

## Approaching Low-Carbon City — Humble Opinions on the “Harmonious City” Concept of the World EXPO 2010, Shanghai, China

The world has entered into an era of rapid city development, with over half population staying in cities. All the cities, although occupying 2% of the surface area of the Earth, consume 3/4 of the global resources. At the mean while, cities contribute out over half of the residual greenhouse gases in the atmosphere, and billions of tons of solid wastes as well as toxic water pollutants<sup>1</sup>. As warnings to this kind of industrialization-oriented city mode, since the 1970s there have been international declarations against climate change, including the *Kyoto Protocol* with effect from the year 2005, which symbolizes that the human beings have made their first regulation restricting discharge of greenhouse gases: the space for discharge of carbon dioxide has been a type of limited natural resource.

It is thus a global common topic how to find a sustainable way with low energy consumption, low pollution and low discharge, without sacrifice in the property of cities of collection and innovation. The Low-Carbon Economy, is commencing to infiltrate the modernization march of worldwide cities, not only seems to be some trial committed to save discharge of greenhouse gases, but also to begin a new revolution against the economic development method, energy consumption method and people's living method actually. It will comprehensively renovate the modern industrial civilization built based on fossil fuels (energies) to be ecological economy and civilization.

Meanwhile, cities in China have stayed in the High-Carbon Mode for quite a long time.<sup>2</sup> Especially in the recent years with rapid economic development, despite of significant reduction in the energy consumption per GDP of RMB 10,000, increases still can be observed in the national gross energy consumption of overall CO<sub>2</sub> discharge. For a developing country with not-so-rich personal average resources, investigation to integrate a sustainable mode into the demand of rapid city development is not only realistic, but also strategic.

Just in response to such special background, Shanghai World EXPO, since its planning stage in 2001, has raised up the idea of sustainability. Later in 2004 when there was a worldwide collection of proposals, the organizing committee again promoted the idea of Harmonious City to match the theme of the World EXPO. Nowadays in the implementation stage, they further specifies in their plan to investigate out a method realizing a Low-Carbon City, which is a more healthy, rational and practicable way for city development, with the EXPO Park as the experimental yard and demonstrating area. Such investigation will be shown in theme development, in planning coordination and control, in reservation of historic heritages, and in ecological design of buildings and environments.

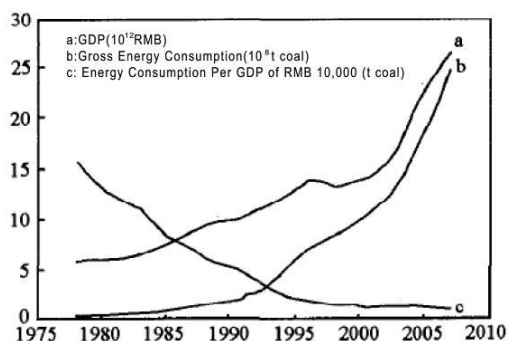


Fig1: GDP, Gross Energy Consumption & Energy Consumption Per GDP of RMB 10,000 of China

Source: Hu An'gang & Guan Qingyou(2008), "Fighting Global Climate Change: China's Contribution—Also as Comments on Tony Blair *Breaking the Climate Deadlock: A Global Deal for Our Low-Carbon Future*" [J], *Journal of Contemporary Asia-Pacific Studies* (Bimonthly) 2008-4.

### 1. Theme development of the World EXPO

The theme of Better City, Better Life is the first thinking by the World EXPO over its history of

150 years on city issue. It is thus the primary question to ask during planning how to realize such theme within the World EXPO Park.

As the result, the following questions have been thought:

- What will the World EXPO, leave to worldwide cities especially those in China?
- What will the World EXPO leave to the hosting city Shanghai?
- What will the World EXPO leave to its own vision?

### ***1.1 What will the World EXPO leave to worldwide cities especially those in China?***

The World EXPO Plan has released the target of Harmonious City, i.e., harmony between the people, between people and nature, and between history and future<sup>3</sup>, and primarily structured the sustainable bottom lines in the four fields of normal operation of a city system.

#### ***1.1.1 City sustainable bottom line in terms of social life***

Cities play the role of both sources of civilization and dispute gathering points. The primary target of Harmonious City is to realize harmony social life within city. The Shanghai World EXPO Plan has specially strengthened the presentation of cultures and beliefs, and invited the whole world to co-discuss city sustainability, realizing more forgiving understanding & cooperation between China and the world.

#### ***1.1.2 City sustainable bottom line in terms of the nature***

City is a symbol showing the human beings no more rely on the nature. But the urbanization oriented to industrialization finally contributes out the opposition between city and the nature. From Utopia to the concept of Ecological City nowadays, people have always devoted to seek for an ideal mode of city development and realize the minimalism in consumption of the natural. The Shanghai World EXPO Plan also declaims its technical beliefs of Zero Discharge and Eco+, with commitment to promote development and application of various new technologies and find the methods of harmonious improvement of both city and the nature.

#### ***1.1.3 City sustainable bottom line in terms of cultural inheritance***

City is where civilization gathers and accumulates. As believed by the city historian Lewis Mumford, in order to secure quality of the new life, we must firstly understand the historic characteristics of the city. Nowadays many China cities under rapid development are still lack of respect to city heritages and minds to maintain both the new and old. Shanghai World EXPO Plan expects not only to create a “new world”, but also to care about the past world as well as the existing one. Under the current Plan, nearly 250,000m<sup>2</sup> of historic buildings and the surrounding 1.4km<sup>2</sup> of residential areas will be maintained.

#### ***1.1.4 City sustainable bottom line in terms of city- region coordination***

Sustainability of a city is closely related with its region. Normally all the negative external environmental impacts resulted from city development, such as toxic discharge to water and air and over-collection of water, will be forwarded via close space relationship to the downstream, downwind and even the whole region. Globalization further worsens the scope and distance of such impacts. Thus the Shanghai World EXPO Plan expects to stay out of concern on an individual city, but to discuss regional strategies and cooperation in the fields of ecology, culture and economy, realizing coordinating & integrated development of the whole Yangtze River Delta.

### ***1.2 What will the World EXPO leave to the hosting city China Shanghai?***

Relying on its population of 16 millions, Shanghai has been the biggest city in China and the 7<sup>th</sup> biggest city region in the world. While widely appraised that it will provide an opportunity to save the World EXPO from fading, the city is undertaking more expectations and requirements compared with ordinary cities in a developed country.

#### ***1.2.1 Location selection and land operation***

Benefits of a World EXPO will come from not only incomes of ticketing and consumption, but also the intangible assets shared by the hosting city and attendees.<sup>4</sup> Prior to selection of the location for the Shanghai World EXPO, the focus shall be integration and upgrading of the central urban area, in the way of wholly relocating the industrial area in the city center, releasing the land values and promoting function transformation for the areas along the Huangpu River. With direct investment in the World EXPO up to RMB 30 billions, the

investment for rectification/ upgrading in business services and urban environment as well as other associated fields will be 5-10 times of such direct investment, contributing to economic doubling up to RMB 100 billion.

### **1.2.2 City infrastructure construction**

It has been common acknowledgment that a large public project will facilitate the regional construction. Shanghai World EXPO also cares more about how to realize effective promotion of the new round of urban construction via such big event. Software & hardware configuration in airport, port, railway transport and information communication, further to completion of large-scale infrastructure in the whole region, will warrant presenting the integrated strength of the city and even the country. Location selection for the EXPO Park in 2002 that the Park will cross the Huangpu River, reflects not only the development strategy of integrating the functions and images of Pudong and Puxi, but also the clear intention of the city government of strengthening Shanghai as an international metropolis. Especially under the current economic mode activated by investments mainly from the China Government, such intention looks more obvious.

### **1.2.3 Pavilions and facilities**

Aichi World EXPO, once completed, had most of its pavilions and facilities demolished back to be parks for the young. At the beginning of the planning work for Shanghai World EXPO, concurrently there had been the plans for pavilion/ facility reuse consisting of the Pre-Post Operation Mode, ensuring that all the permanent pavilions and facilities can be promptly converted for city service and realizing smooth transformation from the 6-month display period to 60-year long-term development. As the result of a series of plans & researches, what the central city area of Shanghai is short of or requires was finally specified, and it's thus decided to, with contribution from the World EXPO, facilitate large-scale ecologic green landscapes, urban creative industry, convention centers, performance centers & museums of the city, and build the city cultural sub-center of Shanghai.<sup>5</sup>

### **1.2.4 Environmental load, resource & energy utilization**

Over the years China has encountered the problems varied from intense population, rapid urbanization, to over-reliance of economic increase on non-recyclable energies, all of which are more typical in Shanghai as the economic center. With more and more serious environmental risk, Shanghai Government has to try to work out a new development method different from traditional industrial mode, and upon success in such transformation, Shanghai will be a sample for other cities in China to follow. Under the World EXPO Plan, the World EXPO will be guided to be a platform integrating experimental research & promotion of urban environment, resources and energies. Since 2004, just Tongji University has applied and executed 127 latest technical projects covering the majors/ fields from city, transportation, environment, energy, material, civil engineering, building, information, to project management.

## **1.3 What will the World EXPO leave to its own history?**

All are from the World Expo. Since the London World EXPO in 1851, the World EXPO has been a grand convention for the human beings to display their innovations and progresses, and such innovations refer to not only products, but also the display themes & methods. In the Chicago World EXPO in 1933, launch of the theme Century of Progress meant the World EXPO had transformed from the pre-industry stage oriented to new products to be the post-industry stage oriented to ideas. All the later World EXPOs further went ahead, imagining the future without reduction in reviewing the reality. However, in contrast, the display methods has always maintained since 1933<sup>6</sup>.

The 2010 Shanghai World EXPO, focusing on the theme of city, innovatively raises the display concept of Best City Practices and invites global cities to attend with their own city missions. There will be a 15-hectare area stimulating urban life, work, recreation and transportation and collectively displaying all the innovative and valuable practical proposals aimed to promote life quality in cities. Such area of Best City Practices is an area to display practices, but itself is also to be displayed, as part of the display theme. Here City is no more part of a national pavilion, but a carrier with independent membership and spiritual connotation in the whole World EXPO. Such innovation expands the display method and

connotation of the World EXPO, and facilitates the World EXPO to further go ahead to the globalized era with more popularity and diversity.

## **2. Space planning of the World EXPO**

### **2.1 Concerns & thinking routes**

Within domestic area or worldwide, there are two types of understandings to the term Low-Carbon Economy. One is energy saving: no matter in production or life, energies especially carbon-based energies shall be saved, in the way of improving energy efficiency and reducing overall quantity. The other is modification in energy structure: to reduce the carbon intensity in energies. In such sense, coals with relatively high carbon intensity must be progressively replaced with natural gas with relatively low carbon intensity, and even wind and solar energies with further lower carbon intensity.

Compared to the traditional construction of city environments, Shanghai World EXPO, under the belief of Low-Carbon City, will investigate to realize the ideal targets of Zero Consumption and Eco+ in the way of considering cities as cells and organic bodies of the whole natural system and designing them in accordance with key elements of the nature. On one side, the balance between energies, water, materials, air, lands and other main natural elements and artificial environments must be maintained, and planning and simulating technologies will be applied to arrange various facilities, finally realizing low-carbon operations of energies, water, and material resources, such as non-polluting fuel battery car, semi-conductor lighting system, and waste harmless treatment. On the other side, it will be investigated how to realize back-feeding to the nature through a series of technical measures including land saving, energy saving, discharge reduction, water purification, and greenization, such as purification system for the air and water and photovoltaic power generation.

### **2.2 Land saving & structural optimization**

#### **2.2.1 Scale rectification**

In response to more and more restricted lands for city use, the Plan encourages intensive utilization of land. Where the World EXPO Park is located is an important origin of the modern industry of Shanghai and even China, with large amount of residential buildings inside.



Fig2.: Aerial photograph & Master Layout of the World EXPO Park area

Source: Regulatory Plan of the EXPO Park ( version III )

After a series of surveys, the Plan makes the guideline to demolish, rectify or maintain those industrial buildings within the World EXPO Park area. The maintained industrial plants will be rectified to be joint pavilions or service facilities. Over 10,000 thresholds need not be re-located within the 1.4km<sup>2</sup> of residential area.

#### **2.2.2 Structural adjustment**

The layout plan will be modified and completed in order to facilitate sufficient integration between construction and the natural environment and reduce consumption of artificial energies. There will be multi-level function groups from Park, District, Zone, Group to Team, with pavilions laid in groups. Green land parks will be provided by water, with a green land corridor reserved to connect to the Huangpu River, which can not only satisfy requirements in

large-scale temperature reduction and ventilation, but also work as fire engine access. During planning stage, the Ecotect~DCFX software will be applied to simulate and research solar radiation and wind speed, whose conclusions will be used to guide local rectification, layout of sun/ rain shelters, plantation & landscape design.



Fig3.: Pavilion Grouping of the World EXPO and the Ventilation Corridor

Source: Wu Zhiqiang etc.(2006), *Integrated Technical Research on Temperature Control & Reduction of the World EXPO Park, Shanghai: CAUP, Tongji Univ.*

综合分析流程图

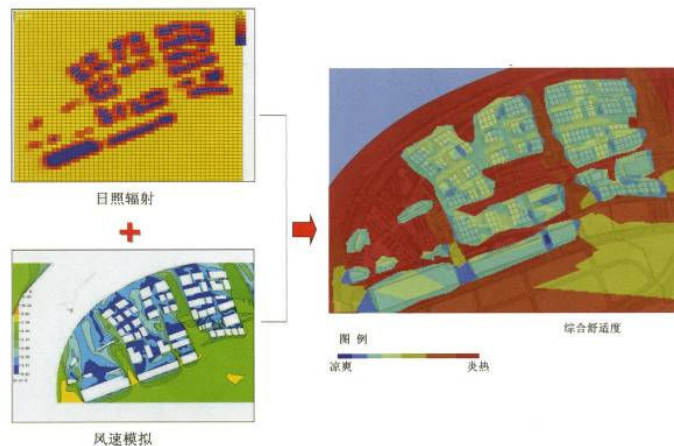


Fig4.: Environmental Simulation with Ecotect~DCFX software for Pavilion Grouping

Source: Wu Zhiqiang etc.(2006), *Integrated Technical Research on Temperature Control & Reduction of the World EXPO Park, Shanghai: CAUP, Tongji Univ.*

### 2.2.3 Shape optimization

Buildings, to be laid permeably, will form a street network with around 30° angle to the prevailing wind direction of Shanghai, which will enable wind to smoothly travel from streets to the riverside while ensuring the air pressure differences in front of and behind buildings so as to strengthen potentials in natural ventilation and reduce requirements in mechanical ventilation.

There will be optimization of the building internal & external spaces and combination of functions so as to increase the land utilization efficiency. The EXPO Axis<sup>7</sup> will connect the main entrance with heavy people stream and the riverside theme square, furnished with the composite functions of access and service. The “sunshine valley” roof will guide sunshine to the underground to realize natural lighting. There will still be a 2-storey pedestrian platform laid in east-west direction within the display area, which creates multi-level views while creating large-area shading on the ground and thus contributing to temperature difference & better ventilation effects.

## 2.3 Energy saving & discharge reduction

### 2.3.1 Temperature control & reduction

Ecotect~DCFX software will be based to make an integrated environmental simulation, under which temperature reduction & ventilation measures will be configured to improve local climate conditions and form a summer “cool island” within the city. Water, road, greening and



building layout will also be utilized to present natural ventilation corridors and thus reduce the temperature. Besides, for sunshine condition in the summer especially those external areas where the temperature is higher than 30°C and the relative humidity is lower than 70%, sprinklers will be provided to spray purified water in the form of super-tiny water mist, utilizing the method that water will absorb heats when converting from liquid to be gas to modify gas temperature, humidity and body comfort. As experiments show, there will be brought with 2-7°C temperature reduction, depending on distances to the sprinklers.

location		time	Temperature	The 5 <sup>th</sup> minute	The 10 <sup>th</sup> minute	The 15 <sup>th</sup> minute	The 30 <sup>th</sup> minute
Direct sunlight area	1 Direct sunlight (in the air)	14: 20		38.5°C	36.5°C	34.5°C	34.5°C
	2 Direct sunlight (on the ground)	14: 20		42.5°C	38.5°C	36.0°C	36.5°C
Shade area	3 Shade( in the air)	14: 20		35.5°C	35.0°C	34.0°C	33.5°C
	4 Shade (on the ground)	14: 20		41.0°C	39.0°C	34.0°C	33.5°C
Water Mist area	5 (Direct sunlight area)	14: 20	35.5°C	30.5°C	29.0°C	28.5°C	28.0°C
	6 (Shade area)	14: 20	33.5°C	27.5°C	27.2°C	28.0°C	28.0°C
	7 on the edge of 5m away from (Direct sunlight area)	14: 20	37.5°C	36.5°C	37.0°C	32.7°C	31.5°C
	8 on the edge of 5m away from (Shade area)	14: 20	36.5°C	34.0°C	33.5°C	33.1°C	31.5°C
	9 on the edge of 10m away from (Direct sunlight area)	14: 20	40.5°C	38.5°C	35.8°C	41.5°C	35.5°C
	10 on the edge of 10m away from (Shade area)	14: 20	35.5°C	34.5°C	34.1°C	34.5°C	33.5°C
	15 in the water	14: 20		34.5°C	34.0°C	34.0°C	34.5°C
others	11 on the grass	14: 20		38.0°C	35.0°C	37.0°C	34.0°C
	12 in the bushes	14: 20		36.0°C	35.0°C	35.0°C	34.0°C
	13 on the façade of a dark colour vehicle	14: 20		46.0°C	42.0°C	48.0°C	44.0°C
	14 in the Sealed plastic bag	14: 20		43.0°C	44.0°C	44.0°C	40.0°C



Fig5.: a brief Experimental Correlogram & Tables of the Experiment by Tongji Univ. on the research of Control & Reduce Temperature with Water Mist

Source: Wu Zhiqiang etc.(2006), *Integrated Technical Research on Temperature Control & Reduction of the World EXPO Park, Shanghai: CAUP, Tongji Univ.*

### 2.3.2 Energy collection & saving

As the World EXPO is abutting to the Huangpu River, it has been one important technical innovation to have the heat pump treatment system with natural river water as water source. In the EXPO Axis project known as the No.1 underground complex, as well as the Performance Center, Conference Center, and Upgrading of the Nanshi Power Plant, such heat pumps with Huangpu River water as the water source are all to be used. Such heat pump sets, laid to utilize surrounding river water, will have its heat generation in the winter more efficient than normal oil/ gas combustion methods, plus cost saving up to about 30%. If in the summer with river water as the cooling water, lowering of 2-3°C compared with normal water will help increase the cooling efficiency for about 7%. In addition, there will be a large-scale solar power generation experiment against the one Axis and four pavilions, i.e.,

the solar power generation system installed in the roofs of all the main buildings with total generation capacity up to 4.5MW, including 0.36MW from the China Pavilion, 2.57MW from the Theme Pavilion, 1MW from the World EXPO Center, and 0.5MW from Nanshi Power Plant.

### **2.3.3 Energy-saving lighting**

Large area of LED systems are to be applied within the World EXPO Park area, giving high lighting efficiency but low power consumption. The City Best Practices area will be used for collective use and display of such systems.

Light guide technology is also to be used in the projects such as the EXPO Axis project and Nanshi Power Plant reconstruction. Basically there will be the grouping system of light gathering via heliostat, reflection via plane mirror and dispersion via prism, known as Ecological Optics Valley under the Plan, which guides natural light to the deep areas of court yards, thus optimizes the interior light environments and introduces in green landscapes.



Fig.: EXPO Axis : Complex Building & Greening Design , Ecological Optics Valley

Source: Shanghai Expo Bearue <http://www.expo2010.cn/>

### **2.3.4 Discharge reduction**

Discharge reduction mainly embodied in control and guiding of transport methods. One is to control travels via private transport, and through transport calming design, encourage walking instead of motor vehicles. With the belief of developing public transport and railway transport, 50% of the visitors are planned to be supported by railway transport. Within the urban area, there will be collective provisions of the P+R systems to realize coordination of public transport and discouragement to private vehicles. On the other side is to reduce carbon discharge of vehicles. In order to realize the target of Zero Discharge, all the public transport within the Park will be cars in new energies such as super-capacity cars, fuel battery cars and hybrid cars.

## **2.4 Water recycling & greening compensation**

### **2.4.1 Reclaimed water reuse**

Under the Plan the reclaimed water system will be introduced in, collecting rainwater, air-con condensing water and Huangpu River water, which will be naturally purified through the artificial wetland technology<sup>8</sup>. The purified water will be reused for river channel feeding, landscape/ water view, plant irrigation and road washing. There has been an experimental area for purified Huangpu River water planned inside the riverside EXPO Green-land, which purify the 17-km long water system layer by layer until the Level V water turns to be Level III-IV.

### **2.4.2 Green lands compensation**

Increasing green land area and greening amount, optimizing ecological functions of green land systems, and promoting ecological efficiencies of green lands can effectively compensate the ecological impacts to be brought in.

**Horizontal direction.** The EXPO Planning and landscape design strengthened the integration of the green lands and water systems (river channels, landscape water) to increase the compensating the ecological effect. In Pudong riverside area, there have planned with green lands over 1 million m<sup>2</sup> with wetland systems inside, including World EXPO Green-land,

Houtan Green-land, and Bailianting Green-land. Studies have shown that rational distribution of the water and green can in the summer create a relatively comfortable micro-climate, which will help lower the temperature, more sun sheltering and less thermal. With network infiltration, roadside greening and temporary plantation, the boundary effects of green lands and water systems have been expanded, realizing maximized ecological effects.

**Vertical direction.** Vertical continuous greening, court yard greening and green roof will help increase the total amount of greening. The green roof to be used in the China Pavilion will balance the thermal load at roof, protect roof structure and provide an outdoor exercise area. In the western and eastern sides of the Theme Pavilion, the external walls are to be furnished with one layer of 3D greening of about 4,000m<sup>2</sup> which will not only maintain wall temperature but also present good heat insulation effects in the summer. Plants under greening purpose will be irrigated with the rainwater recycling system in the roof and help release building heats.



Fig.: Schematic Diagram of Greening Design for the Walls of the Theme Pavilion

Source: Architecture Design of the Theme Pavillion , Tongji University , TAJADRI

## 2.7 Architectural design of important pavilions

Building construction and maintenance is a main energy consumer, and statistics show that energy consumption by buildings takes 40% of the overall consumption.

A key component of the Low-Carbon City concept is green building. All the main pavilions of the World EXPO, especially those permanent buildings such as the One-Axis & Four-Pavilion in Pudong: EXPO Axis, Conference Center<sup>9</sup>, Theme Pavilion which will be analysed detailly as below, China Pavilion and Performance Center<sup>10</sup>, and the upgraded Puxi Nanshi Power Plant, have been fully considered with green environment protective technologies and utilization of recyclable energies/ resources at the design initial stage, with the 3R principles adopted to coordinate energy saving and resource recycling, thus saving the impacts on the environment.

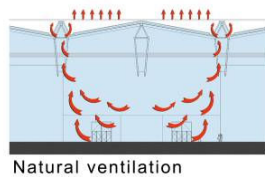
Following is the brief analysis with the Theme Pavilion project as samples:

- The Theme Pavilion (Main Pavilion) is located in the center of Pudong EXPO area, with 80,000m<sup>2</sup> of superstructure and 40,000m<sup>2</sup> of substructure. The Pavilion has commenced its construction since Nov. 10, 2007 and is predicted to complete by the end of Nov., 2009.
- In terms of building shape, it is under south-north collective layout in order to reduce the shape coefficient and fully utilize the south-north permeability to realize natural light collection and ventilation. On the external south elevation is large-scale overhung roof, which can shelter direct sunshine in the summer and save cooling loads.
- Window/ wall ratio strictly controlled. With the maintenance structure tried to be free from curtain wall method, the glass area on the external wall is only 26.2% of the wall area, and the window/ wall ratio is 0.36 only. Elevations are mainly solid wall, with window/ wall ratios less than 0.3.
- External wall heat insulation. Elevation curtain systems are integration of composite heat-insulating metal plates and high-efficiency safety glass. Windows/ doors are all energy saving types, with wind screens provided above entrances/ exits to save energy

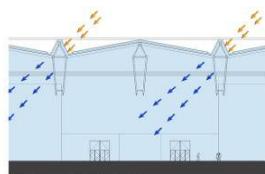


loss. It is also planned to provide 3D greening on the external walls, which will insulate heats in the summer in addition to the effect of temperature maintenance over the walls. Plants will be irrigated through the roof rainwater collection system.

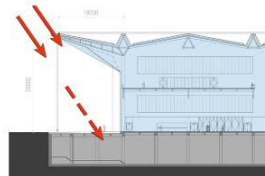
- Roof ventilation & light collection. Certain part of the roof has been designed with skylights for natural light collection over the central area of the big-depth pavilion. Such skylights, customized to match appearance design, are positioned where the upper roof interfaces the lower one and thus come to be side skylights, with area less than 10%. Compared with flat skylights, side skylights have better working effects and more properly satisfy exhibition buildings. Some opening windows are designed within such side skylights in order to strengthen indoor air convection and promote interior ventilation.
- Roof heat insulation. The roof may be classified into non-transparent part and transparent part. Non-transparent roofs are made from composite light-duty heavy-strength metal panels combining honeycomb aluminum plates and heat-insulating materials in order to secure the heat transfer coefficient  $K \leq 0.7W (m^2 K)$ . As for transparent roofs, they are made from 3-layer hollow laminated toughened glass with Low-E coating and heat-insulating aluminum alloy channels, whereby the hollow glasses shall be either glass products attached with electric-powered sun-sheltering curtains, or other high-efficiency and energy-saving glasses such as intelligent glasses that can automatically adjust the transmission and reflection rates of glasses in accordance with direct sunshine, ensuring the heat transfer coefficient  $K \leq 0.3W (m^2 K)$  and the sun sheltering coefficient  $SC \leq 0.4$ .



Natural ventilation



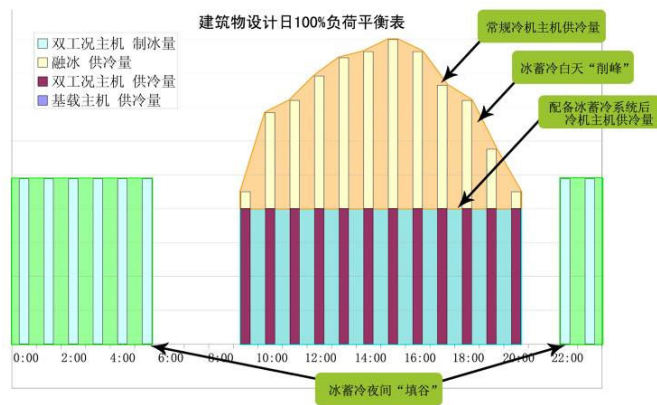
Natural lighting



Roof shading



Rainwater collection and reclaimed water reuse



Ice storage system balance the energy consumption

Fig: Schematic Diagrams of Main Low-Carbon Technologies in the Theme Pavilio

Source: Source: Architecture Design of the Theme Pavillion , Tongji University , TAJADRI

- Indoor space & air-conditioning system. The Theme Pavilio has a huge exhibition space, thus its air-con design is applied with various air-con systems depending on use requirements and function partitions. For those frequently used parts or office areas, there will be small systems with independent cold/ heat sources so as to save

management costs, while the big exhibition hall will be laid with air-con in groups, which can be flexibly separated for small exhibition halls.

- Rainwater collection. Variable roof shapes divide the originally large-area roof into middle-scale catchments, and each downward roof consists of a sloping roof, guiding rainwater into multi-bucket gutters. With rainwater collection & treatment equipments for filtering and sedimentation, rainwater will improved in quality and can thus be used for site irrigation, water view, or sanitary washing.

The World EXPO Theme Pavilion (Future Sub-Pavilion) was upgraded from the old plant of Shanghai Nanshi Power Plant. Its exhibition installation, known as the earliest one in the whole World EXPO Park, started on June 30, 2009. The sense it has made is how to apply new building standards and introduce in ecological technologies over old industrial buildings.

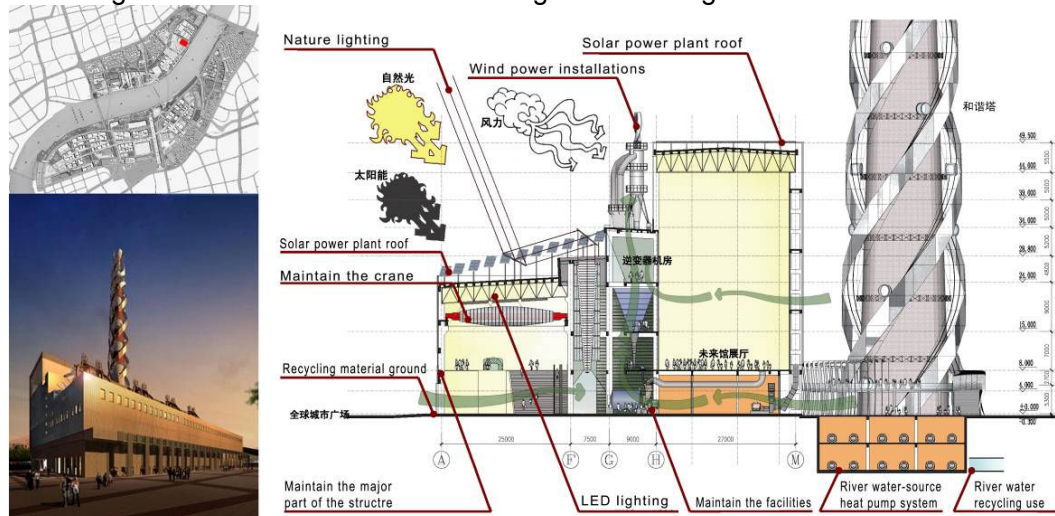


Fig: Schematic Diagram of Relevant Ecological Technologies Used in the Nanshi Power Plant

Source: Source: Architecture reconstruction Design of Nanshi Power Plant , Tongji University , TAJADRI

## 2.8 Other securities

Realization of a Low-Carbon city is not only about technical method and physical space environment, but also about the environment for human activity. In addition to the various technical measured as introduced above, the Plan expects to build the World EXPO to be a large-scale collective display base and experience center of low-carbon life, including the ongoing (1) digital operation management, (2) exhibition planning, (3) policy/ code formulation, and (4) lifestyle promotion, so as to guide the de-carbonizing production management & living methods. The item of Shanghai Ecological Home<sup>11</sup> presented in the Best City Practices area on behalf of Shanghai is just a good sample.

## 3. Conclusion

Big events within cities may happen to be the catalysts for future city developments. It is less than 10 years from application for hosting the World EXPO to completion of construction, but has symbolized the transforming point of the city development mode of China. Different understanding on the concept of Low-Carbon City, as well as other pressures from time, technology to capital that China is encountering, result in full of objection, coordination, insisting and reciprocation in the march of low-carbon trials under the World EXPO Plan. And the real difficulty is just that the transformation still requires commitment of large amount of, probably unprecedented, and mutually coordinating policies and systems. Capital and technology is one issue, to strengthen the systems and policies against climate change is more critical.

Our concern is, whether the concept of low-carbon city that Shanghai World EXPO has brought will be acknowledged instead of misunderstood, whether a better life can be realized

concurrent to economic construction. This is not only a worldwide answer that China must make when joining back to the world trend, but also a review and team work when the Chinese feedbacks to the more and more serious pressure on sustainability.

Endnotes:

1. As statistics of the UN Human Settlements Programme show, urbanization in the recent years mainly concentrates in Asia and Africa. By the end of 2008, over half population had stayed in cities, and there had been over 20 super cities with population over 10 million each. At the same time, main increasing points for city population come from intensively appeared small-scale cities with population less than 0.5 million each.
2. Coal in China always maintains 70% as its rate in production and consumption of primary energies. Carbon-free or low-carbon energies such as nuclear, solar, water & power, although under rapid development, due to small radix and rapidly increasing demand in the total energies, still take a relatively low proportion in the overall energy structure. Currently the carbon dioxide discharge per unit GDP of China is about 4-5 times of that of developed countries. As predicted by the International Energy Agency, in 2009 China will replace the US to be the biggest country discharging greenhouse gases, while with its personal average discharge staying at the average level of the world. Under the 11<sup>th</sup> Five-Year Plan made recently, the energy consumption per unit GDP is planned to lower for 20% and the total discharge of main pollutants lower for 10%.
3. In the winter of 1997, over 50 planners and planning scientists signed the Declaration by Urban Planners in the 21<sup>st</sup> Century written by Prof Wu Zhiqiang. The Declaration, based on review & study on the history of cities & city planning in the 20<sup>th</sup> century, raised up the core guidelines of Three Harmonies, i.e., harmony between the people, between people and nature, and between history and future. In the spring of 2003, Prof Wu Zhiqiang first time stated the idea of Harmonious City in his report to the government and put such idea into the Planning Proposal by Tongji University for the World EXPO in 2004.
4. For example of the Hanoverian World EXPO, the Federal Government and Lower Saxony State co-undertook the red figure of Euro1 billion, but as pointed out by Dr Arno Brandt, the World EXPO brought over the investment of Euro over 5 billion to the region and contributed the taxes of at least Euro 1.35 billion.
5. The Post-use Plan also influenced the policy for pavilions. According to the original plan, all the self-constructed pavilions of foreign countries will be temporary structures. In Aug. 2007, the authority officially agreed to re-locate some excellent self-constructed pavilions inside the EXPO Park for the international cultural sense.
6. In the Austrian Vienna World EXPO in 1873, pavilions in the themes of industry, machinery, agriculture and arts appeared. In the US Philadelphia World EXPO in 1876, pavilions in country themes appeared. In the US Chicago World EXPO in 1893, cultural pavilion and recreation area appeared. In the French Paris World EXPO in 1931, local pavilions of the hosting country appeared. In the US Chicago World EXPO in 1933-1934, enterprise pavilions appeared. Since then there has been no new change in display.
7. The EXPO Axis. (28 Dec, 2006-). With the south-north span of about 1,000m, east-west span of about 110mm and the total construction area of 220,000m<sup>2</sup> (20,000 above ground and 200,000 below ground), the whole building occupies a land of 140,000m<sup>2</sup>. If referred to absolute elevation, the complex will be classified into 3 levels(10m,4m and -6m). The EXPO Axis and its basement complex, furnished with both commercial and transport functions, consist of the biggest individual project within the EXPO Park. Covering the whole building is a piece of 833m-long roof membrane of 98m span, which can realize the functions of sun sheltering, material saving and rainwater collection. There are still 6 large cup-shape curtain walls presenting the Sunshine Valley structure and penetrating from roof to Basement 2 level, utilizing natural light collection. As for air-con system, heat pump systems with river water source and ground source are fully adopted to realize 100% application of recyclable energies for cold/ heat sources.
8. Artificial wetland technology. A series of physical, chemical & biological processes between microorganisms, plants and feeders are applied to purify water, with the advantages of low energy consumption, high efficiency, strong resistance to impact load, easy operation/ maintenance, complete function in denitrification & dephosphorization, and obvious benefits in ecological landscape. The mechanisms of removing pollutants are: (1) removal of organic matters; (2) denitrification; (3) dephosphorization; (4) heavy metal removal.
9. The World EXPO (Conference) Center. (7 June 2007-). With the length about 350m and width about 140m, total construction area about 140,000m<sup>2</sup>, and total building height less than 40m. The

- building, already awarded the Green Building Design Label and LEED International Green Building Certificate, has its building energy saving rate up to 62.8%, 52% domestic hot water supplied by solar energy hot water systems, and rate of utilizing non-traditional water sources up to 61.3%.
10. The World EXPO Performance Center. Land area 67,242.6m<sup>2</sup>, total construction area about 126,000m<sup>2</sup>, including 74,000m<sup>2</sup> superstructure and 52,000m<sup>2</sup> substructure. External peripheral structures of the building consist of aluminum plates, heat-insulating roof panels, external heat-insulating wall, hollow curtain wall, and heat-insulating green roof. With contribution from the water source heat pump energy system, ice storage technology, and air-con system heat recycling unit, the target of energy saving and consumption reduction will be facilitated.
  11. Shanghai Ecological Home. The prototype comes from the first ecological demonstrating house with “zero energy consumption” in China as constructed in Shanghai. There are 30 items of technical integrated, the building integrated energy saving shall be 60%, rate of utilizing recyclable energies 50% of the design energy consumption, rate of utilizing non-traditional water sources 60%, and rate of using recyclable solid wastes as wall body materials 100%.

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