite towns should be completed. Increasing of vehicles of high fuel consumption and high pollution should be curbed. Use of energy-saving vehicles, the ones fueled by new energy and electricity should also be encouraged. To build 12 to 15 compressed natural gas stations and increase the proportion of gas-fueled buses and taxis of the total vehicles to over 20% by 2012.

2.3.4 Sino-Singapore Tianjin Eco-City (SSTEC)

"Master Plan for Sino-Singapore Tianjin Eco-City (2008-2020)", was launched in November of 2007 and would be accomplished by September 28, 2008. In Sino-Singapore Tianjin Eco-City, the focus of the program is on infrastructure in the starting area, environmental management, industrial introduction and ecological housing. Solar heating and ground source heat pump technology in ecological houses and large public buildings. Moreover, the construction of wind power and photovoltaic power generation programs, and of cooling and heating energy supply station in the anime comic park as well has been started. In order to meet the need of connecting renewable resources to the power grid, the eco-city cooperated with power grid companies on building a smart power grid featuring informationization, automation and interactiveness and a sustainable energy supplying system characterized with security, reliability, clean, good quality, high efficiency and interactivenss.

Fig. 17 Sino-Singapore Tianjin Eco-City

SSTEC formulated a series of stipulations on building eco-cities including comprehensive eco-city index system, overall city planning, standard for green buildings and promotion of low-carbon industries. In order to achieve the goal of building the eco-city, a total of 26 indicators guiding the construction project has been detailed into 51 key elements, 129 essential steps, 275 control targets, 723 control measures and 100 statistical methods, fully covering key areas including energy conservation and emission reduction, use of water resources, green building, green traffic, renewable resources and waste disposal. In addition, the eco-city formulated

and promulgated standards for green building design and construction. And promising progress has been made on research of affordable housing policy and new social management. All these contribute to the standard system for developing the eco-city.

Fig. 18 The standard system for developing the eco-city

2.3 Hong Kong, China

Hong Kong is one of the world's largest financial center, freight center aviation center. Although it only has a population of over 7 million, there are more than 30 million visitors and tourists pouring in. Therefore, Hong Kong sets specific goals for low-carbon development and workable measures to keep its sustainable development.

Although the total area of Hong Kong exceeds 1100 square kilometers, its urban area only accounts for a quarter of that. Besides, 70% of the total has not been reclaimed yet, of which 43% is natural parks. Since 1990, a series of measures have been taken by authorities in Hong Kong to cut emissions from the major sources including power plants, transportation and industrial activities in the aim of improving the air quality. These measures include requiring local power plants use the latest emission reduction technologies and cleaner fuels, adopting the best international practices in regulation of exhaust emission and fuel standards and enforcing the use of ultra-low-sulfur diesel by all industrial and commercial enterprises.

To effectively improve the overall air quality in Hong Kong, low-carbon living tips, use of natural gas and renewable energy, increase of natural gas power to 50%, use

and increase the proportion of natural gas to 50%, disuse of vehicles of heavy pollution and use of hybrid electric, electric vehicles or other similar environmental friendly vehicles are advocated. Besides, local ships are only allowed to use ultra-low-sulfur diesel which has been denitrated. Efforts also been made on the use of electrified support equipment for ground service.

Meanwhile, the local government also increased subsidies for energy-saving buses and vehicles in Hong Kong, which add up to over 500,000 (including multi-purpose vehicles and private cars). That makes 85 vehicles per thousand people, which is relatively low globally. Aside from the policies, the authorities also uses fiscal and taxation measures to reduce the emission of greenhouse gases, such as the introduction of environmental friendly electric vehicles and imposition of high tariffs on imported vehicles.

Given the high expectations of Hong Kong residents on environment protection, the strictest regulatory standards are used in each area. Taking diesel as an example, Hong Kong ushered in the Euro V Emission Standard for Diesel Vehicles. The target of carbon emission reduction set in 2009 is to decrease by 50-60% from the current level by 2020. If the target is accomplished, the greenhouse gas emission in Hong Kong in the next decade will decrease one fifth to one third of 4200 million tons.

Environmental protection is a systematic work, and thus energy conservation and emission reduction in other areas other than air pollution also need to be dealt with, such as solid waste disposal, treatment of water resources and use of new energy. At the moment, the daily sludge in Hong Kong amounts to over 800 tons, and the figure will soon increase to over 1000 in a few years. In order to deal with the situation, the local government built a sludge treatment facility in Tuen Mun. Its maximum daily capacity is 2000 tons with a floor area of 7 hectares. It’s also attractive due to the exterior design themed ocean waves.

In the field of water treatment, centralized sewage collection and management will be carried out. Sewage from all districts of Hong Kong will be delivered to Stonecutters Island Sewage Treatment Works and then drained out to the sea after being disinfected. The treatment ability of the works including sterilization needs to be constantly improved.

Energy conservation in low-carbon life is also reinforced from system and management in other areas. For example, the electricity use in buildings in a district is centrally controlled to cut the waste of energy. At present, strict standards have also been set on energy conservation in buildings. Buildings to be built and renovated need to follow the rules on selection of building materials and installation design of systems and etc.

2.4 Japan

As the initiator of Kyoto Protocol, Japan made corresponding plans based on a series of ideas aimed at creating a low-carbon society. The concept of “low-carbon society” holds the belief that low-carbon economy cannot exist without the idea of “low-carbon society”. The principles it upholds are as follows: reduce carbon emission; advocate frugalness; reach a life of high quality through simpler lifestyle; shift from society of high consumption to that of high quality; live in harmony with nature; keep natural environment preservation as the original pursuit of human society.

In April 2004, Global Environment Research Fund founded by Japanese Ministry of Environment launched a research program titled “Prospects of Japanese Low-Carbon Society in 2050”. This program involves around 60 research personnel from colleges, research institutions and corporations and so on. The researchers are divided into 5 teams which focuses on 5 different aspects, namely, development scenarios, long-term goals, city structure, information and communication technology and transportation. At the same time, this project team, together with some colleges and overseas research institutions, aims to work out specific measures in terms of technological innovation, institutional reform and change of lifestyle by studying the scenarios and roadmap of the Japanese low-carbon society in 2050.

Japanese Ministry of Economy, Trade and Industry compiled the *New National Energy Strategy* in May 29, 2006, striving to promote the implementation of energy conservation and emission reduction in all respects. The strategy includes the following goals. First, to form the most advanced energy supply-demand structure in the world. Second, to enhance cooperation in resources-oriented diplomacy and energy environment. To achieve this, Japan should carry out the strategy of overall resource

supply by establishing relationship with more host economy of the resources and providing support for its companies to develop resource in the host economy of the resources and pursuing more diverse source of supply. By 2030, the proportion of trading volume of crude oil controlled by domestic businesses in Japan's total imports of crude oil is hoped to increase to 40%. At the same time, Japan will also carry out Asia energy and the environment cooperative strategy by cooperating with Asian economies with increasing energy demand such as China and India in areas of energy conservation, efficient use of coal, production safety, new energy, and nuclear energy. Third, to strengthen emergency capacity. Fourth, to make energy technology strategy.

New National Energy Strategy proposes to carry out plans in 6 areas, including developing energy-saving technology, reducing the dependency on oil, promoting diversified energy use. It also focuses on reducing the dependency on oil by developing renewable energy sources such as solar, wind, fuel cell and Phytofuel and promotes the international cooperation in energy programs such as renewable energy power generation. To increase the energy efficiency, Japan has made 4 plans, one of which is energy conservation. Its goal is to increase efficiency of energy by at least 30% by 2030 through the means of technological innovation and improvement of social system. To reach this goal, Japan plans to promote energy-saving technology strategy by setting out energy-saving standards for different sectors and carrying out evaluation.

In February 2007,the global environmental research foundation project team of the Ministry of the Environment issued a report titled"Japan Low-Carbon Society Scenarios: Feasibility study on emission reduction of CO2 by 2050: 70% lower than that of 1990". It suggests that the emission in Japan is expected to be 70 percent less than 1990,and Japan can still meet the resources requirement of social and economic development by 2050 at the same time. Japan's capability of relevant technology affirms the feasibility of Low-Carbon Society. The proposal of low-carbon planning proposed by Ministry of the Environment of Japan advocates the prudent spirit of making the best of resources,and raises the living quality through easier lifestyle,whose target is transforming the high-consumption society to a high-quality one.

In May 2007, Ministry of Economy,Trade and Industry to decided to put 209 billion yen into developing the technologies of clean energy vehicles,which was not only to

decrease fuel consumption greatly, but also to reduce the emission of greenhouse gases. In June 2007, Japan's Cabinet Council suggested its goals to overcome the environmental crisis like global warming and achieve the goal of "building sustainable society" in the 21-Century National Strategy based on Environment. To achieve these goals, it proposed to build a "low-carbon society", "recycling society"and "a society where people and nature co-exist harmoniously" comprehensively. The Earth's Environment Branch of the Japan Central Environment Council discussed basic concept, concrete conceptualization and implementation strategy in making the building of a low-carbon society a reality.

Since September 2007, Japanese relevant government departments have sorted out the basic concept and revealed the scheme of building low-carbon society based on suggestions of experts and pundits through the convening of 12 meetings. The Earth's Environment Branch of the Japan Central Environment Council proposed 3 basic concepts on creating a low-carbon society. First, the key of the achievement of the minimum emission of carbon lies in constructing a social system in which all the social sectors including industrial circles, government and citizens could be aware of the rreplaceability of global environment, rule out the traditional view characteristic of a social model of mass production, mass consumption and mass waste. Before making final decision, they can take into full account the utilization of low-carbon energy, promotion of circular economy and increase of the efficiency of resource utilization to realize the minimum emission of carbon. Second, the achievement of affluent and prudent life. It would help encourage people to get out of the trap of gaining the sense of affluence through mass consumption, especially for developed economies. The change in people's values by choosing and pursuing plain lifestyle and plentiful spiritual world will accelerate the reform of social system,and make it easier to build a low-carbon and affluent society. In addition, production department should take into consideration of consumer's preference to reform itself. For example, to commit itself to researching and developing environmentally friendly products based on consumers' tendency to choose these products. Third, the achievement of harmonious co-existence with nature. To preserve the source of absorbing carbon dioxide as well as resolve the unavoidable problem of global warming, we should protect the diversities

of natural environmental resources such as forests and seas and make them renewable. We should also promote the development of “Natural Harmonic Technology”including utilization of social biomass across regions, to ensure the places and chances to get in contact with nature.

The Council for Science and Technology Policy (CSTP) of the Japan’s Cabinet announced the Low-Carbon Technology Program on May 19th, 2008, which put forward technological strategies for realizing low-carbon society and measures for facilitating environment, energy and technology innovation. The program involved innovation in five key technical fields, including super combustion system technology, super dimensional energy utilization technology, energy-saving information life space creation technology, low-carbon transportation society construction technology and new-generation energy-saving semiconductor device technology etc. The Japanese government also made the “technical strategy map”, according to which the national innovation system comprised of the government, industry and academics is encouraged to mobilize national and civilian resources, carrying out comprehensively innovation researches on low-carbon technology. The Program is actually the technical strategy for Japan to realize the low-carbon society.

The Global Environment Research Fund project team of Ministry of the Environment of Japan also completed the research report for *A Dozen of Actions towards Japan Low-Carbon Society Scenarios in 2050* in May 2008. The dozen of actions are related to residential sector, industrial sector, transport sector, energy transformation sector and relevant overlapping sectors, each of which includes three portions of future goals, obstacles in achieving the goals and the corresponding strategic countermeasures as well as processes and steps for implementing the strategic countermeasures. The new Japan Low-Carbon Society Action Plan proposed that the price of the solar power generation equipment would be reduced to half of the current price within 3 to 5 years while the development of carbon capture and storage techniques that store carbon dioxide underground would be vigorously promoted. The Ministry of the Economy, Trade and Industry of Japan expressed that those having installed solar energy equipment would be provided subsidies of 70,000 yen per kilowatt in 2009, thus the expenses on installing domestic solar power generation

equipment reduced to half within 3 to 5 years thereafter. The low-carbon society is constructed depending on the transformation of the city based lifestyle and the supporting reforms improving the function of cities and the transportation system. In June 2008, Yasuo Fukuda, Japanese prime minister, brought up Japan's new countermeasures against global warning, referred to as "Fukuda vision", which pointed out that the long-term goal for Japan's greenhouse gas reduction is that Japan's greenhouse gas emission will be reduced by 60%-80% by 2050. The low-carbon society is constructed depending on the transformation of the city based lifestyle and the supporting reforms improving the function of cities and the transportation system.

In order to build the low-carbon society worldwide, in July 2008 the Japanese government made an assessment on candidate cities according to the advancement and regionality of their proposals. On 22nd July, the "local active integration department" announced that six local cities were chosen as the first "environment demonstration cities" for taking effective measures actively to prevent greenhouse effect and seven urban neighborhoods including Kyoto were elected "candidate demonstration cities" at the same time. The selected demonstration cities comprise big cities with population over 700,000 like Yokohama and Kyushu, local key cities with population less than 100,000 like Toyama and Obihiro as well as small-scale counties with population less than 100,000 like Minamata Kumamoto and Shimokawa Hokkaido as "environment model cities" promoting transition to the "low-carbon society" and leading international tendency. These "environment model cities" quicken the steps of transition to the low-carbon society by means of multiple activities such as decreasing the amount of garbage, carrying out "green energy program", "zero emission transportation program" etc. These big cities strive to develop wind and solar energy, promote the environmentally sustainable transportation system and implement carbon dioxide emission reduction so as to promote the low carbon development of the society and build low-carbon city. It is specified that residents in the selected cities primarily consume local food and make full use of local natural resources like solar energy, wind, bio-energy and geothermal energy. The carbon emission produced by people and objects are reduced as much as possible by popularizing energy-efficient houses, fully

utilizing biological resources, improving rail transportation network to establish convenient public transportation system.

Japan's cabinet council approved "Action Plan to Achieve Low-Carbon Society" in July 26, 2008, elaborating explicitly on Japan's goal to establish a low-carbon society and efforts need to be made. This plan was formed on the basis of wide discussion and soliciting of opinions on conception, specific projects and implementation strategy of low-carbon society by Central Environment Council Global Environment Division. For example, the solar generating power of Japan will be nine times than that of present by 2020. In terms of the reduction of vehicle emissions of green house gases, Japan plan to increase by a wide margin the usage of new generation of environment-friendly cars such as electromobiles and build equipment for quick charge of automobiles within half a hour. At that time, half of the new cars in the market will be the new generation of environment-friendly cars. To implement "Low-society action plan", Japanese government established a strategic research institute "Low carbon research center" aiming to create a low-carbon society. Ministry of economy, trade and industry, Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of environment, as well as Ministry of Land, Infrastructure and Transport jointly issued Action Plan for Promoting Solar Power Generation.

In April 2009, Japanese Ministry of Environment issues a draft entitled Green Economy and Social Reform, aiming to strengthen Japan's low-carbon economy through measures such as reduction of emission of green house gases. Apart from measures relating to environmental protection and energy conservation, the draft also worked out medium and long term policies such as building a low-carbon society as well as a society of harmonious coexistence with nature. These policies mainly involve social assets, investment and technological innovation.

In March 2010, Japanese Ministry of Education, Culture, Sports, Science and Technology launched comprehensive strategic projects and founded "Low carbon research center", striving to combining low-carbon technological research and development and production practice closely.

Japan formulated numerous incentive policies through preferential finance and tax, among which the policy of financial budget input occupied an important position.

Japanese government also attached importance to investment on energy security, putting a large amount of funds into the development of new energy and new technology. In 2000, Japanese government invested $622 million in the development of energy-saving technology, which was no match among member economies in IEA. In the “New Sunshine Plan” initiated by Japanese government, more than 57 billion yen is put annually in the production and convey of renewable resources, and development of storage technologies. Japanese Ministry of Resources puts more than 40% of its financial budget into energy conservation and emission reduction each year. For example, in 2001, the financial budget of Ministry of Resources amounted to 130 billion yen, among which 52 billion yen was put into new energy and energy conservation. In the budget of fiscal year of 2009, the budget of research and development of environmental energy, which reached up to 10 billion yen, was made separately, among which R&D of solar power generation solely accounted for 3.5 billion yen. Another budget item was added in fiscal year of 2010, which was R&D of cutting-edge technologies of low carbon, numbering 2.5 billion yen.In addition, in order to encourage the active emission reduction of behavior subjects, the Japanese government subsidizes emission reduction from many aspects. For example, Japanese Ministry of Resources will provide special budget funds for energy-saving and emission-reduction, 50% of which will be subsidized in way of allowance. The funds are mainly for the purchase of energy-saving equipment of families and enterprises. In order to promote the use of environmentally friendly vehicles, the government provides allowance for individuals and corporations to buy clean cars. The Ministry of Economy, Trade and Industry allocates 38,000 million yen each year to subsidize efficient household water-heaters and new energy management systems of buildings. The Japanese government also subsidizes the purchase of solar generators of households and medium-sized and small enterprises. In addition, the Japanese government subsidizes enterprises to manufacture resource recycling equipment, with the amount of subsidy accounting for nearly half of the cost of production and experiment. Enterprises can get subsidy of 1/3 if they buy advanced energy equipment. This form of direct subsidy greatly reduces the cost of emission reduction of consumers and enterprises, and promotes their initiative.

From 2008 to 2010, the Japanese Ministry of Environmental protection has implemented a series of bonus point demonstration projects of environmental protection. By utilizing and purchasing environmentally friendly goods and services, people can get corresponding bonus points, which could be used to purchase all kinds of goods. In this way, Japan has established a bonus point mechanism for environmental protection in all industries. Points of environmental protection act can be understood as proof of people's participation in all kinds of environmental protection activities. Through the issuance of points, the government economically encourages people's environmental protection behavior. In 2011, the Japanese Ministry of Environmental Protection introduces a new bonus point project of environmental protection. Environmental protection activities identified by the project include not only the purchase of environmental protection goods and services such as energy-saving appliances and equipment, but also environmental protection activities such as participating in the management of pollution nuisance(such as the management of chemicals), 3R(such as recycling), and the protection of nature(such as the protection of biological diversity). Different from government-dominated bonus point demonstration projects of environmental protection, the subject of the project has changed into private consumers and enterprises, with private enterprises being the main investors and managers of the project.

Japan's environmental accumulated points system has a direct bearing on its energy conservation and emission reduction. Take the environmental accumulated points system in terms of household appliances for example. Since the implementation of this system, sale and upgrading of such appliances as air-conditioner, refrigerator, and TV have been greatly promoted, especially with sharply increasing needs for household appliances of high energy-saving performance. According to statistics, the sales to dealers of air-conditioner, refrigerator, and TV increased by a wide margin during the implementation of this system. The total sales of these three appliances increased by 24% in 2009, which reached up to 43% in 2010. Thanks to the improvement of the performance of these three appliances year-on-year, Japanese people bought or changed household appliances in large quantities, which contributed a lot to energy conservation and emission reduction of Japan. By comparing consumed

power among different appliances in 2010 and 1996, refrigerator was considered as product with best energy-saving performance, the consumed power of which in 2010 decreased by 30% and air-conditioner was considered as product with worst energy-saving performance, the consumed power of which in 2010 decreased by 20%. What's more, according to calculations, thanks to the promotion of energy-saving appliances during the implementation of Japan's environmental accumulated points system, there is a decrease of 2.7 million tons in CO2 emission yearly in Japan.

2.5 Tokyo

Remarkable measures taken by Tokyo in building a low-carbon city are mainly reflected in the formulation and implementation of three strategies.

First, the *Tokyo Renewable Energy Strategy* published in March 2006 proposes to increase the proportion of renewable energy use out of Tokyo's total energy consumption to aim at around 20 percent by 2020. To implement this Strategy in detail, Tokyo intends to promote the needs and choice for renewable energy through government's policies and endeavors, strengthen guidance and control through financial and taxation measures, and propose specific project designs targeted for different subjects in different fields. Specific measures in implementing this Strategy include remarkable achievements in the development of second-generation bio-diesel fuel, application of fuel cell in buses, promotion of wind power generation along the coast of Tokyo, improvement of waste power generation, popularization of solar power generation in the whole city starting from the City Hall, comprehensive exploration of power generation in feasible fields (ocean thermal, wave, tide, current, etc.), which provides solid foundation and guarantee for the building of a low-carbon Tokyo.

Second, *Tokyo's Big Change: the 10-Years Plan* proposed in December 2006 can be summarized into: "One focus", namely eliminating the negative heritages left by the development in the 20th century and establishing a beautiful, safe and charismatic metropolis across the world by taking advantage of rebidding for the Olympic Games; "Three perspectives", including advanced science and technology, concentration of talents, and the center of technological revolution and advanced environmental policies in East Asia or the whole Asia; "Eight goals", including such contents relevant to

environment and low carbon as creating 1000-hectare green land, developing world-leading energy-efficiency policy through various measures, becoming a city with the least environmental load in the world, etc. To implement this strategy in detail, Tokyo intends to propose distinctive environmental policies, promote the supply of safe and nice drinking water and utilization of water resources, reducing wastes and improving recycling rate, etc. Besides, another important measure is to establish the *10-Year Project for a Carbon-Minus Tokyo*, clearly stipulating that “reducing the CO2 emissions of Tokyo by 25 percent from 2000 levels by 2020”. In 2020, Tokyo made a period summary on the implementation of this Project: 98 projects with a budget of 20.3 billion yen in 2008, 107 projects with a budget of 36.5 billion yen in 2009, and 115 projects with a budget of 39.1 billion yen in 2010, demonstrating a steadily rising trajectory.

Third, the *Tokyo Environmental Master Plan* formulated in March 2008 on the basis of the version of January 2002 is an important guiding document in consideration for the new trends in the development of Tokyo, Japan and the whole world. This Plan has its unique thinking mode: guiding Japan and regional organizations through the pursuit of high target and implementation of strategic policies in Tokyo; integrating development in accordance with the *10-Years Plan* and setting up goals for 2016; prospecting predictions and possible thoughts for 2050; thinking about practical policies through back stepping or back casting; setting goals, realization approach and test criteria in a way that is easy for citizens to understand and convenient for implementation.

2.6 Toyama

As the forerunner of low-carbon cities in Japan, Toyama, an industrial city along the coast of Japan Sea with a population of about 420 thousand, is a model city in building a low-carbon society. With a target of reducing CO2 emission by 30 percent from 2005 levels by 2030 and 50 percent by 2050, Toyama takes various measures in transforming social forms in such aspects as transportation, lifestyle, urban construction, etc., such as promoting the development of public transportation to increase the proportion of people who living in areas with convenient access to public

transportation from 30% to 40% in 20 years, subsidizing residents buying homes in downtown, introducing clean-energy vehicles, developing new energy resources, and building facilities in the eco-town of suburb area for the recycling of waste oil, timber, kitchen garbage, etc.

2.7 Other smart low-carbon cities in Japan

There are many low-carbon cities combining the concept of smart city in Japan, such as the sustainable smart city built by Panasonic in Fujisawa, the smart low-carbon community built by Toyota Motor in Toyota, the Kashiwa-no-ha Smart City mainly built by Mitsui Fudosan, etc. In the Kashiwa-no-ha Smart City, the intelligent terminal system can pass the information about forecasted and actual power consumption of every home, every building and the whole community to home owners in a timely manner, which is convenient for the self-management of home and community. For homes with saved power consumption exceeding certain standard, they can exchange their energy-saving points for regional contribution credits in community shops, therefore improving residents' motivation for power saving.Strengths of these schemes include:

Aiming at serving home and community as well as meeting their needs, these schemes reduce the energy consumption of home and society and improve the efficiency of energy and resource uses by taking advantage of various modern technologies, emphasizing the popularization of intelligent and visual management of energy and resource demand through the development and utilization of renewable energy. Such as, reminding people to save energy and resource through visual image or digital display of power, gas and water consumption; generating power from solar energy, methane gas and ground-source heat pump, and developing storage and transformation system to provide emergency power for homes; helping people choose a more energy-saving trip mode through intelligent traffic management system.

Human-oriented, these schemes focus on making life more convenient and comfortable. Many technologies applied in the building of smart cities in Japan are directly targeted at lifestyle of family and people, and closely linked with people's needs, demonstrating better practicability in people's life. For instance, adopting visualized software for energy consumption is convenient for demand management, such as

displaying total power consumption of a family in changing cartoon ice cubes is intuitive and easy to read for a child; the intelligent operating system realizes automatic power off in 3 seconds after people leave the room and enables people to control the air conditioner in advance when they are out; the office temperature control system controlled by the IC chip human body sensor enables the air conditioners to automatically adjust to the designed temperature wherever people go in the office; connecting the charging system for electric vehicles with household grid is convenient for utilizing the surplus electricity from vehicles in daily use in case of emergency.

Promoted mainly by private enterprises, these schemes pay more attention to market demand. In the background of energy and resource shortage as well as marketization of energy price in Japan, private enterprises, including Toyota, Panasonic, Hitachi, Toshiba, Mitsui Fudosan, etc., focus on developing integrated intelligent solutions for reducing energy and resource consumption based on their own professional technologies, with comprehensive consideration of reducing cost, realizing diversified choices, and serving the needs of home and society.

These schemes aim at exploring a broader service path for smart city and community. Kashiwa-no-ha proposes three concepts for the building of smart cities: environmental symbiosis, health and longevity, creation of new industries; nine specific applying themes, including unified management of regional energy, low-carbon transportation system, regional medical care network, social participation of individual value creation, development of individual entrepreneurial space, etc. All of these demonstrate concerns of government, enterprises and communities for environmental protection and public security, interest demands of residents for personal health and entrepreneurship, needs of academic institutions for research and development space, provide great assistance for relevant enterprises in building an attractive city, and transform the concept of modern city from low-carbon and energy-saving to contents on community service.

2.5 New Zealand

As the extension of urban strategic planning, the Greenprint of Waitakere paints a picture of eco-city and illustrates specific actions taken by the city council and local

communities to realize this picture. As the guiding document for the actions of city council, the Greenprint stipulates the city council's obligations, procedures and specific actions in building an eco-city. However, this Greenprint is ultimately realized by community members instead of city council. Major achievements of it include: a) building cooperative partnership, formulating Shellfish Reserve Act as well as development and resource management plans for commercial exploitation and downtown construction, and establishing more secure community council and health summit; b) developing such projects as conceptual planning for harbor view, renovation of Henderson and Titirangi Districts, and improvement of water quality in Piha/Karekare District; c) establishing policy obligations, including enhancing the strength of urban area, building green network and recreation service strategy, reducing solid garbage and realizing cleaner production.

Three goals for building an eco-city in Waitakere are sustainable, dynamic and just, all of which apply to three aspects---environment, economy and society.

(1) Environment:

Sustainable environment: as the foundation of New Zealand's *Resource Management Act*, sustainability means "a state of development within certain range". It requires that renewable resource consumption shall not exceed its regenerated amount so as to avoid irreparable damage to the ecosystem; however, it is often not easy to determine the limit accurately, which means we shall keep cautious and take precautions sometimes, or implement "No Regret" Policy.

Dynamic environment: it means the stable moving process of environment under the action of human activities and natural forces. Biodiversity shall be protected for the extinction of species would lead to the collapse of ecosystem and the damage of the adaptive capacity of the environment.

Just environment: it means that everyone has the right to enjoy the environment and lead a life with certain standards for environmental quality regardless of one's wealth, as the beaches and national parks open to the public are best examples. Besides, everyone has the obligation to ensure that his or her action does not affect others' rights to enjoy the environment whether now or in the future.

(2)Economy:

Sustainable economy: the primary task is to have a long-term vision and realize the economic significance of environmental protection, which requires fundamental reforms on production mode. For instance, using renewable energy and resources, reducing packaging, and producing biodegradable or reusable products; reducing waste materials from production process; recycling and reusing waste.

Dynamic economy: it enjoys various types of economic activities on different scales, with numerous enterprises producing and providing all kinds of products and services. Diversified economy can adapt to all kinds of changes in a better way, such as economic downturn, and take full advantage of new opportunities; besides, it tends to be with certain characteristic in some aspects, demonstrating the strengths of local economy.

Just economy: it means that all people have the opportunity to show or improve their technical abilities through paid works. The law also inhibits discrimination of employment, including discrimination against age, race, gender or disability, which promotes equal employment to some extent. It breaks down barriers that forbid some people, such as those lacking business knowledge or financial assistance, to participate in economic activities, and endows people engaging in domestic service with equal status as traditional employees.

(3) Society:

Sustainable society: it pays close attention to environment, takes responsibilities for the welfare of society members and their descendants, and lays great importance to the health and security of social members, enabling them to participate in work and decision-making, enjoy recreation activities and cooperate in decision-making, sharing innovative thought and information so as to realize the common goal.

Dynamic society: it believes that the difference among social members is of value and shall be encouraged; social members are challenged by the exploration of innovative thought and method. Besides, “identity” is treasured by dynamic society the same as “difference”.

Just society: it shall at least ensure that the welfare standards are not determined by wealth level and everyone shall be endowed with opportunities for medical service, education and recreation as well as reasonable housing standard. Except from this, it

can meet various needs caused by the difference of social members and endow everyone with opportunities to fully participate in all aspects of social life, including paid or unpaid works and decision-making. It means that just society shall get resilient, listen to public opinions and provide social members with information required by decision-making. Besides, it also promotes personal freedom up to the hilt on the premise that the freedom and rights of others shall not be affected whether now or in the future.

2.6 Singapore

Singapore is a world-famous “Garden City”. To ensure that Singapore enjoys green and clean environment in the rapid development of urbanization, Singaporean develop a strong concept of pursuing harmonious coexistence between human and nature. There is a special chapter in the city planning project, “Green Plan and Blue Plan”, aiming at making best use of green and water space to improve the quality of Singaporean people’s life. The following points are specially mentioned in the city planning and construction: building more parks and public spaces; connecting major parks with green belts; paying attention to environmental protection; making best use of coast to make the water system meet the recreation needs. In this prosperous city, it is the plants create a cool environment, soften the stiff lines of reinforced concrete structure and glass walls and give more colors to the city; therefore the goal for city construction in Singapore is making people feel like living in a garden city when they go out of offices, homes or schools.

Singapore plans to reduce the energy consumption by 30% on the level of 2005 in the next 10 years; by 2030, the waste recycling will be enhanced by 70%, the water consumption of each person reduced by 10%, particulate matters reduced by 25%, and PM2.5 per cubic meter reduced to below 15 mg. To obtain more green space, Singapore plans to building 900-hectare public green land, 100-kilometer green belt and 50-hectare green roof area, so as to transform Singapore into a low-energy and low carbon city by 2030.

2.7 United States

Although United States refused to join the *Kyoto Protocol* and fulfill the obligation of reducing greenhouse gas emission, all forces of its society neither have a negative attitude towards climate change nor stop the exploration on low-carbon development while they are trying to solve the climate change problem through a large number of innovations, especially technological innovations.

In November 2007, the Center for American Progress released a report titled “Capturing the Energy Opportunity: Creating a Low-Carbon Economy”, stating that United States has lost key technological advantages in the environmental and energy fields and proposing the plan of 10 steps to a low-carbon economy. On July 11, 2007, the Senate of United States proposed the *Low Carbon Economy Act*, indicating that the development path towards low-carbon economy is expected to be a strategic choice for United States in the future. In January 2009, President Obama announced the *American Recovery and Reinvestment Act*, considering new energy development as investment priority and planning to invest 150 billion dollars to double the new energy production of United States in 3 years, and increase the proportion of new energy power generation in the total to 10% by 2012 and 25% by 2025. On February 15, 2009, United States officially enacted the *American Recovery Reinvestment Act* with a total investment of 78.7 billion dollars, ensuring that 10% of power consumption in United States comes from renewable energy by 2012 and the ratio increases to 25% by 2025; the Federal Government will invest 90 billion dollars in improving energy efficiency and promoting the development of renewable energy. As an important part of the Act, the development of new energy requires developing high-efficiency cell, smart power grid, carbon storage and capture, and such renewable energies as wind power and solar power, etc.; requirements on energy saving focus on energy-saving vehicles. Besides, United States develops low-carbon economy through a series of environmental protection measures in order to cope with climate warming.

Under the influences of reorganization caused by financial crisis and strategies of Obama administration, low carbon and emission reduction have become one of the importance development strategies of most state governments. Originating from local states, the low-carbon development policies can enter into proposals of the Federal

Government and expand to federal scope through regional cooperation and joint efforts. At present, the low-carbon development policies mainly originate from three major areas---northeast, west and Midwest. The *Regional Greenhouse Gas Initiative* has been launched in northwest states since January 2009, putting limits on power generation enterprises with a capacity exceeding 25MW, who contribute 95% of CO2 emission of the whole region. The Initiative is divided into two stages, respective goals of which are: keeping the emission unchanged from 2009 to 2014; reducing 2.5% of emission annually from 2015 to 2018; the Initiative also allocates emission quota for each state according to its emission level from 2000 to 2002. The *West Climate Initiative* led by California Government came into effect in 2012 and lasted for 3 years, putting restrains on facilities with greenhouse gas emission exceeding 25000t (amount of CO2), who contribute 90% of the greenhouse gas emission in the region; the Initiative aims at reducing greenhouse gas emission by 15% on the level of 2005 by 2020. In the meantime, the *Midwestern Greenhouse Gas Reduction Accord* was also launched, covering most middle states of United States and Manitoba of Canada and aiming at large industrial facilities and power plants; the goal for the Accord is to reduce the emission of 2005 level by 15% to 25% by 2020 and 60% to 80% by 2050.

2.7.1 Seattle

As one of the best examples for low-carbon city in United States, Seattle is the first city to meet the greenhouse emission standards set by the *Kyoto Protocol* as the carbon emission of Seattle was reduced by 8% from 1990 to 2008.

Led by large enterprises, based on climate cooperation project of Seattle and participated by all departments of the city, a climate initiative has been formed in Seattle. It includes a special project of family energy audit, which can calculate the carbon emission of family and office on a low audit cost. Seattle hopes to reach three goals through the audit: providing training course for unemployed youngsters to engage in audit works, therefore creating more jobs; helping family reduce energy cost through energy audit, therefore shutting down some fossil or oil power plants by reducing family power consumption; preventing the expanding of urban area and turning the attention to city construction again.

Besides, endeavors of Seattle include improving energy efficiency of buildings; enhancing the efficiency of public transportation and controlling the carbon emission of public transportation; actively improving the structure of power supply as the Seattle Power Grid generates power by taking advantage of such water conservation facilities as melt snow and invests wind power plant in east of Washington State; employing third-party organization every three years to evaluate the extent of emission reduction and whether the 7% reduction goal is reached.

Promoting the initiation and development of emerging industries during the construction of low-carbon city is of constructive significance. Firstly, taking the lead in advocating green building creates plenty of job opportunities for designers, engineers and builders, whose specialty, experience and knowledge can be shared with other cities, thus providing them with great development opportunities; secondly, Replacing fossil or oil power plants with solar power, geothermal energy, wind power and tide power also creates more job opportunities; thirdly, the research and development as well as application of new material and technology has the same function, such as the development of bio-fuel by Boeing for replacement of aviation oil can not only reduce the carbon emission of the whole civil aviation industry greatly, but create more job opportunities in developing and applying the new technology.

2.7.2 Portland

Portland, Oregon, a city on the west coast of United States, is evaluated by the Environmental Protection Administration of United States as “Capital of Clean Energy”. The CO2 emission of Portland in 2010 is 2% lower than the level of 1990 while the per capita emission is down by 20%. The success of Portland lies in its citizen-based mode from bottom to top, in which citizen activism plays an important role.

The development of Portland relies on four pillar industries, including software, outdoor sports, clean energy, etc., the rapid growth of which leads to that of employment. Portland is spread its experience in building a green city to the whole world and exporting clean technologies in quantity. In terms of software industry, due to the advantageous environment and low living cost here, a large number of talents are

willing to start businesses in Portland, where such companies as Nike and Columbia are headquartered. Guided by the principle of sustainable development, the traditional manufacturing industry regains its vigor. For instance, the arrival of advanced technical talents makes the truck base of Portland enjoy sound popularity and influence.

It is the tradition of this city to value and protect the quality of living environment. Differing from the other cities in United States, the urban planning and construction of Portland has been “human-oriented” instead of “vehicle-oriented” in decades. Portland refused Federal Government’s plan to build a trans-regional motorway across the east of the city long ago, but built the public transportation system of light rail with the investment. During the process of urban expansion, Portland clearly defined the legal boundary to protect the precious agricultural land from the invasion of property developers.

Citizens in Portland can choose from traditional thermal power and renewable energy in electricity consumption, the latter of which is more expensive though. At present, 14% of citizens choose the latter voluntarily and the proportion maintains a upward trend. Portland plans to make the renewable energy account for 25% of the total energy consumption by 2025. With the guidance and support of the government, clean energy has not to be so expensive unless as always. Take solar power as example: many citizens in Portland are willing to use solar panel for power supply at home, but the upfront cost is so high; therefore the government reduces the costs of developer and solar panel by uniting different communities to install in bulk, leading to the quadruple increase of solar panel installation in two year.

Citizens in Portland are willing to refit their home buildings to improve the energy efficiency while the upfront cost of the refit is high. Citizens can borrow money from banks to buy a new house, yacht or car, but there is no loan mechanism on the above-mentioned refit in any bank. Therefore, the government establishes a program of clean energy, in which citizens can get loans for refit that aims at improving energy efficiency. Provided by local banks, the loan has a fifteen-year repayment period with the monthly repayment cut from power fare.

With 300-mile bicycle lanes in hand, Portland plans to increase hundreds of them over the next years; the hybrid electric vehicles owned by citizens in Portland

outnumbers any other cities in North America, with 2000 charging station installed across the city. Providing citizens with more choices and alternatives can not only reduce carbon emission, but bring good economic benefits---driving 4 miles less than other Americans everyday saves 2.4 billion dollars of oil expense a year for Portland. Apart from saving fuels, the tram system of Portland also brings 3.5 billion dollars of private investment for citizens in the three blocks adjacent to the tracks, thus increasing the property tax of these blocks by 30 million dollars annually while the government can gain 11.5 million dollars from every mile of the track.

2.7.3 Bonita Bay

Bonita Bay, with a planned floor area of 9.7 square kilometers, is a community based on the concept of ecological design. It preserves and enhances the diversity of local eco-system. Different from many areas in the southern part of Florida, Bonita Bay boasts a land without being destroyed, that is farmed, or changed by human activities. It is embraced on three sides by water and perfectly integrated with the beautiful eco-system, including freshwater and saltwater marshes, mangroves, broad-leaved forests, an ancient river and a creek. The overall density of the region is 1.4 household per acre. Less than 3300 houses overlooking the Gulf of Mexico, Bonita Bay, lake, golf course and nature reserves are planned to be built in smaller areas independent from each other. Besides, much efforts for low-carbon cause are also made in Bonita Bay:

Take environmental protection as the guide for city planning. Before the environmental movement in the early 1980s attracted wide attention, the planning of Bonita Bay had been started already. Developers did a detailed site assessment of the south Florida. They identified habitats of wildlife covering 40 different types and marked 22 spots for drainage in the area to be developed. The key issue for their planning and design is to protect these natural features and the fragile ecosystem. The master plan of Bonita Bay relies not only on a strong geometric design, road network of axis, ring or grid or even structures of other shapes, but also on the assessment of the local natural system to find the area appropriate for development. The potential complexity of the natural system is also addressed in the final development plan.

Hundreds of wildlife habitats are preserved with a selective land clearing by preserving or transplanting some typical trees.

A trail of 19 kilometers is for bicycling and walking in the community to encourage less use of vehicles. The cross-shaped trail leads to waterside park, coastal footpath, tennis and golf clubs and gym as well. The community park is meant to satisfy various interests and hobbies of the residents.

To achieve a visual harmony. The elegant and beautiful scenery of 53 neighborhood communities scattered between a wide water network and the golf course highlights the idyllic feature of Bonita. Each neighborhood has its own characteristics and architectural design themes, with residential households ranging from 18 to 120. The project is based on extensive surveys and environmental landscape design requirements. The developers formulated strict architectural design standards to ensure the community designed with detached houses, townhouses and houses of other forms accords with the generally concerned ecological principles. It's for sure that the accomplished community reflects the integration of human and natural environment in Bonita . The scenery observed from the streets and walkways seems to always have natural landscape as its foreground with buildings in the dense vegetation. Part of the program follows the following steps: decide the location of roads first, and then design the houses with wide buffer space, but still preserves the natural features of the neighborhood. Landscape design combines with the original vegetation with the natural species as a supplement. Elegant landscape design is used on the main roads in the community to enhance its natural beauty. Moreover, the developers actively coordinated with the local governmental planning agency and fixed the landmark and architectural design standards for the new development program along the Channel No.41 in the United States. Channel No. 41 leads from the community to the highway. The harmonious design bestows artistically appealing features on the Channel No. 41 and distinguishes it from the neighborhood. The developers who stuck to sustainable development hold that the lake design should accord with the original natural waters running through the area after a comprehensive site assessment. In order to protect the beautiful ecosystem of the bay, natural wetlands have been retained, which contributes to a rainwater system allowing plants to filter out sludge, nutrients and contaminants.

Twenty years of water quality monitoring shows that the land development and maintenance of the community golf course did not result in significant long-term impact on the natural environment of the region.

In fact, all of the five golf courses in Bonita meet the stringent American national standards. And in return, they protect and enhance the natural eco-system. The original vegetation is largely retained in the course, and artificial turf only covers a small part. Before building the golf course, the developers did a survey on the wild plants. Seven years later, they did the same research and found that the type of plants increased by 50% after the development compared to the previous result. A comprehensive environmental management plan has been formulated, which includes plant disease and insect pest management , recycling of natural resources, transplant of old trees without destroying the original habitat of plants, standardized hand weeding without using any pesticides and cultivation of local grass to cut down on maintenance and facilitate the growth of wildlife.

The community uses a complex water conveyance system with dual pipe, which separates high-quality drinking water from the reclaimed water for washing and irrigation. Before the principles of Xeriscape landscaping are widely understood and recognized, they have been realized in the community of Bonita Bay. South Florida Water Management District designates Bonita Bay project as the first Xeriscape sample for the region to show their approval of the innovative water protection measures taken by Bonita. Using reclaimed water to wash and irrigate could save water of about 11 million gallons each year.

3 Development Model and Toolkit

The low-carbon cities in the APEC Region differentiate from each other in terms ways and focuses of development due to their distinctive natural conditions, economic development, industrial structure and cultural tradition. Drawing from the experiences from all the member economies, the report offers the following suggestions for the development models and toolkit of low-carbon cities.

3.1 Low Carbon Implementation Path

To realize low-carbon development of output value, specific areas such as industries, layout, construction, transportation, energy and resource recovery needs to be taken into account, and a green low-carbon life style and consumption pattern should be advocated.

To take energy as an example, the International Energy Agency (IEA) put forward in Lima during the Climate Conference 2014 five ways and specific practices to get low-carbon energy and suggested that all participants bring these practices into their Intended Nationally Determined Contribution.

First of all, to take urgent actions to further reduce carbon emission, and push the current target by 80% by the year of 2020 without causing additional cost of GDP. The focus of the action is to advocate the use of highly efficient energy, less use of energies of lower efficiency such as thermal power and less subsidies on fossil fuels.

Second, to emphasize low-carbon electricity. A strong low-carbon policy could cut the greenhouse gas emission from power firms by half by 2030.

Third, reallocate investment and accelerate the innovation of low-carbon technology. Technology solutions adaptive to specific conditions in each economy could be brought forward with multilateral cooperation to promote national development.

Fourthly, to promote low-carbon development of the energy sector using non-climate factors. Carbon emissions can also be cut through improvement on health, transportation and energy security and other actions.

Last, to strengthen the ability of the energy sector in each economy to adapt to climate change. Climate change would still threaten energy security even if the global temperature rise is within 2 degrees Celsius by 2050. Therefore, policies and market should work together to adapt energy sector to climate change.

Diagram for developing low-carbon cities is below:

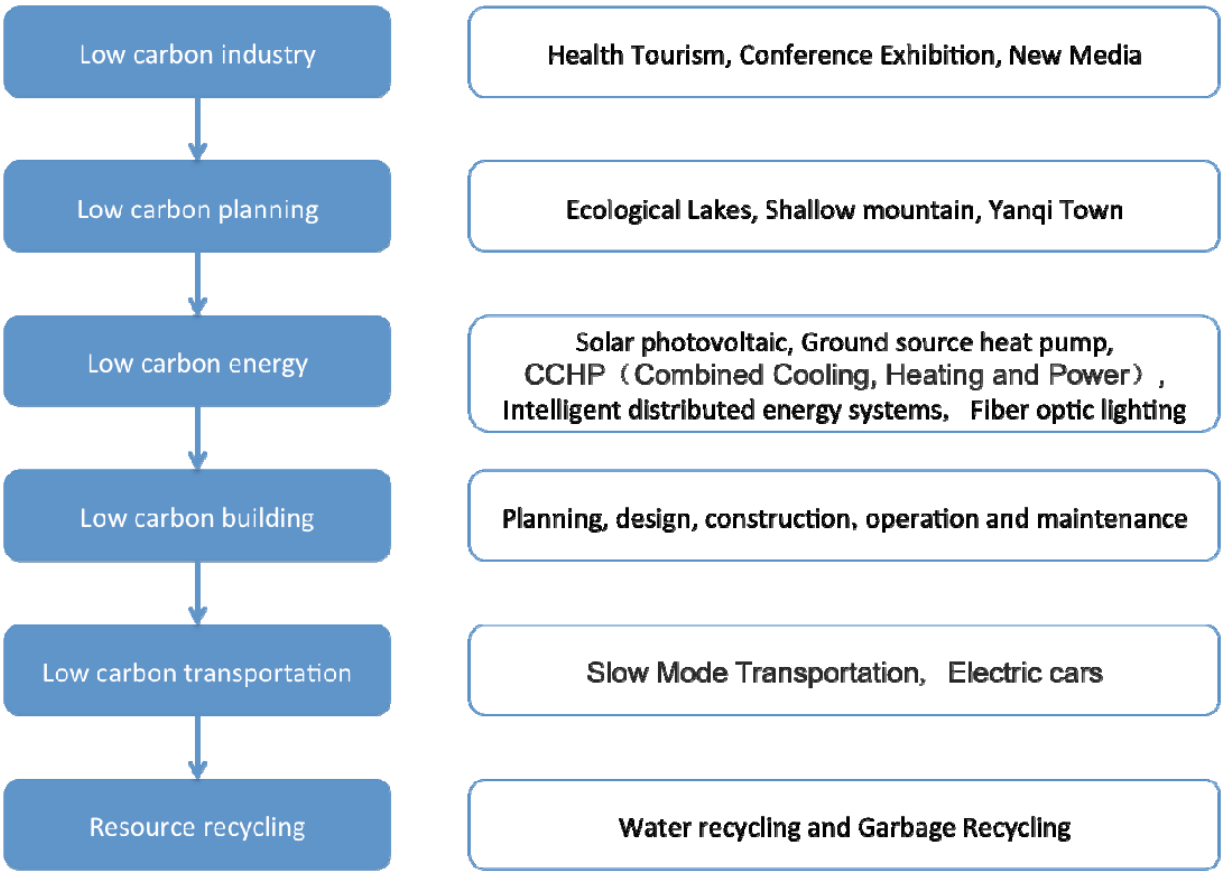

Fig. 19 Diagram for developing low-carbon cities

3.2 Low carbon development cycle

Urban low-carbon development cycle includes planning, design, construction and operation. That is, to specify development goals for the city through planning first, and design development framework and blueprint for low-carbon cities, analyze and decide the supporting mechanism for the construction, and then specify implementation roadmap and optimize construction process to improve operation efficiency.

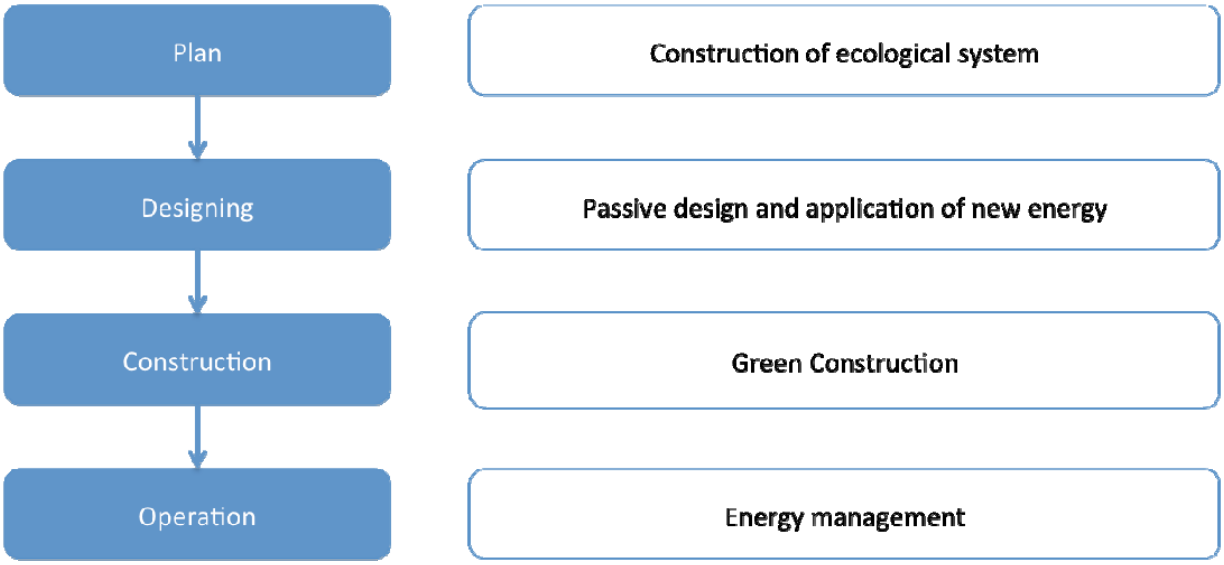

Fig. 20 Implementation roadm

3.3 Low Carbon Evaluation System

3.3.1 Evaluation System for Low-Carbon Cities

Tab. 4 Evaluation System for Low-Carbon Cities

No.	Index System	Formulator
	low-carbon target indicator system	Nikken
	index system for sustainable development	SOM
	Sino-Singapore Tianjin Eco-city index system	Sino-Singapore Tianjin Eco-City (SSTEC)
	Caofeidian Area, Tangshan Bay International Eco-city index system	Caofeidian Area
	index system of Guangming New Town in Shenzhen, Guangdong Province	Guangming New District
	ow-carbon eco-city index system of Wuhan in Hubei Province	Wuhan
	index system of the "style town" -- Anji County in Zhejiang Province	Anji County
	eco-city index system of Foshan, Guangdong Province	Foshan
	eco-city index system of Yangzhou, Jiangsu Province	Yangzhou
	eco-city index system of Yueqing, Zhejiang Province	Yueqing

	eco-city index of Weifang Binhai in Shandong Province	Weifang Binhai Economic-Technological Development Area
	index system of Wuxi Taihu New City in Jiangsu Province	Taihu New City
	index system of Zhongrui Eco-demonstration zone, in Wuxi Taihu New City, Jiangsu Province	Taihu New City
	pilot index system of Kunming Chenggong New City in Yunnan Province	Chenggong New City
	eco-city index system of Xiamen, Fujian Province	Xiamen
	Changzhutan eco-city agglomeration index system	Changzhutan City Agglomeration
	index system of Chongming Smart Eco-Island in Shanghai	Shanghai
	eco-city index system of Shangqiu, Henan Province	Shangqiu
	Eco-city index system of Hebei Province	
	low-carbon eco-city index system of China	Chinese Academy of Social Sciences (CASS)
	CASS index system for sustainable cities	CASS
	indexes for eco-county, eco-city and eco-province	Ministry of Environmental Protection (MEP）
	national standards for building ecological garden city	Ministry of Housing and Urban-Rural Development
	Index system of China Habitat Award	Ministry of Housing and Urban-Rural Development
	evaluation index system for overall urban environmental improvement during the Eleventh Five-Year Plan	MEP
	circular economy evaluation index system	
	evaluation system for Chinese low-carbon cities	China Low-carbon Economy Media Federation (CLEMF)
	OCED environmental index	United Nations
	sustainable indexes in the UN Agenda 21	UN
	Global Cities Index	Global Cities Index

	Green City Index	The Economist
	index system for environment and sustainable development	The World Bank
	social development index	The World Bank
	Yale University and Columbia University index system for sustainable development	Yale University and Columbia University
	evaluation index system for low-carbon cities based on DPSIR	
	British index system for sustainable development	
	Scottish index system for sustainable development	
	environmental statistics index system for planning and construction in Germany	
	European Green City Index System	Siemens Economic Think Tank
	Asian Green City Index System	Siemens Economic Think Tank
	North American Green City Index System	Siemens Economic Think Tank
	Sydney Green City Index System	Institute for the Future of Sustainable Development
	Study of Green City Index	Green City Research Network

3.3.2 Examples of and Advices on LCMT Evaluation System

3.3.2.1 Yujiapu Low Carbon Index System

Tab. 5 Yujiapu Low Carbon Index System

Low Carbon Environment	Natural Environment	Atmospheric Environment	number of days when air quality index surpass Level II of the National Ambient Air Quality Standards (NAAQS)
		Water Environment	sea water quality
			surface water quality
		noisy environment	noise ratio in functional zones

	Urban Environment	Forestation	ratio of afforestation
			proportion of trees to green area
		Thermal Environment	Urban Heat Island Intensity Index
Low Carbon Resources	Energy	Supply	regional energy station coverage
			smart grid
		Energy Structure	utilization of renewable resources
	Resources	Water Resources Utilization	utilization of non-traditional water resources
			per capita domestic water
			tap water compliance rate
		Recycling	rate of classified collection and disposal of waste
	reduction of carbon emission	carbon emission	total carbon dioxide emission
			carbon dioxide emissions per unit of GDP
			per capita carbon dioxide emission
		Innocuous Disposal	rate of innocuous disposal of household refuse
Low Carbon Transportation	Green Transportation	Transportation System	sharing ratio of public transport
			ratio of non-motorized traffic
			proportion of new energy bus
		Transportation Efficiency	accessibility index
			average commute time within the city
	Multi-level Transportation		proportion of underground carriageways
			ratio of seamless interchange stations
Low Carbon Space	Building Industry	Green Building	proportion of green buildings
	Underground Space	Utilization Rate	proportion of pipe networks in the same ditch
			proportion of developed underground space
	High-density Space	Space Planning	index of land occupancy per capita
			Transit Oriented Development (TOD)
			urban structure of small neighborhood with dense road networks

	Spatial Accessibility		proportion of public green area (1-3ha) accessible within 500 meters
			ratio of waterfront green spaces accessible within 500 meters

	Intensive Land Use	Mixed Function	utilization ratio of mixed-function land
			residence / office / service ratio of different neighborhoods
Low Carbon Economy	Economic Vitality		per capita GDP growth rate
			number of multinational headquarters or their regional headquarters
	Aggregation Intensity		economical extroversion
			economic aggregation
			gathering of international financial industries
	Low Carbon Finance		green credit
			proportion of financial industry output value to GDP
	Carbon Trading		annual carbon trading
Low Carbon Society	Smart City		smart city index
			information network completeness
	Happy City		happy city index
	Safe City		coverage of city emergency response system
			occurrence of traffic accidents in the region
	Vibrant City		sleepless city
	Low Carbon Policy		completeness of carbon and tax policies
			popularity of low carbon economic knowledge among the public

3.3.2.2 Sino-Singapore Tianjin Eco-city Index System

Tab. 7 Sino-Singapore Tianjin Eco-city Index System

social indexes	Control Indexes	proportion of green travel
		proportion of affordable housing to the total housings
		equilibrium index of employment to housing

	Inductive Indexes	regional policy coordination
		social and cultural coordination
Economic Indicators	Control Indexes	full time equivalent of R&D scientists and engineers per ten thousand workers
	Inductive Index	regional economic coordination
Environmental Indexes	Control Indexes	ambient air quality in the region
		surface water quality in the region
		noise ratio in functional zones
		net loss of natural wetlands
		native plants index
	Inductive Index	natural and ecological coordination
Resource Indicators	Control Indexes	tap water compliance rate
		carbon emission intensity per unit of GDP
		proportion of green buildings
		per capita public green area
		daily domestic water per capita
		daily waste output per capita
		garbage recycling rate
		residential communities with free sports facilities within 500-meter walking distance
		rate of accessible facilities
		hazard-free treatment rate of hazardous waste and household refuse
		penetration of municipal pipeline network
		utilization of renewable resources
		utilization of non-traditional water resources

3.3.2.4 Caofeidian Area, Tangshan Bay International Eco-city Index System

Tab. 8 Caofeidian Area, Tangshan Bay International Eco-city Index System

Green Life	ensure that low-income residents can afford housing expenses
	provide complete public facilities

	improve citizens' living standards
Green Building	establish a thorough management system for green buildings
	encourage energy efficient buildings and layout
Green Transportation	introduce TOD to cut transportation energy consumption and reduce traffic pollution
	efficient public transport system
	humane traffic system for non-motor vehicles
Green Energy	encourage utilization of renewable resources
Green Environment	maximum reuse of waste
	recycling of water resources
	beautiful scenery around the community
Green Industry	providing opportunities to work at home
	encourage entrepreneurship
	optimize the industrial structure to create more jobs
	create economic value through the recycling system

3.3.2.5 National Low Carbon Index System for Cities in China

The indicator system is divided into two parts, Base Indicator and Application index.

The base Indicator is compulsory, which indicates the economic development, regional environment and urban construction that an APEC Low-carbon Model Town should pay attention to.

Application indicator centers on guiding towns to apply the most appropriate modes to construct low-carbon city by means of optimizing the energy structure and implementing energy saving technology. The applying Indicator includes control Indicator and selectivity index. Control Indicator is compulsory while each selectivity Indicator is with a minimum of 70 points.

（1）Basic Indicators

Tab. 9 Basic Idicators

Class	Items	Description	Notes
1.Economic Development Indicator	1)Develop local characteris-tic industry	Makes full use of local natural resources and social conditions; develops suitable local industries in accordance with low-carbon concept.	This Indicator requires the town to fully recognize its advantages in natural resources, location and transportation.
	2)Carbon intensity per unit of GDP	Indicates the carbon emission per unit of GDP from economic activity Carbon dioxide emissions refer to the emissions during the burning of fossil fuels and cement production process. GDP is constant gross regional product. This Indicator should meet the requirement of regional "twelfth five-year" plan.	Combination of the Item1) and Item2) maintains the low-carbon development for towns.

Class	Items	Description	Notes
	3)Local employ -ment ratio	Refers to the proportion of employment of local residents in local population. Requires no less than 50%.	This Indicator promotes merger of industrialization and urbanization and avoids becoming empty city.
Class	Items	Description	Notes
2.Regional Environment Indicator	4)Per capita carbon emissions	If per capita GDP is below the national average, so is per capita carbon emissions; if per capita GDP is above the national average, the per capita carbon emissions should not higher than 50% of the exceed part.	This Indicator requires the towns to reach the national advanced level.
	5)Sewage treating ratio is above 85%；	Refers to sewage attaining the draining standard (or above) after treatment of total sewage discharge.	This Indicator indicates the importance of sewage treatment in low-carbon town.
	6)100% pollution sources meet the required standards to discharge；	Pollution source refers to production facility and workplace which are harmful to environment by means of discharging waste gas, water, residue and heat or produce noise. All the pollution sources should meet the national or regional required standards.	This Indicator emphasizes not only the total quantity but also each component to meet the standards.

Class	Items	Description	Notes
3.Urban Construction Indicator	7）per capita public green areas in built-up areas	Requires more than 12 / person. Public green areas exert great impact on upgrading urban quality, improving air quality and the comfort of life, and reducing carbon emission. This Indicator can be reflected by the urban green coverage rate.	The low-carbon town requires a good environment not only for industrialization but also for livability. Reduces emission by building green areas.
	8）comprehensive capacity ratio	Requires more than 1.2.	This Indicator aims at the intensification of land use.

（2）Applying Indicators

Tab. 10 Applying Indicators

Class	Primary Indicator	Secondary Indicator	Indicator property	Description
1.Energy Efficient Utilization （30 points）	Comprehensive indicator	1) Energy consumption per unit of GDP （tce/10000RMB）	Compulsory	Achieves the mission implemented by the provincial government. Must-have, no point.
		2) Efficiency of energy utilization	Optional	20% above the basic expectation value, then 5 points.
	Buildings energy-saving	3) Proportion of green and energy-saving	Compulsory	Achieves 100%. Must-have, no

	efficiency	building in all buildings		point.
		4) Proportion of green and energy-saving building with two star in all buildings	Optional	Reaches 30%, then 5 points.
		5）Implementing building energy-saving efficiency renovation plan	Optional	If yes, get 3 points.
	Transport energy-saving efficiency	6)Improvement of urban non-motorized system construction	Compulsory	Must-have, no point.
		7)Public transportation utilization rate（%）	Optional	Reach 25%，then 3 points；Reach 30%, then 5 points.
	Industry energy-saving efficiency	8)Energy consumption per industrial production（tce/10000RMB）	Optional	No more than 0.5，then 4 points.
		9) Comprehensive energy consumption of key industries per industrial production（tce）	Optional	Achieves advanced industrial average, then 4 points.
		10)Implementing Industrial energy recycling measures	Optional	If yes, get 4 points.
2. Energy Structure Optimization(35	Comprehensive indicator	11)Proportion of clean energy consumption（%）	Compulsory	Achieves 45%, Must-have, no point.

points)		12)Renewable energy innovative technology application	Optional	One innovative technology gets 2 points. Up to 6 points.
	Construction of regional power station	13)Regional station coverage rate（%）	Optional	Reaches 70%, then 6 points.(not for non-heating area)
	New energy utilization for buildings	14)Proportion of Renewable energy utilization in buildings' total energy consumption（%）	Optional	Reaches 4%, and then 3 points; reaches 6%, 6 points.
	Clean energy utilization for public transportation	15)Proportion of clean energy utilization（%）	Optional	Reaches 80%, 4 points.
	Renewable energy utilization	16) Reasonability of Renewable energy utilization plan; formulates plan in accordance with the analysis of potentiality.	Optional	The analysis is accurate, scale is reasonable, the plan is feasible. Utilizes one kind of renewable energy, then 0-7 points, two kinds; 8-10 points; three kinds or more than three, 11-13 points.
3.Resource Recycling Efficiency	Water recycling	17)Urban recycled Water Utilization rate（%）	Compulsory	Reaches 25%, Must-have, no point.

（20 points）		18)Industrial water repeated utilization rate（%）	Optional	Reaches 90%, 5 points.
	Daily-life waste recycling	19)Recycled household garbage utilization rate（%）	Optional	Reaches 60%, 5 points.
	Industrial waste recycling	20)Proportion of recycled industrial solid waste utilization rate（%）	Optional	Reaches 90%, 5 points.
	Construction waste treatment and recycling	21) Proportion of construction waste treatment and recycling	Optional	Reaches 90%, 5 points.
4.perfection of policies and management(15 points)	Low-carbon development planning	22)Compiles the low-carbon town development planning	Compulsory	Must-have, no point.
	Energy management	23)Establishes the supervision and statistics system for carbon emission and energy consumption	Optional	Meet the requirement, 3 points.
		24) Forms a digital and information platform	Optional	Meet the requirement, 3 points.
	Garbage classification management system	25)Systematizing garbage classification management	Optional	Meet the requirement, 3 points.
	New energy and energy-saving technologies	26)Creates specialized funds and other measures for promotion and utilization of new	Optional	Meet the requirement, 2 points.

		energy and energy-saving technology		
		27) Establishes the platform (Data Service Platform, Professional services company, Technician Training etc.) Establishes energy service system to improve market operation, then form a service network	Optional	Meet the requirement, 2 points.
	Low-carbon publicity	28)Publicizes the concept of low-carbon life to improve the social recognition; Actively advocate green and recycling development, low-carbon lifestyles and consumption patterns	Optional	Meet the requirement, 2 points.

3.4 Life Circle Assessment

Life Circle Assessment is one of the systemic analysis methods. It collects and evaluates the input and output value and potential environmental impact during the life cycle from acquisition of raw materials to final treatment of the product system made out of them.』 (ISO14040,2006). The so-called "product system" refers not only to physical products, but also to service system, utilization of resources, human health and ecological impact as well. The life circle assessment consists of four steps: defining

target and scope, examining and analyzing, evaluating impact and interpreting results. Main content and methods of each step is as follows:

Tab. 11 Four steps of the life circle

Step	Content	Method
Goal and Scope Identification	define the purpose of study, system boundaries and functional units	Attributional Consequential
Life Cycle Inventory Analysis	summarize and quantify the system input and output, including data collection, routine calculation, quantifying of the input and output of the product system	Process-oriented Input-Output Hybrid Approach
Life Cycle Impact Assessment	examining the results and classifying them in a characteristic pattern into environmental impact of each type	Damage-Oriented Impact-Oriented Combined-Approach

4 Outlook and Suggestions

Urbanization is a process of gathering talents and industries, a process of developing knowledge and technology, a process of accumulating material and spiritual wealth and a process of lavishly spending resources and energy. Excess consumption of fossil energy aggravated greenhouse gas emission, deterioration of air quality and resource exhaustion, which has threatened people's life. The harsh reality forces us to change the traditional concept of development and values. As more and more APEC economy members promote the strategy of developing low-carbon cities, this report recommends the following experience and suggestions for reference:

First, promote the optimization of industrial layout and industrial upgrading in low-carbon cities with energy internet. Computer Internet has profoundly changed the global economic pattern and citizens' daily life. With the declining cost of solar photovoltaic energy and marketization, and development of energy storage, electric vehicles, demand response and other technologies, the rapid development of the energy Internet, will have a great impact on manufacturing, service, transportation and resource recycling.

Second, promote transit-oriented development (TOD). The main principle of TOD is to ensure the priority of urban public transport. In this way, rapid transit system and non-motor transport could achieve rapid development, and the utilization of private cars could be reduced. Planning and design of Curitiba is based on TOD. That's why it could successfully avoid traffic jam during its rapid urbanization, with its population soaring from 300,000 in 1950 to 2.1 million in 1990.

Third, use as many low-carbon and economical innovative technologies and solutions as possible. For example, recycling of solar wall panels, reclaimed water and rainwater; enclosed disposal of waste and conversion of thermal energy; covering of vegetation in urban space and on building surface; direct rainwater infiltration; promotion of energy-saving building technology and materials and use of recyclable materials.

Fourth, develop compact cities. Compact city strategy emphasizes mixed use and intensive development. People in compact cities could live closer to their workplaces

and daily infrastructures. The strategy not only contains geographical concept, but also emphasizes interrelations inside the city and concept of time and space. The concept of compact city mainly includes high-intensity residence, low independence on automobiles, clear boundaries between urban and rural areas and landscapes as well, mixed use of land resources, diversification of life, clear identity, social justice and self-enrichment of daily life. Intensive use of land not only reduced the occupation and waste of resources, but also realized the mixed use of land, restoration of city vitality, promotion of public transport policy and trial of some ecological measures in the communities.

Fifth, introduce the model of community driving development The ultimate success of eco-city relies on residents in the community. The model of community driving development is closely related to public participation, which enforces the role of the public as producer, builder, consumer and protector of the city Waitakere in New Zealand set forth in the eco-city blueprint the specific actions needed from the city council and local community to realize the perspective. It also specified the responsibility of the city council for the eco-city construction and the steps it is to take.

Sixth, continuously optimize policy guidance and support. Government plays an important role in the planning, design, construction, operation and maintenance of low-carbon cities as a policy maker, investor or sometimes a coordinator. Whether it is for industrial instruction, business support, or individual reward and punishment, the low-carbon policies made at different development stages of the city are irreplaceable.

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