The Pennsylvania State University
The Graduate School
Department of Architecture

DEVELOPING A ZERO CARBON COMMUNITY AT
SHANGHAI WORLD EXPO PARK

A Thesis in
Architecture
by
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ABSTRACT

In the past few years, China has been ranked as the world’s largest energy consumer. The surge in cement production and the broad use of coal-fired electricity generation have also made China the biggest CO2 emitter. The increasing environmental concern has motivated China to make a substantial effort to decrease energy consumption and reduce carbon emission. Despite the effort, China is still at the primary stage of a zero carbon community design. China’s limited environmental progress is partially attributable to the urban planning method that it has adopted. Following the pattern that the US used in the last century, China uses the mono functional urban method. The core characteristic of mono functional urban plan method is to segregate land use through zoning: each geographic area can only be used for one purpose such as residential or commercial use.

Adopting a zero carbon community model is essential to any successful environmental plan for China. From 2000 to 2010, the Chinese government invested 18 billion yuan (2.3 billion U.S. dollars) to build the Shanghai World Expo Park. With the end of the 2010 World Expo, most of the pavilions were removed leaving a large expanse of empty land waiting to be redeveloped.

The purpose of my thesis is to create a plan for the Shanghai World Expo Park that incorporates a zero carbon community. As a model, I rely on Toronto’s success in the redevelopment of its harbour. My design adopts the following to achieve a zero carbon community:

- Utilizing a balanced transportation system to reduce transportation pollution.
- Increase efficiency by adopting a mixed use community design (in contrast to the mono functional urban model).
- Increase the efficiency of cooling and heating systems by adopting low carbon energy district energy.
- Diminish underground water waste by encouraging rainwater harvesting.
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Chapter 1
Introduction

A transformation is taking place in communities all over the world. Thousands of citizens and their governments are embracing a new way of thinking and acting about the future. Recent concern about global warming and a growing energy crisis has compelled China to act more decisively in tackling its environmental problems. Sustainable development has become a central part of the solution to these problems. Repetto gives a definition for sustainable development in the following:

“Sustainable development [is] a development strategy that manages all assets, natural resources, and human resources, as well as financial and physical assets, for increasing long-term wealth and well-being. Sustainable development, as a goal rejects policies and practices that support current living standards by depleting the productive base, including natural resources, and that leaves future generations with poor prospects and greater risks than our own.” (Repetto 1986)

The increasing concern over sustainable development leads to the question of how to live a sustainable life. One of the answers offered is a Zero Carbon Community; it is hoped that building such communities will contribute to the achievement of an environmentally sustainable society. There are many definitions of Zero Carbon Communities. A goal for the Zero Carbon Community is a “…design [that] maximize[s] the quality of life, while reducing the impact on the environment to zero (Wang 2009; Huang 2010)” Here, we can see that the concept of Zero Carbon Community includes two components: improvement in people’s quality of life and a reduction in the community’s environmental impact. A Zero carbon community is a new concept in China. However, China’s serious environmental problems necessitate discussion on how to develop Zero Carbon Communities in China.

According to a report from China’s Current Status of Energy Consumption, China’s
residential buildings account for 37% of China's energy consumption (Changhong 2008). The Chinese government is determined to reduce residential energy consumption; the 12th five-year economic emphasizes this goal as well as the need to reduce CO2 emissions in other sectors of the economy. Shanghai is one of the biggest cities in China. The rapidly expanding economy has made it the biggest CO2 emitter in the world. The end of the 2010 World Expo left Shanghai with vast swaths of empty land that are in need of redevelopment. This presents a good opportunity for research and planning for a zero carbon community. Toronto is world famous for its efforts in sustainable development. Studying Toronto’s environmental strategies may act as a guide for finding solutions to Shanghai’s environmental problems, and thus contributing to China’s environmental improvement.

1.1 China’s energy crisis

China is the biggest energy consumer in the world (Figure 1.1). The extensive use of coal-fired electricity generation has made China the biggest CO2 emitter in the world. It seems this trend will continue because China’s population is predicted to continue growing in the next century (Tollefson 2010). Increasing global awareness of the need for environmental conservation has led China to become more environmentally responsible. Developing energy efficient buildings is an important part of this effort.

Figure 1.1. Countries by carbon dioxide emissions world map. (Jrockley 2006)
In the past few decades, approximately 2 billion square meters of floor space were built in China, which is almost half of all new construction in the world. Only 4 percent of these new buildings were built using energy-efficient designs (Xinhua News reports) (China Pushing for Energy Efficient Buildings 2010). Limited knowledge by the designers of these buildings prevented them from using energy-efficient technologies at the planning stages. According to a report from the Natural Resources Defense Council (NRDC), China has spent up to 45 percent of its total energy on manufacturing and transporting building materials, constructing homes and offices, and heating and cooling systems. (Simon 2010; Fridley 2007) This allocation of resources is unsustainable.

In order to ease the expanding energy crisis, the Chinese government has approved a series of policies intended to increase the construction of energy-efficient buildings. For instance, China’s latest five year plan 2006-10 called for making all newly constructed buildings 50 percent more efficient than previously built structures. This policy applied nationwide. However in four metropolises: Beijing, Shanghai, Tianjin and Chongqing, the increased efficiency target was 64 percent. In early 2006, the Chinese government issued the Energy Conservation Design Standard to encourage contractors to use energy-efficient materials and adapt energy-saving technologies, which is actually similar to the energy use requirement of LEED silver(Ben Christensen 2007). Despite these efforts, China has lagged in the energy-efficient design market. Here is a citation from Christian monitor science: “China has 11 so-called “green cities” as well as 140 green projects. But few of them can pass an international green test – involving low energy use, low cost, recycling water system and “intelligent integrated design and materials.”(Marquand 2006) There are at least 150 building projects that the government has placed a priority on but builders are reluctant to invest. The problem is that these projects have relatively high environmental standards attached, leading to higher construction costs. An energy-efficient building is 13 -19 dollars per square meter more expensive to build than a standard building (Robert 2000). Buyers,
also, are typically more concerned with location, design, or neighborhood than with environmental factors.

According to the report from Worldwatch Institute, environmentally beneficial projects could be more profitable than standard projects. While energy-efficient building typically cost 2-5 times more than standard building, the benefits over 20 years could be more than 10 times of the original investment (Steffen 2007). More money could be saved if we take into consideration the cost of stopping global warming, saving underground water, and keeping global bio-diversity.

The Chinese government recognizes the significance of the energy crisis and the urgency of solving this problem. China’s 12th five-year economic plan (2011-2015) is a reflection of its ambitions on increasing its use of energy efficiency technology (Huang 2010):

“The country will strive to reduce carbon emissions per unit of gross domestic product (GDP) by 17 percent in the period 2011-2015, as part of a larger target to reduce the amount of carbon to 40 percent in 2020 from the 2005 level. China will reduce energy consumption per unit of GDP by 16 percent in 2015, and hopes to increase the percentage of non fossil fuels in energy mix of 11.4 percent from 8.3 percent last year”.
1.2 Shanghai’s environmental problem

Shanghai is located in eastern China, at the middle portion of the Chinese coast. The longest river in China, the Huangpu River, flows across it. It has a humid subtropical climate and experiences four distinct seasons. Winters are chilly and damp; the cold northwesterly winds from Siberia can cause temperatures to drop below freezing. Summers are hot and humid, with an average of 8.7 days exceeding 35°C (95°F) annually. (Shanghai Statistic Yearbook 2006)

Shanghai is China’s most important industrial and commercial center. It is also the fastest growing city in China. The rapidly expanding economy attracts millions of migrants. Choosing the correct strategies with respect to the construction of housing, workplaces, and transportation systems to accommodate the rapidly increasing population is crucial to Shanghai’s sustainable development. In the past two decades, Shanghai experienced rapid economic growth. In 2009, the GDP of Shanghai grew 9.9 percent faster than in 2010. This city accounts for over 4.5 percent of China’s total output. The rapid economic growth led to Shanghai’s rapid population growth. From 2004 to 2009, Shanghai’s population increased from 16.7 million to 19.2 million. It is predicted that more than 20 million citizens will live in Shanghai and its adjacent area by the end of 2011 (Yanlin 2011).

The rapidly expanding economy and the surging population has made Shanghai one of the biggest energy consumers in the world. Its reliance on inefficient energy systems has also made Shanghai the biggest CO2 consumer in the world. As shown in figure 1.2, Shanghai emits 212 million tons of CO2 equivalent each year, almost two times the CO2 emission of Los Angeles. The blue chart

Figure 1.2 Carbon Emissions from selected cities (Tollefson 2010)
shows the per capita carbon emission of ten big cities in the world. Shanghai’s per capita CO2 emission is two times as high as Tokyo’s CO2 emission (Tollefson 2010). This figure shows Shanghai has a low efficiency in energy consumption. Currently, there is a broad discussion about the cause of Shanghai’s low CO2 efficiency rating. Most scholars agree that the following factors contributed to Shanghai’s huge CO2 emission:

1.2.1 The rapid growth of motorized vehicle
Traditionally, bicycles and public transportation have been the dominant modes used by Shanghai residents. But recent social and economic changes have resulted in a dramatic growth in motor vehicle use and overall traffic volumes. The role of bicycles within Shanghai is being overtaken by motorized vehicles throughout Shanghai. In 2005, Shanghai had 1-million licensed vehicles. This number increased to 1.6 million by the end of 2008. This figure is likely to be 2 million by the end of 2020. Table 1.1 shows Shanghai’s energy demand from 1995 to 2030. Shanghai’s transportation energy consumption tripled from 1995 to 2010. Transportation energy consumption is predicted to double from 2010 to 2030.

<table>
<thead>
<tr>
<th>Year</th>
<th>Agriculture</th>
<th>Industry</th>
<th>Transportation</th>
<th>Commercial</th>
<th>Residential</th>
<th>Total</th>
</tr>
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<td>341</td>
<td>34</td>
<td>40</td>
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<td>22</td>
<td>546</td>
<td>204</td>
<td>319</td>
<td>100</td>
<td>1192</td>
</tr>
</tbody>
</table>

Table. 1.1 Useful energy demand in Shanghai, 1995 – 2030 (P. J.)

The rapid growth of motorized vehicle transportation is a big environmental problem in Shanghai because vehicle emissions are one of the leading contributions of energy consumption, climate change, CO2 emission, smog and other air quality problems. Moreover, the construction of many miles of roads and parking lots has had an adverse effect on water quality and required massive amounts of energy to construct. (USGBC LEED Green Associate Study Guide 2009) Local government has noticed the environmental stress that
such projects cause. Since 2007, a series of policies were implemented to limit the number of private vehicles. However, these restrictive regulations cannot serve as a long term solution to the rapidly increasing car demands of Shanghai residents. Chinese urban dwellers are likely to demand the transportation options that commonly exist in Western countries, including prolific use of private automobiles.

1.2.2 Mass produced single-use community

Figure 1.3 shows the residential community built near the World Expo Park. Most residential communities in China are not uniquely designed; rather they are built using a “standard building” model which is duplicated many times over. Such models have few trees or open spaces. Parking lots are typically scattered in poorly lit areas behind high-rise buildings, leaving little room for open areas. Most communities are designed only for residential purposes; there are hardly any parks or recreational areas. Consequently, many residents must drive long distance to work and to engage in recreational activities. The roads were not designed to accommodate the large number of vehicles that use them; the result is severe traffic congestion. This in turn, leads to great energy waste.

![Fig. 1.3 Single used community in Shanghai, image made by author](image)

The urban problems described are largely attributable to the separation of uses doctrine still dominant in urban planning matters in China. The separation of uses doctrine, calls for
permitting only one function for each designated urban area. Thus residential districts cannot include commercial or industrial sections. Chinese cities tolerate few exceptions to this doctrine. A single-use community forces its inhabitants to travel long distances to work and relax. This makes urban dwellers particularly dependent on transportation systems, leading to high energy waste. The alternative to the single-use community model is the mixed-use community model; the adoption of the mixed-use model is a crucial part of a community’s zero-carbon plan.

In many Western countries, the single-use community model is being overtaken by the mixed-use plan. In Toronto, the mixed-use community model has become a mantra in contemporary planning, and its benefits have been taken for granted.

A new community mode is required to help Shanghai out of its traffic problem. Toronto designers have for many years researched and studied the problems associated with the single-use community and the challenge of switching to mixed use. I will further explain the model in Chapter 3.

1.2.3 Broad use of coal-based energy
Coal is a very inefficient and highly polluting fuel. The combustion of coal adds a significant amount of dioxide to the atmosphere per unit of heat energy, more than does the combustion of other fossil fuels. (Conti 2008) Shanghai used to be China’s biggest heavy industry center. Many engines are coal-fire powered. This makes Shanghai one of the biggest coal consumers in China.

Figure 1.4 Shanghai’s primary energy consumption in 2004.(Changhong 2008)
Figure 1.4 shows Shanghai’s primary energy consumption in 2004. As shown in the figure, 61% of Shanghai’s primary energy consumption is coal fuel. During the 2010 Expo, many heavy factories were moved out, leaving a vast amount of empty structures waiting to be redeveloped.

1.2.4 Low efficient cooling & heating systems

Due to China’s geography, heating is required in many regions. Figure 1.5 shows China’s Climate Distribution map. According to the map, the districts where the average January temperatures are below -20°C is regarded as a “Severe Cold District.” Average January temperatures between -20°C-0°C is regarded as “Cold District”. According to statistics from the World Bank, 19% of China’s population lives in a “Severe cold” region, and 27% in a “cold” region. (Geoff Feb 20, 2009) A significant amount of heat is required to keep those residing in these regions comfortable. From the 1950s to the early 1990s, China suffered a great economic recession. The energy market was unable to provide sufficient heating energy to Chinese families. In 1993, the Heating Zoning Regulation of P.R. China (GB 50176-93) authorized a conservation program for heating energy. A law was passed to help the regulatory authority to achieve its objectives. One provision of the law prohibited the use of central heating in Hot Summer & Cold Winter districts. Shanghai fell into this category; in this city there were no provisions made for central heating until the very late 1990’s and central heating systems remain limited to the present time.

The law kept energy use for heating low. At the time that the law was implemented, most Chinese families could not afford to buy individual heating and cooling units. However, by the early 2000’s many Chinese families were becoming wealthy enough to purchase such units for their homes. These units were not prohibited by law. As they became more prolifically used, energy usage in China increased. Dr. Jiang Yi of the Chinese Academy of Building Research estimates that these units have led China to use 2-3 times more energy per
square meter for heating and cooling than buildings in comparable zones in Europe or the US (Yi 2000). Central heating and cooling systems are actually more efficient than the individual heating and cooling units that had come to be prevalent in China. Recently, some voices came out favoring improvement in Shanghai’s energy use through the use of central heating and cooling systems. The urgent heating requirements can be nicely captured by a China Daily editorial in its title “Freezing Shanghai Needs Central Heating.” (Hongfu 2005)

Shanghai needs central heating. However, not enough energy generating plants are constructed to facilitate the city’s heating needs. The city’s rapid growth makes it difficult to find space for central heating plant construction.

![Climate District Zoning in China](image)

Fig. 1.5 Climate District Zoning in China (P.R.China 1994)

### 1.2.5 Over exploitation of underground water
Since early last century, Shanghai has sunk more than two meters because of the removal of groundwater, oil, and gas beneath it. Since 2002, a series of methods have been employed to limit the over pumping of underground water. Meanwhile, the city has also taken steps to pump water back into underground reservoirs to make up for the overuse of underground
water sources. But none of these methods have proved successful. Every year, factories draw more than 100 million cubic meters of water from underground sources—twice the annual pumping limitation of around 50 million cubic meters. The rapid population growth has further exacerbated the city's dependence on underground water.

The encouragement of rainwater reutilization could serve as a way to relieve the city's water emergency. Shanghai has an average annual precipitation of 1,302 mm. An improved rainwater collection system can greatly reduce the need for underground water. Meanwhile, rainwater reutilization can diminish the energy used to pump out underground water. Such changes would contribute to solving Shanghai's environmental problems.

1.2.6 Conclusion
The fast economic growth and the rapid population growth have brought Shanghai great environmental problems. Research studies have shown the following to be factors in Shanghai's deteriorating environment. In Chapter 2, I will discuss Toronto's solutions diminishing these five factors and reversing their ill effects.

♦ The rapid growth of motorized vehicles
♦ Mass-produced single-use communities
♦ Broad use of coal-fire energy
♦ Low efficiency cooling & heating systems
♦ Over-use of underground water
Chapter 2
Case study and Guide Line

In “Chapter 1,” I discussed Shanghai’s environmental problems. Shanghai is not the only city to have these problems. In fact, most Western metropolises have faced very similar problems in the past century. It is understandable because Shanghai was originally built up by Western colonial powers for trading silk, tea and opium. The Western ideas have greatly effected Shanghai’s urban planning and economic development. Now, Shanghai is facing the same environmental problems as many Western cities experienced in the last century. Studies conducted on sustainability for cities in Western countries could prove helpful as a guide for Shanghai in its efforts to tackle its environmental problems. In this chapter, I will discuss Toronto’s strategies for sustainable design. After the discussion, I will summarize the discussed techniques for promoting sustainability. My purpose is to create a foundation for further discussion on finding solutions Shanghai’s environmental problem.

2.1 Toronto – a Sustainable City

Toronto lies on the shore of Lake Ontario, the easternmost of the Great Lakes. Toronto is a city with high population density, which is very similar with Shanghai. It is also one of North America’s most vibrant regions. 6.0 million Canadians live in the Greater Toronto Area (GTA). Toronto is Canada’s commercial, distribution, and industrial center. It is also the financial capital of the nation.

In the past few decades, Toronto has been successful in its efforts to reduce global greenhouse gas emissions. Since 1990, Toronto has reduced 40% greenhouse gas emissions by 40%, using its green strategies. Now, Toronto is listed as one of the greenest cities in the world. There are 1500 parks and 8,000 hectares of parklands – ravines, valleys, woodlots, waterfront natural areas, parks and farmland. There are also 187 km of bike paths, 7.8km pedestrian paths, and 3 million publicly owned trees. There are 307 km of rivers and creeks that run through the city; all flow into Lake Ontario and are part of the Atlantic Ocean.
Drainage Basin. (Statistic source: Land Information Toronto, Parks & Recreation, Natural Resources Canada)

Toronto is gaining a reputation as a leader in sustainable design. In 2005, the David Suzuki Foundation listed Toronto as the leader of North America in addressing climate change. The Climate Group, an independent UK-based nonprofit group bestowed a “Low Carbon Leader” award on Toronto for being one of the five cities internationally in reducing greenhouse gas emissions. Toronto is leading sustainable design in other areas too. For instance, Toronto has one of the largest and most progressive waste diversion programs in the world. In 2006, Toronto became the second candidate city to encourage green roofs. Currently, Toronto is developing a Clean Air Action Plan, a Comprehensive Energy Strategy, a Renewable Energy Action Plan, and a Green Economic Development Strategy.

2.2 Similarity between Toronto and Shanghai

Toronto and Shanghai have many similarities. These similarities make it possible to apply Toronto’s sustainable development experience to Shanghai’s urban planning strategy. Here, I will discuss the similarities between the two cities focusing on the following factors: economic, historical and geographical.

Economy

Both Shanghai and Toronto are ranked among the top 30 global urban agglomerations (Hawksworth 2009). In fact, both of the two cities are regarded as the “economy capital” of their countries. Table 2.1 is a GDP comparison between the two cities. Shanghai and Toronto have very close GDP scale and GDP rank. Both of the two cities are ranked as fast growing. A rapidly growing economy leads to a tremendous need for living space. Traditionally, a population faced with increasing housing costs due to shortages in this sector have adapted by living in smaller spaces. The result is higher population density and less public open space. Shanghai’s massive single-use communities exemplify this trend. Toronto has done a
much better job in balancing the construction of massive living spaces with the preservation of environmentally beneficial living space.

Table 2.1 GDP comparison between Shanghai and Toronto (Hawksworth 2009)

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>Canada</td>
<td>22</td>
<td>$253</td>
<td>10,287.40/sq mi</td>
<td>6.60%</td>
</tr>
<tr>
<td>Shanghai</td>
<td>China</td>
<td>25</td>
<td>$233</td>
<td>8,472.3/sq mi</td>
<td>2.00%</td>
</tr>
</tbody>
</table>

Source: PricewaterhouseCoopers UK Economic Outlook, November 2009 p25

**Geography**

Both Shanghai and Toronto are famous for their water resources. Toronto lies on the shore of Lake Ontario, the easternmost of the Great Lakes. It has 46 kilometer-(29mi) long waterfront shoreline on the northwestern shore of Lake Ontario ("Getting Here" Visit Toronto 2008). The Toronto Islands and Port Lands extend out into the lake. The Toronto Harbour is made possible by the protection these features offer from the lake; the harbor lies to the immediate south of the downtown core. Shanghai is also known for its rich water resources. Shanghai owns the second biggest sea port in the world. It has 697 square kilometers of water area, accounting for 11% of the city’s total territory. Most of the river, including the Suzhou Creek, Chuanyang River and Diangpu River are tributaries of the Huangpu River. The river is about 300 to 770 meters wide with an average width of 360 meters.

Their waterfronts provide precious natural resources for both cities. Development of the waterfront is a central part of their urban planning strategy. In Shanghai, redeveloping the waterfront along the Huangpu River is a central target of the city’s 12th five year urban planning strategy (Huang 2010). In Toronto, redeveloping the Lower Don Lands is regarded as the most promising project in the city. Studies of Toronto’s waterfront can provide important guidance for Shanghai city planners for their city’s future waterfront developing plan.
Shanghai has two main rivers: the Yangtze River and the Huangpu River. The Huangpu River is a tributary of the Yangtze River. By the early 1990’s, the Huangpu River had become heavily polluted. (Environmental impact of waste water discharge at Zuyuan 1990) According to a report from the Shanghai Environment Department, the city’s daily consumption of groundwater was $2.26 \times 10^9$ m$^3$; its daily wastewater discharge was $2.03 \times 10^9$ m$^3$. Only 25 percent of the industrial wastewater was subjected to primary and secondary treatment. (Zhang 1997)

In 1978, the Environmental Protection Law of China was enacted by the National People’s Congress. Following this legislation, the Chinese Government authorized a series laws to control the cleanliness of the Huangpu River and the air pollution along its banks. Despite these efforts, the water quality of the Huangpu River was still very poor. One cause was the rapid increase in Shanghai’s industrial sector. Although, many older factories have closed, there are many new ones that continue to pollute the river. Also, a large amount of organic substances in the Huangpu River is left untreated (Zhang 1997).
The Don River is the larger of the rivers that flow through Toronto. The other is the Humber River which flows east to west through the city. The Don River is formed from two branches: the east branch and west branch. The two branches meet about 7 kilometers (4mi) north of Lake Ontario. (Poll J 2007; Robbertson 2001) By the 1850s, the Lower Don Land became a center of industry, Petroleum storage facilities, and pork processing plants. In 1879, the Don Valley Brick Works opened along the Don River, polluting its water severely. The growing city contributed to the pollution as well; the Don Land and its marshy mouth became heavily polluted. In 1991, the Bring Back the Don committee released a document named “Bringing Back the Don”. The document laid out plans to restore the river. In 1998 a plan to revive Toronto’s waterfront was activated. Now, the area around Don River has become one of the most beautiful places in Toronto.
Industry

Both Toronto and Shanghai have many industries along the waterfront. However, many of the economic activities that once took place in these areas have been discontinued. The buildings housing have been left vacant. This practice has left vast contaminated land waiting to be redeveloped. Redeveloping these industrial lands is an important part of the two cities’ sustainable development.

In Toronto’s earlier industrial era, industrial activity was concentrated along the Toronto Harbour and Lower Don River mouth. The Distillery District and the Lower Don Lands are most representative of Toronto’s old industries. The distillery District contains the largest and best preserved collection of Victorian industrial architecture in North America. It was once the largest alcohol-processing center in the country. In 2001, the site was purchased by Cityscape Holding Inc, which transformed the district into a pedestrian oriented neighborhood. The West Don Land used to be part of the Corktown community, which was home to working class Irish immigrants. Most of the land was industrial or owned by railways, and it became the site of an array of factories and warehouses (Michael Van Valkenburgh Associates 2010). In 2006 a new plan was announced to create a residential community in this area. Currently, the West Don Land is one of the most attractive places in Toronto.
The heavy industrial belt along Shanghai’s Huangpu River is regarded as the largest industrial base in China. In the early 1950s, the area teemed with light machine and raw material industries. In the 1980s, energy and raw material sectors, such as power generation, iron and steel, and petroleum-based chemical industries were given priority in this district. These heavy industries were heavy polluters of the Huangpu River. Later, in the later 1990s, the Shanghai government began a strategic adjustment in Shanghai’s industrial structure, focusing on the development of high and new-tech sectors. Many old industries were closed (Jinsong 2003). Jiangnan Shipyard is one example. Jiangnan Dockyard was built in 1865. As the the place where the first generation of the heavy industry sector emerged in China, the yard is regarded as China’s first national industry. With the approach of the 2010 World Expo, the old industry was closed, leaving 7000m² empty space for redevelopment.
2.2 Balanced Transportation

Automobile dependency is defined as high levels of per capital automobile travel, automobile oriented land use patterns, and reduced transport alternatives. Its opposite is balanced transportation, meaning that consumers have viable transport choices and incentives to use each mode for what it does best (Litman 2000),(Litman 2002) In early 1990s, Shanghai owned most advanced balanced transportation system. The trend is changing due to Shanghai’s rapid growth of private vehicle. As shown in Table 2.2, Shanghai’s retail sale of automobiles almost doubled from 2000 to 2004. Official statistic data showed Shanghai’s private car in increasing much faster after 2004. The rapid increasing private car further aggravated the city’s automobile dependency. Automobile dependency has obvious negative impacts to communities, as Daniel Carlson described in his book “At Road’s End”:

“The activities in which people engage or desire to engage in may affect their vulnerability to traffic impact. So many of these activities have been suppressed that we sometimes forget they exist...Children wanting to play, and people talking, sitting, strolling, jogging, cycling, gardening, or working at home and on auto maintenance are all vulnerable to interruption [by traffic]...One of the most significant and discussed aspects of street life is the amount and quality of neighboring. Its interruption or ‘severance’ has been identified as one of the primary measures of transportation impact in Britain.” (Carlson 1995)

Table 2.2 Retail Sale of Automobiles in Shanghai (Civil Motor Vehicles Statistic 2005)
The problem is how a balanced transportation system could be developed despite the rapid growth of private automobiles in an urban environment. Automobile dependency effects many aspects of the urban landscape and urban life. It includes various transportation and land use factors as described in Table 2.3. These tend to be mutually reinforcing so it is generally inappropriate to consider any one factor to be the “cause” of automobile dependency (Litman 2002).

<table>
<thead>
<tr>
<th>Factor</th>
<th>Automobile Dependency</th>
<th>Balanced Transportation</th>
</tr>
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<tbody>
<tr>
<td>Motor vehicle ownership</td>
<td>High per capita motor vehicle ownership.</td>
<td>Medium per capita motor vehicle ownership.</td>
</tr>
<tr>
<td>Vehicle use</td>
<td>High per capita motor vehicle use.</td>
<td>Medium per capita motor vehicle use.</td>
</tr>
<tr>
<td>Land use density</td>
<td>Low.</td>
<td>Medium.</td>
</tr>
<tr>
<td>Land use mix</td>
<td>Single-use development patterns.</td>
<td>Mixed-use development patterns.</td>
</tr>
<tr>
<td>Land for transport</td>
<td>Large amount for roads and parking.</td>
<td>Medium amount devoted to roads and parking.</td>
</tr>
<tr>
<td>Road design</td>
<td>Road designs favoring automobile traffic.</td>
<td>Road designs balancing modes.</td>
</tr>
<tr>
<td>Street scale</td>
<td>Large scale streets and blocks.</td>
<td>Small to medium streets and blocks.</td>
</tr>
<tr>
<td>Traffic speeds</td>
<td>Maximum traffic speeds.</td>
<td>Lower traffic speeds.</td>
</tr>
<tr>
<td>Walking</td>
<td>Mainly in private malls.</td>
<td>On public streets.</td>
</tr>
<tr>
<td>Signage</td>
<td>Large scale, for high speed traffic.</td>
<td>Medium scale, for lower-speed traffic.</td>
</tr>
<tr>
<td>Parking</td>
<td>Generous, free, rigid requirements.</td>
<td>Modest, some priced, flexible requirements.</td>
</tr>
<tr>
<td>Site design</td>
<td>Parking paramount, in front of buildings.</td>
<td>Parking sometimes behind buildings.</td>
</tr>
</tbody>
</table>

A balanced transportation system needs thorough consideration of design elements such as high speed transportation, bicycle, pedestrian, parking space. As R. Kitamura discussed in his book "Self-Reinforcing Motorization (Kitamura 1999): "A mixed transportation system is generally in the middle range of most factors, with nodes of low automobile dependency, where transit and non-motorized travel is favored, and other areas that are more automobile dependent. " This chapter extends this topic by studying the way that Toronto designers balance the relationship among pedestrian, bicycle, subway, public transportation and private vehicle.
Removing Barriers and making connections

The success of any new waterfront community depends on the quality and quantity of transportation links to the surrounding city. This includes pedestrian, bicycle, public transit and private automobile. Designers are trying to improve the Lower Don Lands' traffic conditions by removing existing barriers and improving the transportation connections between the Lower Don Lands and Toronto’s city center. Before redeveloping the Lower Don Lands, Lake Shore Boulevard was the only main street linking the site with the existing urban center. According to traffic and transit analysis, this street would be unable to fulfill the requirements of future residents. Instead of simply widening the existing street, designers of the Lower Don Lands decided to provide multiple connections to the surrounding neighborhoods so that local residents could have easier access to nearby destinations. Figure 2.5 is the proposed Lower Don Lands Crossing Plan. The figure shows the four portals and nine bridges that are to be built to connect the neighborhood directly with Toronto’s downtown, located to the north of the Lower Don Lands. The Queen Quay will be extended as a second main road across the site. Two flood crossings will be constructed allowing excess water to flow into the lake, reducing flood risks that could threaten the safety of the Queen Quay. The following proposed changes can further improve multi-modal transportation systems in the Lower Don Lands:

- Extend light Rail Transit (LRT) Route to improve high speed transportation.
- Realign Lakeshore Boulevard to provide a spine for new community development
- Widen existing Cherry Street to improve the connection between Lower Don Lands and the city center on its north. (Lower Don Lands Frame Work Plan 2010)
Figure 2.5  Lower Don Lands Crossing Plan (Lower Don Lands Framework Plan 2010)
High Speed Public Transportation

Automobile dependency tends to increase overall congestion costs. Figure 2.6 shows the relationship between annual vehicle travel and congestion delays. Automobile dependent cities such as Los Angeles and Houston have much higher per capita delays than cities with more balanced transportation, such as Toronto. Increasing the highway infrastructure does not reduce traffic congestion (Daniel Brod 1997), but grade separated transit can reduce congestion on adjacent highways by attracting travelers and thereby discouraging the use of private vehicles.

Toronto reduced automobile dependency by making private vehicles less attractive economically and being aggressive in supporting and funding high-speed public transportation. The subway and highways are the main components of Toronto’s high-speed public transportation system. Designers of Lower Don Lands improved high-speed public transportation by extending the two transportation systems into Lower Don Land at the very beginning of this project.

Figure 2.7 shows the Lower Don Land’s future LRT plan. The new LRT plan will give residents and visitors new transportation options regarding the port land with an extension of the current LRT lane. Another branch of the LRT will continue south along Cherry Street terminating north of the Ship Channel. In this way, the southbound branch could be extended further towards Unwin Avenue to service Lake Ontario Park, Cherry Beach, and adjacent areas. (Michael Van Valkenburgh Associates 2010) Figure 2.8 shows the Lower Don Land’s future roadway plan. Historically, the Lower Don Lands sat as under-utilized land because of
the significant barriers and infrastructure challenges inherent to the site. A waterfront road in planned for construction; it will be another connection between the current Lower Don Land and Toronto’s downtown center.

Figure 2.7 Future LRT Plan of Lower Don Land Toronto (Inc May 2010)

Figure 2.8 Future highways Plan of Lower Don Land Toronto (Inc May 2010)
Shorten Walking distance

The walking distance to public transit is an important component of transit design. Designers of the Lower Don Land created public transit routes that allowed residents to walk only short distances to get to stops along these routes. Figure 2.9 is Lower Don Land’s transit plan. It illustrates the LRT route and its relationship to the communities. A circle is drawn around each transit stop, indicating the areas that are within a 5-minute walk to the stop. The model privileges active transportation and transit in the Lower Don Land.

Figure 2.9 Shorten Walking Distance to LRT Stop (Lower Don Lands Frame Work Plan 2010)

Shorten Waiting Time

The wait time for public transport is a large component of the total travel time. In Toronto, public transport schedules allow for minimal wait times. Generally, passengers wait less than 4 minutes during rush hours. In downtown districts, high-speed Subway waiting time is no lower than 90 seconds. The metro systems reduce average waiting times to just one minute for many destinations.
**Bicycle Trail Nexus**

Bicycle trails are a very sustainable and important mode of public transportation. In Lower Don Lands, two boulevards are specially designed for the purpose of maximizing this neighborhood’s potential for bicycle transportation.

The Martin Goodman Trail is one of Toronto’s premier bike trails. After redevelopment of the Lower Don Land, the bicycle trail will wind through the Lower Don Lands, connecting the city to the Port Lands, Lake Ontario, and the Don Valley. Besides the Martin Goodman Trail, a new pedestrian trail will be constructed. The new trail starts from the east corner of the Lower Don Land and extends along the north side of Lakeshore Boulevard. The new trail will cross the Don River and then turn north along Parliament, Trinity, and Cherry Streets. Together the two trails will serve as an important complement to the public transportation and recreation.

*Figure 2.10 Create A Bicycle Nexus (Lower Don Lands Frame Work Plan 2010)*
Arrange buildings so that pedestrians can enter them

The design of the Lower Don Land encourages pedestrian transportation by promoting walking activity. Alexander discussed principles of creating pedestrian friendly streets in his book *The Timeless Way of Building*. Several of his principles for creating pedestrian friendly streets are widely used in the design of Lower Don Lands’ pedestrian nexus (Alexander 1979). Among these principles are the following:

- Arrange buildings so that pedestrians can enter them from many different directions. Create stairways connecting upper stories directly with the street, so that people can move between buildings and streets in a more convenient way.
- Keep high Floor Area Ratio (FAR) and mixed use. Typically, Toronto has a FAR higher than 1.5. The combination of high FAR and mixed-use space can help produce a considerable amount of foot traffic, which is crucial for creating pedestrian friendly streets.
- Create attractive small squares and arcades. Scattered small squares are most favorable for pedestrians. Bars, shops and art galleries that are located in small squares are among the most frequently used in Toronto. Arcades are also very satisfactory additions to cities.

Figure 2.11. Enable an extensive pedestrian network (Lower Don Lands Frame Work Plan 2010)
2.4 Mixed-use community

As the 20th century opened, China’s population was exploding. In the attempt to provide housing for the rapidly growing population, the country used the most economic construction techniques. In order to fulfill the urgent need for residential space in China, rows and even fields of identical buildings were built. Most of these buildings followed a single-use community model, which is quite unsustainable and energy inefficient. During this time, Toronto’s city planners noticed the problems inherent in single-use communities and began advocating the adoption of mixed use design for urban vibrancy and sustainability. Today, “Mixed use” community has become a mantra in Toronto’s community planning. The concept of a mixed use community is still new to many designers in China.

The benefit of a mixed use community is generally agreed: *Mixed use forms an integral premise of the popular paradigms of New Urbanism and sustainable development* (Bernick 1997). In theoretical discussions, proponents promise social and economic gains from mixing uses; in design exercises, various approaches promote mix; in planning practice, an increasing number of jurisdictions implement mixed-use zones. Canadian planners realized the importance of developing mixed use communities and have consistently applied this model for many years. The New Urbanists suggest that Canadian planning is far ahead of most countries in the world. (Wight 1995). Both Toronto and Shanghai have high population densities and diverse cultures. These similarities are among the reasons to look to Toronto’s mix-use community as a model that can be of some guidance to Shanghai’s future urban planners.

During the 1970s and 1980s, older Toronto neighborhoods became trendy (Caulfield 1994). Gentrification projects in the city made Toronto a big experimental site for the development of mixed-use communities. Districts such as the Distillery District and Waterfront District experienced rejuvenation and intensification of use (Ltd 1991). City planners supported by
local government, sought to accommodate Toronto’s growth without letting it spill into the suburbs through the strategy of intensification and reurbanization (Housing intensification 1987). Generally, two planning ideologists deeply effected Toronto’s renewal process. Jane Jacobs (1961) had a great influence on Toronto’s urban planning. Her book, taught in most planning schools, remained on the “must read” list for decades (Martin 1998). Jacobs had moved to Toronto by the 1970s and joined the Canadian’s urban planning debate force. The debate got a promising result. A reform slate of councilors and mayor was set to take control of Toronto city government in 1972 (Gordon 1989). The Council decided to change planning in the city with Jacobs’ admonitions in mind. The Distill District and the River Front areas are two neighborhoods whose design Jacobs influenced.

Alexander’s *A Pattern Language* is arguably the most important 20th century planning tool. In this book, Alexander and his associate defined 253 patterns of human habitation. Identifying these patterns have helped design communities that meet fundamental human needs. This book is generally known to planners and is beginning to influence actual planning and development. The community patterns in the book had a profound effect on Toronto’s community design. Both the Old Distillery District and the West Don Lands have many pedestrian friendly street patterns which Alexander discussed in his book.

In the following chapter, I will examine Toronto’s application of the mixed-use community design with the theory provided by Jane Jacobs and Christopher Alexander. I selected the Distillery District and the West Don Lands as case study subject. The Distillery District used to be contaminated industrial land. The World Expo Park used to be Shanghai’s heavy industrial center. Research on the Distillery District can give me precious insight on the nature of an industrial land rehabilitation project. The West Don Lands is a community redevelopment project located close to Waterfront Toronto. Research on this project can help the researcher with developing a water based mixed-use community, which fits with the geographic character of World Expo Park.
The Distillery District

The Distillery District is a national historic site with a rich history. The site once had the largest collection of structures built in the mode of Victorian Industrial Architecture in North America. The Distillery suffered greatly during World War I. Its operators were compelled to produce acetone rather than spirits in support of the war effort. After WWI, the Distillery District shifted to wine and rye whiskey production. In the 1990s, the Distillery district was renovated as the second largest film location outside of Hollywood. In 2001, Cityscape Holding Inc purchased the Distillery and decided to restore the Distillery and transform it into a pedestrians-only village entirely dedicated to arts, culture, and entertainment. The distillery Historic District opened in May 2003 and quickly became a vital part of the city and one of Canada’s top tourist attractions. (Otto 1988)

When visiting this district, the part that made the first significant impression on me was its pedestrian friendly streets; they were filled with works of art. The district is designed for pedestrian use only. Walking in this district feel more like walking through an art gallery than along streets. The district is a multiple use space with the integration of galleries, boutiques spas, restaurants and cafes. The functional integration improved the district’s diversity. I have attached master plan of the distillery district (Figure 2.12). The ground floor is composed of a number of small, multi-function spaces. The intent of the designers was to create a space in which visitors can experience new ideas, new foods, new designs and new ways of living and working. Designers describe their goal in this way:

"Our vision was to combine the romance and relaxing atmosphere of European walking and patio districts with the hip, cool dynamic of an area like New York City's SoHo or Chelsea, where creative minds get together and you feel as if anything could happen."

(Jackson 2003)
This design concept is also quite successful in the commercial market. The Distillery District has improved the local economy. Many new communities are built close to the Distillery, which further enhances the district's diversity.
The part of the district that made the second significant impression on me was the Distillery’s pedestrian based transportation. Most buildings have many entrances opened directly from the indoors to the street. This building pattern facilitates pedestrians’ even movement between indoors and outdoors. Alexander recommended this pedestrian transport mode in his book *The Pattern Language*. “Arrange buildings so that they form pedestrian streets with many entrances and open stairs directly from the upper stories to the street, so that even movement between rooms is outdoors, not just movement between buildings.”(Alexander 1987) Shanghai is much warmer than Toronto in winter, so this pedestrian friendly mode is more applicable to Shanghai.

The third characteristic that attracted me is the Distillery District’s small public square that links these pedestrian streets. These small squares greatly improved attractiveness of this district. In China’s cities, people sometimes see vast squares with few people in them, because most of them are designed as memorial squares. They are designed to boast of the greatness of the cities. In other words, these squares are intended as advertisements for these cities. (Qian 2009) Designers of the Distillery District avoid this situation by forgoing large squares with a great many small squares. Figure 2.14 is a typical small square along the main pedestrian street. There are many
small squares like this. These squares vary in size from about 10 meters square to about 25 by 40 meters. A relatively big square is set at the end of the district, as a way of attracting pedestrians passing through small streets behind the square. Small squares are quite common in Toronto.

The fourth quality that caught my attention was the district’s many positive outdoor spaces. These spaces further increase the district’s economic value. The Pattern Language illustrates the positive outdoor space in such a way: “make all the outdoor spaces which surround and lie between your buildings positive. Give each one some degree of enclosure; surround each space with wings of buildings, trees, hedges, fences, arcades, and trellised walks, until it becomes an entity with a positive quality and does not spill out indefinitely around coroners.” (Alexander 1979)

Figure 2.15 is an outdoor open space enclosed by mixed use buildings. The enclosed space creates an attractive theme square that draws many pedestrians. Shanghai has a yearly average temperature of 55.2°F. Shanghai’s January Average Low temperature is 35°F, which is much warmer than Toronto’s 14°F. People tend to use outdoor space more in decent weather. So, positive outdoor spaces are more applicable in Shanghai.
West Don Lands

The West Don Lands is an 80 acre site mostly owned by the Provincial Government. The project is the start of a massive and ambitious waterfront redevelopment endeavor. With an investment of over $300 million from the Toronto Waterfront Revitalization Corporation, construction of this new waterfront neighborhood is now well under way. The Lower Don Land and the Distillery District Area have different characters. The Distillery District area is a commercial-based district. The Lower Don Lands is a living based area that is designed mainly for living and working. Thus, the two places have different design concepts. Designers of the West Don Lands describe their design concept in this way:

“Mixed-used community in the Lower Don Land is designed to be places with full dynamite and diversity. The design concept of mixed-use community goes beyond a simple incorporation of residential, retail and commercial properties. It also developed neighborhoods with walkable street that provide easy access to service and amenities. In Addition, the community allows people to live in the communities where they work and shop improves the quality of life, increase residents’ sense of belong, and reduce traffic congestion. Moreover, the communities fostered a sense of connection that that bolsters the health and vitality of a community and its residents.” (Michael Van Valkenburgh Associates 2010)

The concept description emphasizes diversity and mixed space used for living, working and recreation. Here is a typical mixed-use community in the West Lower Don Land. The first floor is designed as retail and exhibition place. The 2nd to 5th floors are devoted to office and working space; floors 5 to 30 are composed of small apartments built with an
emphasis on efficient use of floor space. These buildings have green roofs, which provide the city with extra green land. A three level parking deck exists within the building; Open outdoor space that would otherwise be used for a parking lot is utilized as space for public use instead. Bicycle racks are set in front of the building to encourage and help facilitate the use of public transportation. Case studies show that mixed-use communities in the Lower Don Lands have the following characteristics: graduated internal density, scattered work place and accessible green.

**Graduated Internal Density**

Communities at Lower Don Land have a graduated density: Areas near the district center usually have higher density; districts near the edges are a little lower. This is understandable because the higher density at the city center increases the number of people who have short walking distances to transport stops. Meanwhile, public functions are clustered around transport stops, further reducing the amount of walking distance required. J.H. Crawford discusses the structure of graduated internal density in this way:

"the concentration of density at the center increases the number of people who have short walks to the transport stop. In addition, public functions should logically be clustered around the transit stop, further reducing the amount of walking required." (Crawford 2002)

**Scattered Work Place**

Traditionally zoning regulations lead to large concentrations of workplaces without family life around them. The concentrated block pattern leads to many environmental, social and economic problems. Designers of the Lower Don Land avoid the traditional block pattern in a way that
scatters workplace throughout living spaces. This design concept reflects the earlier work of Jane Jacobs, who calls for an end to zoning regulations that require the separation of use. Alexander also advocated the pattern of scattered workplace in his *A Pattern Language*: “Use Zoning laws, neighborhood planning, tax incentives and any other means available to scatter work places throughout the city” (Alexander 1977).

**Accessible Green Space**

Figure 2.17 is a typical green space located at central west Dong Lands. Green space like this scatted throughout the Lower Don Lands. Many public green spaces are designed in a way that most citizens have access to them within five minutes walk. Except for the public green spaces, many private interior courtyards are designed as a complimentary to the accessible green space. Research indicated that people prefer to use green lands, which are more accessible to them. This concept is quite helpful for creating active green space. Alexander also advocated accessible green is his book *A Pattern Language*: “Building open public green within three minute’s walk – about 750 feet of every house and workplace. This means that the greens need to be uniformly scattered at 1500-foot intervals, throughout the city. Make the greens at least 150 feet across and at least 60,000 square feet in area. " (Crawford 2002) From this aspect, build small, easy accessible green space can improve residents’

![Fig 2.18. Scattered work space (Alexander 1987)](image)

![Fig 2.19. Accessible green space at West Don Lands (Artist's Rendering of Don River Park 2001)](image)
living standard in a way that is much high efficient than vast single used empty green land.

Summary

The case study shows that the mixed-use community is far more than a simple combination of separated functions. It is part of a strategy for sustainable development as well as good urban form, with the objectives of economic vitality, social equity and environmental quality (Grant 2002). “When you step back and look at great cities through history, people were used to walking. The pre-war city was a mixed use neighborhood where people could walk, take transit, and drive if necessary. We’ve come full circle realizing that this is the better way for people to live.” (Kuhteubl 2009) Most scholars keep positive opinions towards mixed communities in Toronto. Mixed use forms an integral premise of the popular paradigms of New Urbanism and sustainable development (A 1993). Case study reveals that mixed use communities in Toronto have at least three parallel levels:

1. Increasingly intensive Use of Land

Mixed-use space could help to increase the intensity of land use. Traditionally, urban planners set an upper limit on the development intensity of a single use community. This limit was based on the distance of the community to various public facilities. A mixed-use community gives people choice in the various public facilities to include in the planned development. Such options allow for designs that have greater density overall. The population pressures in China create a need for designing urban areas with high density. Because mixed-use communities can allow for higher density, it would be favorable to adopt this model in future urban planning in China. Greater use of the mixed-use design will lead to improvements in land use efficiency. Diversity is also part of the “mixed use” concept. Dr. Jacqueline C. Vischer, the founder of New Work Environments Research Group, expressed her opinions towards mix use land can increase intensive use of land: “If we believe that households choose housing type based on life-cycle stage or income level, then we could
argue that mixing types of housing brings different households together” (Vischer 1984)

2. Increasing the diversity of Land use

Encouraging mixed-use community can increase the diversity of land use within the urban fabric. Compatible use may generate synergies. For example, adding high-density residential uses to commercial and office districts may prove compatible and even complementary because residents who live near businesses may work in those businesses. Their presence could enhance the community after work hours, creating new business opportunities. Flexibility to allow such mixing will enable markets to restore conditions common in the pre-regulated city. (Molinaro 1993)

3. Integrating segregated land use

To put different function spaces together, it is necessary to overcome regulatory barriers. Single-use communities tend to waste land. In such communities, there are usually barriers between each of the functional spaces. These barriers take up a significant amount of the total land available. Consequently single-use communities tend to be less efficient in their utilization of space than mixed-use communities where such barriers are not used. The distance often becomes a waste of land because of industry’s upgrade and change of function. For instance, the West Don Lands were isolated heavy industry lands. The barriers between the Lower Don Lands and Toronto’s city center were preserved for a long time for the Lower Don Lands were set for single use land. Until the early 2000s, the land was put for mixed use. The regulatory barriers between the Lower Don Lands and residential area are removed. In this way, 6000 new residential spaces were added to the place. While integrating barriers among different functions are still a big challenge, the mixed use land provides a solution to integrate segregated land use. (Butts 2010)

Although Shanghai and Toronto have different geographical characters, the two cities
experienced a very similar modernization process. Shanghai is experiencing the same problems that Toronto experienced fifty years ago. Given Toronto’s recent successes with mixed-use communities, it seems promising that Shanghai too can adopt this design as part of a strategy for sustainable development. In the past few decades, Shanghai’s real estate market developed at an extremely fast rate. Shanghai’s property prices reflected this trend. Fig 2.20 is Shanghai’s Yearly Property Price (1999-2009) (Shuai 2010). From 1999 to 2009, Shanghai’s property price increased 500%. The rapid increase led to an urgent demand to develop any usable land. However, most empty lands are extremely expensive. In July 2009, a 230,000m² piece of land located in a suburban area of Shanghai was sold for 3 billion yuan—500 million dollars (Liu 2009). In order to use land more efficiently, Shanghai’s government has authorized many policies to encourage urban renewal programs. According to the Shanghai Report (the most popular daily newspaper in the city), 20,000,000 M² of land is slated for urban renewal projects. (Xin 2009) Mixed use community models are well suited to such urban renewal projects. In fact, many real estate developers believe mixed use urban renewal programs have great potential in Shanghai. For instance, Tongliang vice president of Dai De Liang Bank believes the mixed use community can have a substantial place in Shanghai’s urban renewal program, because “mixed use complexes can help revitalize the city” (Liang 2010) In chapter III, I will discuss the possibility of developing a mixed-use community at Shanghai World Expo Park as a way of examining this assumption.

Fig 2.20. Shanghai’s Yearly Property Price (Shuai 2010)
2.5 Building Design Requirement

We turn now to a general discussion of building design issues. Toronto Designers intended to design the Lower Don Lands to be both a national and global model for sustainability. To meet the goal, a Mandatory Green Building Requirements (MGBR) was set to guide the Lower Don Lands’ sustainable building design. The MGBR builds upon the Canada Green Building Council’s LEED rating system. It defines the minimum performance measures and targets for sustainable building development. Here I list four requirements that could be helpful for improving Shanghai’s building energy use. The following are several excerpts from Waterfront Toronto Framework Plan (Halsall 2011):

Green Roof
The purpose of this requirement is to provide buildings a visual connection between community residents and plant life, provide habitat and increase biodiversity, help reduce the urban heat island effect and contribute to sustainable storm water management. In order to achieve the goal, all buildings over 3 stories and parking garages must:

“Provide a green roof for 50% of available roof space, or the percentage required by the City of Toronto Green Roof Bylaw (Toronto Municipal Code Chapter 492, Green Roofs), whichever is greater. Available roof space shall be calculated in accordance with the City of Toronto’s Green Roof Bylaw.” (Halsall 2011)

Bicycle Parking and Storage
“The intent of the requirement is to reduce emissions associated with automobile use by supporting an effective bicycle infrastructure. According to this requirement, residential buildings are to provide 1.2 secure and covered bike racks and/or storage spots per suite at a convenient and easily accessible location.” (Halsall 2011)
**Waste Management**

The goal of waste management is to minimize waste going to landfills and to encourage all building residents and occupants to participate in responsible waste management. According to this requirement, all kitchens in building suites must have separate cabinet spaces for each of three waste streams. Residential buildings above three stories must provide tri-sorting or separate chutes of each of the three waste streams on all floors: recyclables, organics and waste. (Halsall 2011)

**High Efficiency Appliances**

The intent of this requirement is to maximize energy and water efficiencies to reduce the burden on the energy supply and municipal water and waste systems. According to this requirement, all appliances supplied by the developer that are eligible under the Energy Star program must be Energy Star compliant. Eligible appliances include the following: clothes washers, washer-dryers, dishwashers, freezers, refrigerators, and ventilating Fans. Shanghai does not have a mandatory requirement for appliance efficiency. Creating such requirements could improve Shanghai’s energy use (Halsall 2011).

**Community Integration**

In order to improve efficiency with respect to build use, building codes in China may require structures to be built so as to allow more than one use. The design of such buildings would have the following characteristics:

- Ground Floor for all development: Clear slab-to-slab height minimum 5m
- Typical Floor Above Ground: Clear slab-to-slab height 2.75m
- Above Grade Parking: Clear slab-to-slab height: 2.4m
- Residential Suites design should ensure that 20% of residential suites, which initially contain fewer than three bedrooms, could be converted or combined with other suites to form new suites that contain three or more bedrooms. (Halsall 2011).
2.6 District heating & cooling, renewable energy

Heating buildings accounts for some of 35% energy use in Canada. (O’Neil 2010) This makes energy conservation important not only in residential and commercial living spaces, but in many industrial buildings as well. Traditionally, most of energy for heating buildings in Toronto was supplied by fossil fuel combustion or electricity, which was quite low in energy use. “The combustion of coal, oil, or natural gas, however, involves temperatures far in excess of those needed for home heating or many process steam applications.” (Rogner 1993) In order to improve the efficiency of heating energy, the district use of heating and cooling is encouraged in many areas in Toronto, such as the Waterfront district in Toronto.

District heating and cooling system improve energy use in such a way: The typical pattern of progress in energy use starts with improving the efficiency of conventional technology, and in the later stages involves replacing fossil fuels with renewable resources (District Energy 2010). District energy in West Don Lands and East Bay Front are provided by a District Energy System (DES). This building will provide heated water and chilled waters to West Don Lands and East Bay Front through a network of pipes in local streets.

Here is the way that the district energy system was built in Toronto: To reach Waterfront Toronto’s sustainability objectives of energy efficiency, (including the renewable and reduced greenhouse gas emissions standards), a District Energy System (DES) will be built to serve West Don Lands and East Bay Front. Buildings in these two districts will be heated with hot water and cooled with chilled water, both supplied through a network of pipes buried in local streets (Waterfront Toronto - District Energy Master Plan Summary 2008). Toronto’s district energy master plan summarized benefits of district energy in Toronto. The following are excerpts from Toronto’s District Energy Master Plan:

- District energy is more sustainable because it is renewable. In contrast, traditional approaches involve long-term dependence on fossil fuels and electricity.
District energy sets high quality standards for itself. Abiding by these standards makes the heating and cooling supply more readily available.

District energy can free buildings from combustible fuels, refrigerants and water treatment chemicals. Electrical service may be downsized. Eliminating or reducing the use of these saves space inside of building, allowing it to be used for other purposes. On the roofs, there will be no need for stacks, cooling towers. This makes roof space more congenial in appearance. (Waterfront Toronto - District Energy Master Plan Summary 2008):

Typically, district energy needs an Energy Transfer Station (ETS) to install necessary pipes, heat exchangers and associated controls and energy meters. ETS can be set in basements or on the ground floor. Typically, ETS occupies a little more space than traditional heating and energy systems. So, ETS must be designed at the very beginning of the design stage. Heating and cooling energy are provided by energy distribution pipes buried under the roads. These pipes connect buildings with energy centers. (Morofsky 1997) Figure 2.21 is Toronto’s Direct Energy Center. It is Canada’s largest and energy convention center. It is home to over 1 million square feet of flexible convention space and host to some of the largest convention events in North America.

I have discussed that Shanghai has very few central heating & cooling systems because of energy regulations implemented in the 1990s. Currently, most families use window units,
which is quite energy inefficient. Shanghai has a huge market for district energy. The problem is that most Chinese communities did not consider planning energy centers at the very beginning of the urban planning stage. Few designers consider ETS pipelines in the building design process. The incomplete infrastructure is a major impediment to Shanghai’s direct energy development.

Historically, many coal-fired power plants are built to serve heavy industries in Shanghai’s suburban area. Shanghai’s rapid expansion has turned formerly suburban areas into central districts of the city. In order to preserve Shanghai’s environment, local governments authorized the creation of Shanghai’s Environmental Protection Regulation. According to this regulation, low efficiency power plants must be closed. Since then, many middle sized power plants have been abandoned. The Nanshi Power Plant in Shanghai’s World Expo Park is one of them. In “Chapter 3,” I will discuss how to develop the old Nanshi Power Plant into an ETS center to provide district energy for the community I will design. (Long Weiding 1998) The goal of this chapter is to impart to the reader the advantages of district energy. It is my hope that the government repeals the ban on the use of central heating systems.
2.7 Rainwater Harvesting

A rainwater harvesting system is a special rainwater storage system developed to harvest rain and use it for daily water needs. Such systems are becoming increasingly common in community designs. Designers are spurred to use them due to the need to conserve water. In 2010, Toronto’s redevelopment committee updated Toronto’s Waterfront Framework Plan. The plan is a guideline to redevelop Toronto’s waterfront area. The plan devotes one whole chapter to a discussion of rainwater-harvesting systems. The following are excerpts from Waterfront Framework plan:

A rain harvesting system captures, stores, treats and delivers rain to both residential and commercial buildings. Simple harvesting systems consist of rain barrels that collect roof runoff for simple outdoor irrigation. More complex pumping systems involve large above ground or buried cisterns that store water collected from the roof (Kinkade-Levario 2007). Collected rainwater is then plumbed into the house, either as a replacement or supplement to the standard municipal water supply. Here are the components of a rainwater harvesting system:

- **Collection Surface**: The roof area draining to the downspouts.
- **Roof Washers**: Usually a filter screen to catch the first flush of debris and pollutants from the downspouts before entering the storage cisterns.
- **Delivery System**: The pipes that carry the water to the cistern - eaves troughs and downspouts.
- **Cistern/Tank**: Storage tank for the water.
- **Filtration System**: A chemical or organic filter to clean and treat the water - the extent of filtration depends on its end use
- **Distribution System**: The pipes that deliver the water to the building. This can be the main water source or a parallel plumbing system (keeping drinkable and non-drinkable
Shanghai suffers greatly from water shortage. However rainwater is inadequately harvested in the city. Figure 2.22 is Average Annual Precipitation for Several Major Cities. Rainfall in Shanghai is abundant with 129 rainy days annually. Average annual rainfall is about 1,143.5 mm (Li Shuping 2002). Yet, few buildings adopt facilities to collect rainwater. Shanghai’s water management authorities say most of the rain is unutilized, finding its way instead into the city’s waterways.
Summary

The first chapter discussed Shanghai’s environmental problems. Toronto experienced a very similar urbanization process. Toronto’s experiences in creating sustainable energy and resource systems serve as a good example for Shanghai’s on how this city can resolve its environmental problems. In figure 2.23, I have listed Shanghai’s environmental problems and the way that Toronto resolved its own comparable problems:

<table>
<thead>
<tr>
<th>Shanghai’s Environment problem</th>
<th>Toronto’s Sustainable Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Rapid growth of Motorized Vehicle</td>
<td>• Develop balanced transportation</td>
</tr>
<tr>
<td>• Mass produced single-use community</td>
<td>• Encourage mixed-use community</td>
</tr>
<tr>
<td>• Broadly use of coal-fire energy</td>
<td>• District Heating &amp; Cooling energy</td>
</tr>
<tr>
<td>• Low efficient cooling &amp; Heating</td>
<td>• Building Design Requirement</td>
</tr>
<tr>
<td>• Over exploit underground water</td>
<td>• Rain water harvesting system</td>
</tr>
</tbody>
</table>

Fig 2.23. Shanghai’s environment problem and Toronto’s sustainable technique.
Made by author
Chapter 3
Site Analysis

3.1 General information

The site that was used for Shanghai World Expo Park was once the city’s heavy industrial center. In the late 1970s, the Chinese economy gradually changed from a Planned Economy to a Market-orientated Economy. Many inefficient factories failed to adapt to the new era and consequently were forced to close. In the past few years, increasing environmental concerns forced the Chinese government to control high polluting industries with a series of industrial policies. The new environmental regulations shut down more old factories. All of these changes weakened the economic strength of this area (Zhiqiang 2008).

In order to redevelop this area, the Chinese government decided to build Shanghai Expo Park in the center of the Huangpu Riverside Boulevard. “From 2000 to 2010, the Chinese government invested 18 billion yuan (2.3 billion U.S. dollars) to redevelop the infrastructure in this district.” (Hanmin 2004). There was a great deal of augmentation to the existing infrastructure in this area. This included pavilion construction, soil cleaning, old house demolition & relocation, water cleaning and the construction of the Shanghai-Hangzhou Maglev train.

With the closure of 2010 World Expo, most pavilions in the park will be cleared up, leaving 1305 acre plot of empty land waiting to be redeveloped (Jing 2007). There is broad discussion on how to rebuild this area into a place that both preserves the cultural heritage of the world expo and meets the highest design concepts in the world. It is strongly advocated that when the area is rebuilt, it be a zero carbon community.
3.2 Geography

The 2010 World Expo Park is located in the central part of the Huangpu District (Fig3.2). The Yantz River Flows across this site. The park has an area of 6.68 square kilometers, with an 8.3 kilometers waterfront (Ping 2003). It is Shanghai’s golden area, located 5 kilometers from the city center. The Xu Jiahui Commercial Center and the Renmin Square lies to its northwest; the Nanjing West Road, the Shanghai Bund and the Lu Jiazui International Commercial Center lies to its northeast; the Shanghai World Theme Park is being constructed on its southeast. The unique river view on grand Yangtze River offers one of the best river cruises in Shanghai.

Figure 3.3 offers some basic information about a subsection within the old park grounds. Generally, this area is rectangular in shape, 363 M long and 210 M wide. It was used as an enterprise pavilion in the 2010 World Expo Fair. With the end of the exhibition, all buildings located here are scheduled for removal. This site has a height limitation of 150M and a Floor Area Ratio (FAR) of 3.0, which is makes it a quite building intensive place.
The Jiangnan Shipyard is located on its west side and the Jiangnan Power Plant lies to its east. Both buildings will be permanently preserved after the exhibition. I will discuss the two buildings at “3.4 General plan of Shanghai World Expo Park”. Ban Songyuan Road runs along the north side of the site. It is also called the Path of Heritage. This road will be main traffic servicing this site. I will discuss the road at “3.8 path of heritage”.

![Site Information](image)

**Fig 3.3. Site Information, image made by author**

**Site Area:**

Site Area: 108,264 M² (1,165,400 sqft)

City Road Area: 18,756 M² (201,900sqft)

Green Area: 6,748 M² (72,600 sqft)
3.3 Site History

During World War II, the Huangpu Riverside was one of the biggest heavy industry centers in China. In the late 1970s, the Chinese economy gradually changed from a Planned Economy to a Market-orientated Economy. Many inefficient factories failed to adapt to the new era and consequently were forced to close (Figure 3.4). In the past few years, the increasing environmental concerns forced the Chinese government to control high polluting industries with a series of industrial policies. The new environmental regulations shut down more old factories. Such changes have weakened the economic conditions of the area (Xuan 2010).

Since the 1990s, Shanghai the government put great effort in redeveloping the Huangpu Riverside Boulevard. On Dec.3 2002, Shanghai was chosen as the host for World Expo 2010. The local government decided to build the 2010 World Expo Park on this site so that the area could benefit economically from the Fair. As shown in fig 7, the Huangpu Riverside is composed of four industries: the Jiang Nan Shipyard, the Nanshi Waterwork, the Nanshi power plant and the Qiuxin Shipyard (Yu Zhiyuan 2010).
**Jiangnan Shipyard**

Jiangnan Dockyard was built in 1865. As the first generation of industry workers in China were nurtured in Jiangnan Shipyard; the yard is regarded as the cradle of China’s national industry. The dockyard has two berths and three docks with an 1100m hover port. With the approach of the 2010 World Expo, the Jiangnan Dockyard was moved to Changxing Island. The Berth # 2 is preserved as historical heritage. The biggest dock in the shipyard was renovated to become the China Ship Pavilion during the 2010 Expo (Andrew Moody 2009).

**Nanshi Water Plant**

Nanshi Waterwork has 100 years of history. The original factory was named Dongjiadu Waterwork and was founded in 1902. In 1956, the Mainland Water Plant was built just north of the Dongjiadu Waterwork. After the P.R. of China was established, the two water plants were combined and given the new name: Nanshi Waterwork. Before the 2010 World Expo, the Shanghai government invested 16.2 million dollars to upgrade and expand the factory, part of the original Dongjiadu Waterwork on its south side was cleared up for the construction of Enterprise Library; the north side was rebuilt to supply portable water for 1.4 million people.
**Nanshi Power Plant**

Nanshi Power Plant has been a coal-fire powered electricity plant for more than one hundred years. It was a private power plant, founded in 1918. In 1955, the power plant was nationalized and given the name Nanshi Power Plant. In its heyday, it provided electricity for 1/3 of the city (ZHANG Zi 2009). Despite its past achievements, the power plant is likely too old to adapt to modern society. The coal-fired generating unit seriously pollutes the environment. In preparation of the Expo 2010, the Nanshi Power Plant was renovated and upgraded.

Following the renovation plan, the southern section of the power plant was demolished to make way for the construction of the Expo's corporate exhibition halls. During the 2010 Expo, the north section was renovated as the Theme Pavilion, “Urban Dreams”. A 165-meter chimney at the site was transformed into a 201-meter “Expo Harmony Tower.”(Yiqin 01-21-2008) No decision has yet been made on how to utilize the north section after the Expo.

**The Qiuxin Shipyard**

The Qiuxin shipyard Founded in 1902, the Qiuxin Shipyard is equipped with one 15000 ton, one 1000 ton, and two 500 ton class slipways as well as one 1000 ton class dry-dock. The yard is mainly used for building container vessels and chemical tanker aluminum high-speed vessels. Before the 2010
Expo, most factories buildings at this site were demolished. Four office buildings have been preserved due to their significance as historical heritage.

3.4 Plan of the Shanghai Expo Park

Fig 3.9 is the basic design concept of the 2010 World Expo Park. The seven belt shape structures are parallel extended along the Huangpu River. The brown belts are intermediate area that connect the park to the city. The purple belt is called the Path of Industrial Heritage; the yellow belts in the middle are pavilions; two green belts are set close to the Huangpu River. One green belt is the World Expo Park that was built parallel to the Huangpu River; the other is a very wide boulevard dividing the lanes of Songjiang Road Figure 3.10 is the basic landscape structure of World Expo Park. The blue axis is the main view axis. Most important landmarks are visible along this axis, identified as the blue arrow in Figure 3.10. Landmarks have been constructed at the orange points and are linked by elevated footpaths, shown as a red line in the drawing. (He Qinghua 2009), (Huang 2010)

Landmarks

Figure 3.11 identifies seven landmarks in the World Expo Park. The seven landmarks are the most important buildings in the park and will be permanently preserved after the Expo 2010:
The Chinese Pavilion, the World Expo Culture Center and the Expo Boulevard are three of the most important landmarks on the west side of the park. The Jiangnan Dockyard is located at the extension of the main view axis. The Expo Boulevard and the Jiangnan Park are located at the Expo Boulevard—the main view axis of the Expo Park.

**The Chinese Pavilion**

The main structure of the Chinese Pavilion is also called The Crown of the East. It has a distinctive roof, made in shape of traditional DouGong or Brackets, which have a history dating back more than 2,000 years. Below the main structure is a 45,000-square-meter joint pavilion featuring the displays from local provinces, cities and regions. After the 2010 World Expo, the Chinese Pavilion will be permanently preserved for its value in helping to preserve the country’s cultural heritage. (Zhi 2008)

**World Expo Culture Center**

The Culture Center is a flying saucer shaped building located close to the Chinese Pavilion. As a landmark of the Huangpu River tour, the building will be permanently preserved. The
World Expo Culture Center has a unique saucer shape. Zhang Zhi, a famous journalist writing for the China Daily described the culture center in this way:

“Viewed from a boat on the Huangpu River, the World Expo Culture Center hovers over the water’s edge, like a huge seashell, some people call it flying saucer. From the air, it presents the quasi-ovoid shape of an egg morphing into a guitar pick. From any angle, its bold architecture commands attention with asymmetrical curves and an otherworldly flair.” (Shanghai World Expo’s Culture Center 2010)

**Expo Boulevard**

Expo Boulevard, which is comprised of two levels and a covering canopy, is located at the center of Expo Park and is the largest stand-alone object within the Expo site (2.4 million square meters). Expo Boulevard has two levels underground and one above plus a canopy. The horn-shaped structure is called “Sun Valley”. It is the main structure of Shanghai 2010 World Expo Boulevard which was the entrance to the Expo. It is linked to four streets, connecting five blocks and serviced by three Metro stations. It also has cafes and restaurants. The Expo Boulevard will be kept after the end of the exhibition. There are 6 “Sun Valleys” all together. In between these “Sun Valleys” there are 69 huge pieces which act as cover allowing pedestrians along the boulevard to be shielded from rain. (Grigo 2010)
Harmony Tower

The Harmony Tower was originally a chimney of the old Nanshi Power Plant. The Nanshi plant produced a lot of pollution when it was in use. In 2006 the power plant was closed. The chimney was transformed into a 201-meter-tall “World Expo Harmony Tower”. For the 2010 Expo the building behind was renovated to become the electricity museum, showing how electricity can be generated by utilizing wind, solar, and tidal energy. The power plant faces the challenge of redevelopment after 2010. (Liwen 2007)

China State Shipbuilding Corporation Pavilion

The China Ship Pavilion was reconstructed from an old dock of the Jiangnan dockyard. The pavilion resembles the keels of ships, which reflect the original use of the site of the pavilion. Some people think it looks like bones of dragons, a symbol for the spirit of China’s national industries. The entire shipbuilding process and model of ships are displayed in the pavilion. In this pavilion people can preview new modes of human civilization, which emphasize portraying what life will be like in the future “water world”. The first floor is a huge open square for public exhibition and recreation. The building will be permanently preserved after 2010. The building is close to my research site. The big square on the ground floor is an important design element worthy of
consideration. (He 2011) It is a huge structure that has great historic value. It resembles the original site of the Jiangnan Shipyard—the first ship factory in China. Currently there is a plan to renovate it into a 27,000 m² exhibition center after the Expo 2010.

**Jiangnan Square**

The Jiangnan Square is a part of the Jiangnan Dockyard, located at the north side of the Huangpu River. It is designed as a visual extension of Expo Boulevard. A renovated 500-ton class slipway is visible from its main viewpoint. There is a 1640 meter curved footpath platform linking most of the pavilions on the east side of the park. Behind it is the South Xizang Road, which is a main underwater tunnel, that links the east and west halves of the park. During the World Expo and Fair, the square included displays that showed the city’s industrial heritage, emergency evacuation, and environmental improvements. After the Expo and Fair, the Jiangnan Square will be permanently preserved.
3.5 Transportation System

From 2003 to 2010, great efforts were made to improve transportation conditions near the World Expo Park. The great infrastructure investment provided the site with a convenient transportation nexus. Figure 3.18 is subway, Maglev, and light rails close to Shanghai World Expo Park. Maglev is a transportation system that suspends train cars with magnetic levitation. Currently, it is the fastest train in the world. This graph clearly illustrates travel routes to the site. The Inner Circle Highway is located to its north; the North-South Highway is located to its west. The Huangpu Bridge and the Lupu Bridge connect the west park with the east; there are four subway stops near the site; the North Xizang Road is a 2670 m long under-river tunnel that directly connects the park with the city center. The Shanghai-Hangzhou Maglev train, the fastest train in the world, directly connects the park with Pudong International Airport.

Fig 3.18. Traffic System for the Shanghai World Expo Park  (Huang 2010)
The Expo Park is located between the Huangpu Bridge and The Lupu Bridge. The two bridges provide the best panoramic view of the park, which is a blend of water and urban texture. Subway No.13 and No.8 across land.

The dockyards are an important part of the transportation network, allowing pedestrians to cross between West Park and East Park. After the Expo and Fair, these docks will be preserved and used for river cruises and storage transportation.

As shown on the map, there are two subway lines that pass through the Huangpu River; they are used by pedestrians to access the park. There are two subway transition stations located at the north and south sides of the Expo Park. The South Xizang Road is a 2670m long under-river tunnel that connects the west park with the east.
3.6 Land use after the Exhibition

At the very beginning of Shanghai World Expo Park planning, designers decided on how to use the land at this site after the exhibition was over. The following factors were considered when making these decisions: providing services on this site from which surrounding neighborhoods and the city as a whole will benefit; retaining the entrance of the exhibition and some of the more significant exhibits for posterity; keeping the appearance of this area in harmony with the surrounding urban landscape. The designers of post expo construction are taking into account these three categories when formulating the structures, shape, and overall character of this site. Figure 3.22 is a land use plan for after the 2010 World Expo (Zha Ai Ping 2009):

Permanently preserved area (Red): The following buildings/structures are marked for permanent functional preservation: World Expo Culture Center, Expo Boulevard, China State Shipbuilding Corporation Pavilion, the Jiangnan Square and the Harmony Tower.

Alter function Area (Orange): The functions of the Chinese center, the regional center and
the industrial center will be altered but the buildings themselves will be retained.

**New construction area (Green):** The structures in these zones are to be removed post expo. New construction will be guided by facility utilization and land use (as mentioned in the diagram) It is intended that demands of the (free) market will direct those responsible for designing this site on creating the right mix of cultural and leisure attractions as well as living space.

**Land Function after 2010 Expo**

Shanghai has an ambitious goal for the redevelopment of the park: “In the new exploration after the exhibition, the Expo Park will be reshaped into a serial of relevant and systematic areas, along the axe of riverfront development, namely west to east (Ke 2006)” Currently, the Shanghai Municipal Bureau of Urban Planning is in charge of deciding land function of the World Expo Park. I have marked out functions of each area in figure 3.23.

*Fig 3.23. use of land after Shanghai World Expo Park  (Huang 2010)*
**Urban CBD:** Located west of the Lupu Bridge and north of the Huangpu Bridge, beside the permanently preserved world Expo Tower at its west end, the new business belt will be developed along the river. Meanwhile a group of high-grade buildings will be built along the south loop, with a public green belt extending westward between the two parts. This will produce a new CBD after Lujiazui, full of vitality serving the dual functions of business and living.

**Urban exhibition center:** This part encompasses the main exhibition center. The various exhibition areas are connected by underground passages. The future purposes of these areas will be to house other exhibitions and similar services that come to Shanghai. The abundant space for parking makes the space amenable for the building of big shopping facilities. The existing neighborhoods around this area leads some to predict that it will be home to one of the biggest shopping malls in Shanghai. Supported by the public Square, the district can attract a great number of visitors and has all of the ingredients to become what might be considered as a modern image of China.

**Riverfront for entertainment and Leisure** - This section is located at the Chinese Island in the center of the district south of the Huangpu River. It is will be composed of the preserved Chinese center and other relevant districts. The former will be rebuilt to become the memorial of Expo. The Chinese center houses an IMAX cinema. It is planned that this theater will run films showing the whole story of the Expos. The regional center will be either totally or partly torn down, and its function will shift from a cultural to an entertainment one.

**Modern district of Urban Living:** This section is just outside of the enclosed area of Expo Park, east to Bailianjing Park. Most of it came to be from the reconstruction of the Expo village. There are numerous residential high rises in this district, built by modern standards.
The construction incorporates some features of the “eco-technique” and energy-saving service systems. Further many of these buildings are multi-use in character. They are designed to cohere with the residential function of the neighborhood and to demonstrate the Expo theme of “Better City, Better Life”.

**Urban district of Cultural Leisure**: This section is located west of the Huangpu River, between the Lupu Bridge and the Nanpu Bridge. Besides the preserved industrial relics and the modern Urban Experimental District, it includes the industrial center. The structures here are will be altered to serve new functions; they will be utilized for business and to house cultural and art attractions. The preserved shipyard building, used as the industrial center during the Expo, will be transformed into the first industrial history museum in Shanghai. The inner harbor will become part of a yacht club. The waterfront space around it is particularly valuable as a sightseeing spot for the city of Shanghai. The rest of the land will be used to accommodate various businesses and corresponding facilities. In sum, the area will be transformed into a multi-functional public space of profound historical significance, balanced in its use functional and comfortable in its dimensions, and dense in cultural atmosphere.
3.7 Site and its relation with adjacent buildings

The Songjiang Road, which marked out in blue arrow is named as the Path of Heritage. It is also the main road adjacent to the site. Many buildings in this area have hundreds of years of history. Although some of these structures were removed during the expo and fair, many structures will be permanently preserved for their historical values. Figure 3.24 shows the master plan of the Path of Heritage. Areas marked with purple lines will be preserved and remain as they are. No new building will be built in the controlled areas. Two revitalized industrial buildings are located close to the site. The building on the west side of the site is Jiangnan Shipyard; this structure includes a huge square behind a canopy cover. The Harmony Tower is located to the east side of the site. All buildings on the site are designed for temporary use. After the World Expo 2010, the site was planned to be redeveloped into a mixed-use community. A zero carbon community is relatively easy to adopt for a mixed use community plan. That is why I chose this site as a research object. In chapter 5, I will discuss how to develop a zero carbon community on the site.

Fig 3.24 Master Plan of the Path of Heritage (Huang 2010)
Chapter 4
Design Goal

The purpose of the thesis is to create a redevelopment plan for the grounds of the Shanghai World Expo Park that meets the standard of a zero carbon community. The Shanghai World Expo Park was a large exhibition center during Expo 2010. Most buildings on the site were designed for temporary use. After the World Expo and Fair, most buildings on the site were razed. Because of its central locale and prestige, the redevelopment chosen for this area will influence future development plans in the city. Among China’s cities, Shanghai is its greatest energy consumer. However, there are few zero carbon communities in Shanghai. Thus there is a need to encourage the adoption of the zero carbon community model among Shanghai’s city planners; such a shift would substantially improve Shanghai’s natural environment.

Toronto is a leader in sustainable development in North America. This led me to focus some of my research on Toronto’s effort in creating zero carbon communities. Through the comparison of Toronto to Shanghai, I intend to develop some guidelines for Shanghai to develop zero carbon communities. The research will include the following characteristics:

- Reduce transportation energy costs by developing a balanced transportation system. This section is organized into the following four aspects: removing barriers and making connections; improving public transportation; developing bicycle transportation networks; building pedestrian friendly nexuses.

- Create an appealing environment by adopting the mixed-use community model. I will develop the model from the two aspects: develop positive green space and develop an appealing urban plan for visitors of the area along the riverside.

- Improve energy use efficiency through the use of low-carbon district energy systems. The following three aspects are used to create a mixed-use community: incorporating
appropriately proportioned city blocks into the plan; integrating living, working, and residential space; apply energy efficient building designs.

- Diminish underground water waste by encouraging rainwater harvesting. I organize this topic into the following three aspects: district energy, rainwater harvesting systems, and sustainable material usage.
Chapter 5  
Practical Application

In chapter 2, I discussed Shanghai’s environmental problems. In Chapter 3, I discussed how Toronto resolved its own environmental challenges. I summarized six principles of a zero carbon community at the end of this chapter: development of a balanced transportation system, adoption of the mixed-use community model; the use of the District Heating & Cooling Energy System, energy efficient building design requirements, rainwater harvesting system, sustainable material usage. In this chapter, I apply these principles to the design of Shanghai World Expo Park. In this way, I examine the feasibility of the identified methods.

- Balanced Transportation. Balanced transportation can reduce energy consumption by reducing people’s dependence on cars. This part includes four components: removing barriers and making connections, improving public transportation, developing bicycle transport networks and building pedestrian friendly nexuses.

- Apply mixed-use community. The concept of a zero carbon community includes a comfortable living environment for residents. This chapter mainly discusses how to improve people’s living standards by developing an attractive mixed-use community model. The concept of a zero carbon community is an interconnected concept that includes traffic, landscape design, and community design. This part includes the following sections: small city blocks, integrating living, working, and residential space, energy efficient building design requirement, and the development of appealing public space.

- Sustainable technique. This part discusses how to reduce carbon emissions through the use of sustainable techniques. This part has three components: use of sustainable material, use of district energy, and use of rainwater harvest system.
5.1 Basic concept

My first impression about the Shanghai World Expo Park site is that the redevelopment plan should be consistent with the integrity of the city’s overall development plan. The new plan should be geared toward not only promoting development along both sides of the Huangpu River that is in harmony with the surroundings, but also promoting a rational functional use for the remainder of the site. These goals are consistent Shanghai’s broader 3-year Action Plan. Shanghai’s Environmental Protection and Sustainable Development Plan is a central part of this plan. According to the plan, a total of 3,000 hectares of green space should be created in the urban area, doubling the green space coverage in Shanghai to 30% and per capita green space to 7.6 m$^2$ (Hanmin 2008). Figure 5.1 shows the proposed green belts to be grown along the Huangpu River in the following three years. The plan leaves 28,000M$^2$ to be used as green lands on the site. The plan must answer the following questions: What design is most conducive to a healthy environment? What design will allow members of the community to take the greatest advantage of the green lands?

Fig 5.1. Suggested green lands along Huangpu River (Dai 2010)
The left figure shows Shanghai’s historical green coverage. Very few green lands existed along the Huangpu River in the past. The dearth of greenery along the riverside is partly due to the high degree of pollution from the old heavy industrial activity that took place in the area. From 2002 to 2007, Shanghai invested 58 billion Yuan to upgrade its urban infrastructure. Many heavy industries were moved out of the riverside area. Two green belts were cultivated. One of these belts is the green land along the Huangpu River; the other belt was seeded along the Path of Heritage site. In the following three years, new green lands are planned so that the two greens line can interweave into a “green net,” as rendered in the picture on the right. Path of Heritage is located in the middle of the two green belts. The figure on the right includes a depiction of the suggested central green land, connecting the green belts on north and south sides of the site. (Group 2008)

Fig 5.2 Basic Concept – Connect green belts on north and south side of the site, Image made by author

Fig 5.3 Design Concept 2: Building shape and its relation to the environment. Image made by author

Fig 5.2 shows the main Boulevard on this site. The green boulevard will link green belts on the north and south sides of the site. Fig 5.3 reveals the location and shape of the proposed buildings. There are two main roads servicing this site: The Songjiang Road (which is also named as the Path of Heritage), located along the north boundary of the site and The Baijing Road, which lies to the west side of the site. These two roads are the main access routes to the site. The roads are considered the site’s main entrances, and the green belt, which
connects to the two entrances, creates a dramatic landscape for motorists as they enter the area. The southwest corner has the greatest commercial value. An “L” shaped building planned for this spot is considered the “anchor” of the building cluster. This “L” shaped building marks the major intersection, presents a solid and complete image, and provides privacy for the inner spaces.

Figure 5.4 shows the location of three high-rise buildings. Three high-rise buildings step down from the north west corner to the south east corner and are the most striking landmarks of this section. The three high-rise building will create a visual corridor in an east/west alignment. This arrangement of the towers gives an opportunity for natural ventilation and creates a visual corridor to the Huangpu River.

Figure 5.5 depicts the functional arrangement of this site. A restaurant is set in the central garden. The spot is designed as a social activity center. The intent is to foster a diverse and high quality of life. A small garden was set on the south side of the site to attract pedestrian traffic from the riverside. It is a place of recreation and exhibition. This green space serves as an extension of Riverside Park on the site’s south boundary. In Chapter 5.3, I will discuss how to develop attractive open space in Shanghai Expo Park from what I have learned studying Toronto’s urban design.
5.2 Develop Balanced Transport

Most of the transportation routes and modes of transport have already been decided. Yet, there is still room to improve the plan in this respect. Here, I discuss four different approaches to make transportation for the site better: add connections to the existing and planned public transportation system, encourage public transportation, encourage bicycle transport, and facilitate pedestrian walk.

5.2.1 Removing barriers and making connections

The success of the new community depends partly on the quality and quantity of connections to the surrounding city. Recognizing that the site is a critical link between the city and harbour, the new plan should provide multiple connections to the surrounding neighborhoods. To weave this large new community together better into the existing urban schema, the streets and blocks that comprise World Expo Park should be an organic (unobtrusive) part of its environment. As it is, the new community is isolated from the city by a highway that envelopes it. Here I list three connections that could facilitate pedestrian traffic and public transportation.
Connection 1

Connection 1 is an underground tunnel that connects the site with an existing residential district on the north side of the site. The planned 92M long overhead bridge is technically difficult to build. Toronto addressed the same problems. For Shanghai, I suggest building an underground tunnel to avoid the high cost of an overhead bridge. The underground tunnel will connect a residential section with a business district. Some retail space will be built inside of the underground square. These retail spaces can improve the commercial value of the space.

Connection 2

The Jiangnan Shipyards is a two level exhibition area. The square on the first floor is separated by a highway that runs between this building and the ship exhibition center. Connection 2 would connect this site with the Ship Exhibition center; my proposed connector is an overhead bridge. The overhead bridge can separate vehicle from predestination transportation. Additionally, the overhead bridge can facilitate visitors to the View Boulevard.
5.2.2 Improve public transportation

Case studies have shown that great efforts have been made to make sure pedestrians can get to the nearest bus stop within 5 minutes walk. The same regulation could be applied in the new community as a way of improving public transportation.

Figure 5.8 shows Shanghai’s main subway lines. Figure 5.9 depicts Shanghai’s main highways. The city’s subway stops and the major highways are long distanced from the site. This disconnect is partly due to how the site was used prior to the 2010 World Expo—heavy industry. Regulations do not allow for public transportation infrastructure to be set close to heavy industry centers. The long distances to the major transportation lines in the city are inconvenient to residents in the new community. To mitigate the problem, additional bus stations and bus routes are required. They will facilitate pedestrian access to Shanghai’s existing main transportation systems. I have marked out new bus stations in figure 5.11. Two principles should guide the decision-making process in selecting new bus station locations: first, a bus station can serve a maximum 300-meter radius area. Second, new bus stations are to be set close to the main entrances of the site.
Fig 5.10 Bus service area and designated bus station location

Drawing made by author
5.2.3 Develop bicycle transport

Drawing 5.11 shows major recreation trail in Shanghai World Expo Park. The trail is constructed to facilitate both bicycle rider and pedestrian use. One limitation of the trail is that its length between the existing residential district and the Huangpu Riverfront is greater than can be comfortably traversed by most pedestrians. A new bicycle trail has been added as an extension to the current recreation trail. The new bicycle route and the existing recreation boulevard form a circle loop. The objective of the design is to attract residents from the residential areas in the north, which can improve the attractiveness of the existing recreation route.

Fig 5.11. Proposed bicycle line (Drawing made by author)

Fig 5.12 Bicycle racks in the designed community (Drawing made by author)
5.2.4 Pedestrian friendly Nexus

Toronto has adopted the following features for its urban landscape in order to create pedestrian friendly streets: mixed-use building with many entrances, high FAR, attractive small squares and arcades. With some modifications, these features can also be integrated into World Expo Park. The following list is my recommendations on the features in Toronto can be applied to Shanghai:

- Develop a connected building network on the north side of the site as a way of creating an integrated habitat for the residents, workers, and visitors. Attract pedestrians with open squares on ground floors of these buildings.

- Keep a diversity of residential buildings on the south side of the site. Ensure that each all tenants of the buildings have easy access to the view of the river. Reinforce connections among individual buildings. Create an attractive recreation space with the addition of an arcade.

- Keep a relatively high FAR so that more land can be saved for public open space. Design each building so that its occupants have easy access to green space.

Fig 5.13 Proposed pedestrian nexus
Image made by author
5.3 Develop Attractive Open Space

The unique geographical character of this area requires that all environmental considerations be given when designing its public open spaces. Each open space should take full advantage of the area’s natural environment. Following the policy of incorporating more green site into the area’s design is apt to help improve the natural environment here.

5.3.1 Positive green space

Figure 5.14, depicts two view axels across the site. One axes start at the Songjiang Road and ends at Expo Boulevard. Most important landmarks in the park are within of this axel, such as the Chinese pavilion, the performance center and the expo Boulevard. The Second axel starts from the north side of Songjiang Road, and ends at the Baijing Park. Vast green lands and preserved industrial heritage structures are located along this axel. The two view axels are a starting point for site analysis.

Figure 5.15 marks important points close to the site. These points include significant landmarks. I advocate build open public squares at these points so that each square has more access to green lands and beautiful views. I also intend favor linking these open spaces with streets, so that the design can take full advantage of the beautiful views that the green spaces offer.
Square 1

Square 1 is the center of Jiangnan Park. The Jiangnan Park is the biggest green land in the site, the square is also the single most visited spot in the park. Dockyard No2 is an industrial heritage site that has hundreds of years’ history. The route connecting this site to square 1 is an important part of the park’s design.

Square 2

Point 2 is located at the conjunction of the Jiangnan Shipyard Pavilion and the research sit. I have marked the site out with red circle in Figure 5.18. The ship pavilion is a steel frame structure with a 20,000m² size square underneath a tension membrane roof. The square attracts pedestrian from the Jiangnan Shipyard Pavilion.
Square 3

Square 3 functions as an outdoor lobby connecting research site with Songjiang Road. As Songjiang road is the main street of the park, its main entrance is through this route too. The entrance and exit of an underground parkade will be set along this square because it offers the most convenient accessibility to the main transportation system.

Square 4.

The southern border of this site is 354 meters long. In chapter 2, I discussed the advantages of a short city block. A 354 meter long block is too long for pedestrians to walk comfortably. In order to deal with this problem, I propose that a square be set in the middle of the southern border. The square would face Baijing Park on the south side of the Huangpu River. The park would provide the square a very good view. A further appeal of Square 5 is that it is in close proximity to a restaurant. Square 4 helps make this portion of the park a good place to relax and enjoy life.

Square 5

Here, a huge “gate” would be set at the crossing point
between Songjiang Road and Shibo Road. In Figure 5.21 I illustrate the lines of sight that would be available to occupants of the office building (identified as “Site” in the figure). A visual connection is created as the occupants would be able to gaze on both Songjiang Road and the Chinese Pavilion (the most important landmark of the site) simultaneously.

**Square 6**

Square 6 is the original site of the Nanshi Power Plant. In 2003, the power plant was moved to Chongming Island. The structure of the power plant has been preserved as an exhibition center. A chimney was renovated to become the Harmony Tower—a landmark of the western part of Expo Park. Many docks are constructed close to the square. These docks are an important part of the Huangpu River cruise.
5.3.2 Enhance riverside experience
The Riverside Park is an existing park along the north side of Huangpu River. It is recognized as one of the most import green lands that among all those designed for world Expo 2010. The park was originally designed by NITA design group. Figure 5.23 is the master plan of Riverfront Park. I transpose my suggestions onto this design with a red line. As shown in the picture, the square is mainly composed of three curve shaped green lands. Square 4 is set in the midst of the biggest circle. The following describes how the relationship between the site and the park is enhanced and thus how the experiences of pedestrians are enriched.

The northern boundary is designed so as to interweave with the park. One passage directs pedestrians into the central green land of the designed community, which is the central recreation area of the site. In this way, the community can enrich visitors’ walking experience. Additionally, the designed community enriches visitors’ experience by creating many small public squares. The site has a 354 meter long, geographically flat southern border. A flat elevation with such a long distance could have been a disaster to the design because the flat façade will isolate the site from Riverside Park, like a defensive wall. Yet by designing many small public squares as a place to hold visitors and providing them with attractions to hold their attention, this area enhances the visitors’ experiences rather than detracting them from it. Figure 5.23 shows how these continuous small squares enriches the boundary.

Fig 5.23. The interweaved relations between the site and the Huangpu Riverside Park
Drawing made by author
5.4 Attractive mixed-use community

A small block is crucial to the creation of a pedestrian friendly community with a lovely and rich texture. In the Death and life of Great American Cities, Jane Jacobs uses a whole chapter to illustrate the need for small blocks. She cites the example of Manhattan blocks, typically 240 meters long and 80 meters wide. Here is the way she describe big blocks in New York:

“The avenues at the ends of the blocks are the major commercial areas. The lack of intermediate, secondary streets running parallel to the avenues greatly reduce the number of routes that people follow to their destinations, with the result that people who live on one cross street rarely walk along across streets parallel to their own.” (Jacobs 1992)

The site is 353 by 225 meters, which is even larger than the standard block in Manhattan. Obviously, more narrow streets are required to cut the block into smaller sections.

5.4.1 Proper city block scale

J.H.CRAWFORD discussed the size of a pedestrian friendly block in his book Carfree Cities:

“The largest normal blocks proposed for the Carfree city are about 75 by 100 meters. Most
blocks are considerable smaller than this..." (Crawford 2002) Figure 5.24 is a comparison of various urban landscapes-- Madrid, Portland, and Paris—to World Expo Park. The comparison shows that most blocks in the western cities are much smaller than at the Chinese site. The site should be divided into smaller blocks to facilitate pedestrian use. Here I selected 75M X 75M blocks as standard block size.

Figure 5.25 shows the development process of the building’s design. At first, a grid with 75m x 75 m sized squares was set to divide the site into 14 small blocks. A park is designed at the central portion of the site. Buildings are set around the central park (drawing 2). Considering the green belt on the south side of the site, a 16461 M² green land is too big. As a result, several buildings have been incorporated into the site on the west corner. The change creates two corridors linking the central park with main streets on the west and east side (drawing 3). The 370m-long street on the west side is too long for a pedestrian friendly street. Thus green land has been allocated on the south side of the main street (drawing 4). A few changes are made to adjust the relationship between buildings and green lands (drawing 5). A restaurant with a green roof is set on the south side of central green land so that the restaurant can take full advantage of the good view that the green land offers. The goal of
this part is to develop zero carbon community by increase Greening Rate of the community. Greening Rate refers to the whole area of a site divided by amount of area devoted to green land. The site is 83,000m². The green land area is 44,820 m². The Greening Rate (ratio) is 54%. Shanghai’s average green land ratio is 38%. (Zang Xi-Yu 2002) That means the designed site has a much higher Greening Rate than Shanghai’s average Greening Rate.

5.4.2 Function analysis
A mixed-use community should integrate spaces devoted to the following kinds of activities: commercial, work, residential, relaxation, and exhibition. The methodology of attributing each block with the proper size and function is important for a successful mixed-use community. Table 5.1 in page 90 shows a comparison of the economic centers in some of the biggest cities. According to an analysis of European cities, commercial centers close to the city center have the following characteristics:

- High FAR (floor area ratio): The average FAR in the table is 2.9, some of these commercial centers have a FAR higher than 4.0. (Table 5.2 in page 90 is FAR comparison in selected cities (Fouchier 1996))
- Large open Space: The average building coverage near commercial centers is lower than 48%, which means most of these communities have very large open space for public use.
- Intensive office space: Office space accounts for nearly 50% of building area.
- Both residential and commercial buildings are important parts of a commercial center. Residential structures take up about 19% of building area; commercial and retail structures account for 13% of the whole area.
Recreation space is crucial auxiliary space for a successful commercial center. Nearly 50% of these commercial centers have large amounts of recreation space, which take more than 10% of the building area.

However, a high percentage of office space could lead to a population concentration, which will lead to traffic jams and result in energy waste. Further analysis of the relationship between work and residential space is required. Let’s return to J.H. Crawford’s Reference district in his book *Carfree Cities*:

“The population of the district is 12,000 residents, each circular district divides naturally along the central boulevard into two communities of roughly equal size. Each of these communities has a population of 6000 residents, which is small enough that people feel that they belong to a community in which their voice can be heard. The reference district also provides workplaces for 8000 people…”(Crawford 2002)

There are two issues in the discussion: first, the referenced community is developed along a highway. Thus, the community can take full advantage of high-speed transportation for the referenced community. Basically, I propose increasing the densities of buildings that are close to Songjiang Road. Most working spaces and public spaces are designed close to the main road. This function arrangement can maximize space efficiency. This arrangement can also better serve residents living close to the site.
Second, the supposed population model serves 12,000 residents. The site is designed to have only 63920M² of living area. Shanghai’s per capita of living space area is 33.4M², suggesting that the designed community can only serve 2000 residents. If the residential population of the park only rises to 2000, the non-residential portions of the park should be designed to accommodate an additional 10000 people (presumably a combination of workers and visitors). Thus the design should account for residents of the community along the area’s northern border frequenting the park. In order to enhance the relationship between the designed community and existing communities nearby, an open square should be added to reinforce the relationship between both sides of the road. Figure 5.27 shows the location of the square and its relations to adjacent communities. The existing community has a main entrance on the Songjian road. Here, I propose a square that directly connects the entrance with Songjian road. In this way, the existing entrance can directly face the new square. After taking the referenced model into consideration, I added more working space for residents in the existing living communities.
The next step is to decide the functions of each building and its relationship to the environment. Here is a function bubble diagram of the designed community. Office space is located at the north side of the site. There are two advantages for this use at this location: first, those who work in this office space have easy access to the main transportation system. Second, office spaces are close to existing communities located to the north of the site. This arrangement gives the best view to occupants of the residential buildings. Restaurant /canteen spaces are set in the middle as a connection between the living and working spaces. An energy control center is set underneath the restaurant to facilitate district energy distribution. The whole project is divided into two phases to save energy and resources during the construction process. To the working, living and restaurant spaces, there are complementary spaces, such as GYM, baby care, art gallery, and a small exhibition center.

![Function Bubble Graph of the Designed City](image)

**Figure 5.28. Function Bubble Graph of the Designed City**

*Drawing made by author*

Figure 5.28 reveals the final allocation of the designed community. In general, two steps are necessary in the construction process to ensure the mixed-use community emerges. The
design process should follow a certain chronology: First, adjust the site to a pedestrian friendly scale. Second, make sure that proper function and the right area are allocated to the site. Third, develop correct relationships between each of the functions. As I discussed in Chapter 1, a rapid increase in the number of vehicles is a big problem for Shanghai’s environment. Mixed use communities can reduce people’s dependence on motorized vehicles. Consequently, the development of mixed use communities would be helpful towards reducing Shanghai’s carbon emissions.
### Table 5.1 Function area percentage in selected cities (Research Report about Commercial Center at Hu Ning District (沪宁铁路周边商务区功能构成研究) 2009)

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<thead>
<tr>
<th>Project name</th>
<th>Description</th>
<th>Area(ha)</th>
<th>Architectural Area(m²)</th>
<th>FAR</th>
<th>Building coverage(%)</th>
<th>Average Level</th>
<th>Office(%)</th>
<th>Education(%)</th>
<th>Residента(%)</th>
<th>Hotel(%)</th>
<th>Shopping(%)</th>
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<tbody>
<tr>
<td>Broadgate</td>
<td>Main commercial district in London center</td>
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<td>359200</td>
<td>4.2</td>
<td>60%</td>
<td>8.6</td>
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<td>0</td>
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<td>0</td>
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<td>Canary Wharf</td>
<td>Commercial Development District</td>
<td>34.8</td>
<td>1626800</td>
<td>4.7</td>
<td>35%</td>
<td>19</td>
<td>93%</td>
<td>0</td>
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<td>2</td>
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<td>Redeveloping plan of the Birmingham district</td>
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<td>14660</td>
<td>2.1</td>
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<td>70%</td>
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<td>9</td>
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<td>43%</td>
<td>4.7</td>
<td>0%</td>
<td>66%</td>
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<td>20%</td>
<td>7</td>
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<td>40%</td>
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<td>Average</td>
<td></td>
<td>22.6</td>
<td>702271</td>
<td>2.9</td>
<td>40%</td>
<td>9.2</td>
<td>52%</td>
<td>2</td>
<td>10</td>
<td>5%</td>
<td>13%</td>
</tr>
<tr>
<td>After Adjustment</td>
<td></td>
<td>7.6</td>
<td>2400</td>
<td>3.4</td>
<td>52%</td>
<td>11(13)</td>
<td>13(26%)</td>
<td>12(19)</td>
<td>12(23)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 5.2. Floor Area Ration (FAR) in selected cities (Crawford 2002), (Fouchier 1996)

<table>
<thead>
<tr>
<th>District</th>
<th>FAR</th>
<th>OR</th>
<th>Avg Stories</th>
<th>Human Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>2.89</td>
<td>0.41</td>
<td>9.2</td>
<td>2178</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>3.73</td>
<td>0.33</td>
<td>11.2</td>
<td>2203</td>
</tr>
<tr>
<td>Paris-Montholon</td>
<td>3.2</td>
<td>0.55</td>
<td>5.9</td>
<td>753</td>
</tr>
<tr>
<td>Central Venice</td>
<td>2.69</td>
<td>0.67</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>French public Housing</td>
<td>0.63</td>
<td>0.15</td>
<td>4.3</td>
<td>186</td>
</tr>
<tr>
<td>Single-family Housing</td>
<td>0.23</td>
<td>0.19</td>
<td>1.2</td>
<td>39</td>
</tr>
</tbody>
</table>
Fig 5.29. Function Allocation in 3D Model
Image made by author
5.4.3 Building design requirement

Both Shanghai and Toronto have very high population densities. Figure 5.30, Figure 5.31 are comparisons of the downtown centers of Shanghai and Toronto. The left photo is a bird’s eye view of Ontario, Toronto. The right photo is a bird’s eye view of Pudong. Pudong is Shanghai’s economic center. The World Expo Park will be Shanghai’s new economic center. Shanghai World Expo Park will have a very similar building density with Pudong. From this picture, it is evident that both cities have very high population densities. Both have many high rise buildings.

Toronto’s Green Building requirements provide a good model for sustainable building design. The similarities of the two cities’, makes Toronto’s building requirements potentially instructive for Shanghai’s city planners. Here I listed several suggested guidelines for Expo Park’s design based on Toronto’s requirements. Several of the following points are execrated from Waterfront Toronto’s Minimum Green Building Requirements:

- Provide a green roof for 50% of available roof space.
- Make sure each building supports a sufficiently large enough amount of bicycle parking storage spots that residents are encouraged to use this method of transportation.
• Improve waste management systems by encouraging separated waste collection facilities.
• Make restaurant, office and residential buildings use high efficiency appliances.
• Encourage district energy from the upgraded Nanshi Power Plant
• Provide building characteristics that allow for future change without structural modification. Building heights should meet the following minimum requirements:
  1. Ground Floor 5m
  2. Typical Floor 2.75
  3. Typical Floor above ground 2.75 (Halsall 2011)

Office buildings in the park should have requirements distinct from other the structures. I advocate the adoption of the following minimum standards for office buildings. Some of these standards are execrated from Toronto’s Minimum Green Building Requirements:

• 75% of the building’s roofs are green.
• A 789 m2 bicycle parking space is placed on the ground floor. An additional 1200M2 bicycle parking space is set parallel to the Songjiang Road as complementary ground parking.
• Separated waste collection facilities are set on each floor; a waste management center is set on an underground floor.
• A district energy center is set on an underground floor as part of the district energy allocation system.
• Encourage natural light and natural ventilation
• Proper building height is set for future use.(Halsall 2011)
5.4.4 Sustainable Material

High standards for the energy efficiency of its buildings should only be one of numerous components of Shanghai’s strategy to solve its environmental problems. The use of sustainable materials in construction is another important component. In this section, I consider the possibility of reducing energy costs by adopting “green” construction materials and improving efficiency in the construction processes.

Concrete is the most broadly used building material in China. (Lepech 2007) It is generally regarded as unsustainable for the following reasons: Concrete is the second most utilized construction material behind water.(Van Oss 2002) Cement production also accounts for 5% of global greenhouse gas emissions. China currently has the world’s largest real estate market, accounting for 35% of global cement consumption. It accounts for 6% - 8% of China’s CO2 and 40% of PM10 emissions. (Toward a Sustainable Cement Industry 2002) Prefabricated durable concrete is generally regarded as more durable, environmentally friendly and reusable. (Lepech 2007) Consequently, I have planned to use prefabricated concrete as the main building material for office and residential buildings.

In order to improve construction efficiency and reduce environmental cost, the project will use Integrated Project Delivery (IPD) in the construction process. IPD is used as a method of organizing construction teams. It can form a collective effort by integrating all team members – owner, architect, construction manager, and engineers together. In this way, IPD can help team members avoid construction problems, reduce construction waste, cut costs and improve productivity.

In 2010, the US National Research Council (NRC) identified three key points to improve the efficiency and productivity of the construction industry: It recommended, “[g]reater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes.”(Parviz Daneshgari 2010) The adaptation of prefabricated concrete and the
application of IPD fit into these requirements very well.

5.5 Sustainable Technique
Sustainable technique is an important part of sustainable design. As discussed in “Chapter 2,” direct energy and rainwater harvesting systems are quite helpful for resolving Shanghai’s environmental problems. In the following unit, I will discuss how to develop the two systems in the designed community.

5.5.1 District Energy
The Nanshi Power Plant was founded in 1897. After renovations begun in 2007, it became the Energy Theme Pavilion of the 2010 Expo and Fair. Its main chimney--Harmony Tower--is one of the most important landmarks of the park. After the Expo and Fair, the 128m x 70m x 50m concrete frame faces the challenge of the second phase of renovation. The problem is identifying the best use for this huge structure? Several factors lead to the conclusion that the old Nan Shi Power Plant should be upgraded into a new energy center to provide district energy for communities close to the Huangpu Riverside (Zhang Jiaqiu 2009).

- During the 2010 Expo and Fair, designers intentionally kept the integrity of the Nan Shi Power Plant’s main structure; the 8970 m² space is big enough for a community scale district energy center.
- The old coal-fired energy generators have been taken out to leave space for new energy generators. This allows for new energy generators to be installed in an easier way.
- The building has a comprehensive water circulation system. These systems could greatly reduce the cost of new system installation.

The above is a conceptual plan for the Nan Shi Power Plant renovation. In order to reduce environmental deterioration, high efficiency, sustainable energy should be used in the district center so that the new power plant has a minimum effect on the environment. Here I have listed several possible sustainable energy resources:
**River Water-Source heat pump**

The site is close to the Huangpu River; it is close enough to the power plant to be a water a water resource. The new power plant can take full advantage of the original water circulation system as a way of reducing cost. The main part of the Water Source Heat Pump could be buried underneath Urban Theme Square, which is adjacent to the site’s northern boundary.

**Solar Panel**

Solar panels could be affixed to the existing roof and south wall. The building has a 9000 m² flat roof. Few buildings can block the roof because the building used to be the highest structure on the site. Additionally, the Global Theme Square is located to its south and the Huangpu River is located to its east. These open lands provide the Nanshi more space for solar panel installation.

**Sustainable technique**

In addition to the River Water Source Heat Pump and solar panels, there are many other sustainable techniques that could be applied to this project as a place to exhibit green technology, such as green material, natural ventilation, structure reinforcement and computer control center.

In short, upgrading the existing Nanshi Power Plant can greatly improve the environment and provide the potential for sustainable energy utilization, which is beneficial for the residents living in the new communities. Toronto’s district energy center is powered by natural gas. In the future, natural gas will be overtaken by more sustainable energies. Here, I plan to follow the same path: Use natural gas at first, and switch to more sustainable energy in the future.
5.5.2 Rain Water Harvesting

“Fei shui bu liu wai ren tian” is a well-known proverb in Fengshui. It means people should keep fresh water from flowing out of the house. In ancient China, many wealthy families built water pools in their yards to collect rainwater. They believed that a water pool can bring them fortune and luck. This habit was preserved from generation to generation. Nowadays, in many luxury communities water fountains are placed in the middle of the homes. Many of these communities use underground water, which is a big waste of natural resources. Besides, every year, Shanghai use lots of energy pump underground water. This is very unsustainable. Rain water harvesting systems can reduce people’s dependence on underground water. Consequently, rain water harvesting systems are an important component of the proposed zero carbon community.

The old tradition could become worthwhile in the present through building rain water harvesting systems in the midst designed communities. As shown in Figure 5.32, a water pool is included in the middle of the designed community as both a place of rain water harvesting and a symbol of fortune and gain. A solar panel powered by a waterfall will be located in front of the Canteen.

![Fig 5.32. Proposed Rainwater Harvesting System.
Drawing made by author](image-url)
Chapter 6
Conclusion of the Study

This chapter is divided into three sections. The first section summarizes the thesis, highlighting significant points of each chapter. The second section identifies areas of future research. The final section offers a conclusion and the major contribution of the study, an assessment of the effectiveness of the design guidelines, and the drawbacks of the conceptual design established in the study.

6.1 Research Summary

One of the objective of my thesis is to help find solutions to with China’s energy crisis. China is the world’s biggest energy consumer. China’s energy crisis forces it to take immediate steps to reduce its energy consumption. Shanghai is China’s economic capital. It is also the biggest CO2 emitting city in the world. The study of Shanghai’s environmental problem could offer a good solution to China’s environmental problem. The Shanghai Environmental Report summarized some of the causes of Shanghai’s environmental problems: The rapid growth of motorized vehicles, mass produced single use communities, broad use of coal-fire energy, and low efficiency cooling & heating system. Addressing the five problems for the Expo Park is one of the themes of the whole thesis.

Toronto is taking a leading position in sustainable design. Both Shanghai and Toronto are well known world economic centers. The two cities also have many geographical similarities. These similarities make it possible to resolve Shanghai’s environmental problem with by examining Toronto’s sustainable design experiences. The case study provided me with solutions to the following five problems: develop a balanced transportation system, encourage the construction of mixed-use communities, improve energy plant efficiency, use district heating & cooling energy and apply building design requirements that further sustainability.
The case study helps to determine which improvements will prove to be most feasible for Expo Park. From 2002 to 2010, Shanghai invested a large amount of money to build the World Expo Park. The investment brought the place a very good infrastructure foundation. With the end of Expo 2010, most of these pavilions were scheduled for demolition, leaving vast empty land waiting to be redeveloped. Determining the best way to redevelop these empty lands became an ideal research object. I evaluated the challenge from the following aspects: develop a balanced transportation system, build up attractive open space, design attractive mixed-use communities, and apply sustainable techniques.

6.2 Conclusion of the Study
The global increase in environmental concerns has added impetus to developing sustainable communities. China, as the biggest energy consumer in the world, must take proportional responsibility for global environmental improvement. China’s energy crisis also provided a huge market for sustainable technology development. Before taking steps to resolve China’s environmental problems, a thorough understanding of China’s current situation is required. The comparative study between Shanghai and Toronto helps to identify China’s position in the rapidly growing global sustainability market. The endeavor to develop a zero carbon community at Shanghai World Expo Park is an important part of the exploration process. In general, I found the following five factors to be the main reasons for Shanghai’s environmental problems:

♦ The rapid growth of motorized vehicles
♦ Mass-produced single-use communities
♦ Broad use of coal-fire energy
♦ Low efficiency cooling & heating systems
♦ Over-use of underground water

Toronto and Shanghai have geological and economic similarities. Toronto is a leader in
sustainability design in North America. Consequently, I decided to use Toronto as an object of research in seeking solutions to Shanghai's five problems. The case study revealed the following five aspects could provide possible solutions to these problems:

- Utilizing a balanced transportation system to reduce transportation pollution.
- Increase efficiency by adopting a mixed use community design
- Increase the efficiency of cooling and heating systems by adopting low carbon energy district energy.
- Diminish underground water waste by encouraging rainwater harvesting.
- Use of sustainable building material

Sustainable design is a huge topic. This thesis can only select a few aspects of the topic upon which to focus. The complexity of the research may cause difficulty for future research because many aspects of sustainable design are interrelated. Isolating research objects from the whole picture may lead future researchers to neglect understanding the relationships between each of the research components. Appreciating the relationships between the topics is of equal, if not greater importance than understanding specific topics. Toronto and Shanghai have a quite different demography and mainstream culture. It is very difficult to examine the feasibility of the design without fully considering cultural differences between the two cities.

In short, my research method provides designers a tool for studying China's environmental problem. The endeavor of developing a zero carbon community at Shanghai World Expo Park provided precious experiences for examining this method.
6.3 Area of future research

The zero carbon community design developed in this study highlights the need for a new approach to Shanghai’s environmental problem. The thesis mainly focused on resolving the five problems revealed in Shanghai’s Environmental Report. However, the concept of sustainability goes far beyond the five issues. BioRegional describe their vision of sustainable development in the following quote:

“a future in which everyone can enjoy a high quality of life, while living within their fair share of the Earth’s resources and leaving space for wildlife and wilderness” (TreeHugger 2007)

That means, that creating a community that allows for sustainability requires more than technological improvement; it necessitates a change of life style. In China, most people know the word “sustainable”, but few of them can really explain what a sustainable life is. A sustainable life does not deplete natural resources. A sustainable life leaves enough resources for the future to help the generations that follow to live prosperously. However, most people in China have not examined the requirements to lead a sustainable existence. For instance, some people in China consider low-gas consuming cars to be sustainable, but few people believe that the proliferate use of private cars to be unsustainable. Toronto did very well in teaching its residents how to live in a sustainable way. The public was given the opportunity to take an active part in the urban planning process. This kind of design method is unimaginable in China. The next phase of implementation suggested by this study is to develop a sustainable education schema with the goal of providing a solution to China’s environmental problem. The purpose is not only to find the right technique to tackle the problem, but also create an educational structure that can disseminate important information about sustainability and the environment to the public. Toronto’s experience in creating a public involvement plan and sustainable education may be a good example for the next phase of research on my topic.
6.4 Epilogue

In recent years, sustainability has become a widely used word: architects use sustainability to refer to design concepts; commercialists use sustainability as a commodity brand; even politicians use sustainability to describe their “advanced” policy. However, few people can give a precise meaning to the word. Many people use it because it has come into fashion. Part of the original intent of my thesis was to identify a comprehensive meaning to sustainable development. In the course of my research, I came to recognize the great breadth of the topic I was studying. I gained an appreciation that I needed to narrow the focus of my studies to a manageable dimension.

In the summer of 2010, I returned to China and visited the World Expo Park. Expo 2010 offered a great opportunity to see some of the latest advances within the field of architecture. Most of the structures at the site of the Expo were designed for temporary use. While the Expo was still running, there was discussion about how best to use the site after the Fair ended. I participated in some of the discussion. At the time, the idea of using the land at the site to develop a sustainable community came to mind. During the spring semester of 2011, professor Madis had a studio in Toronto. Toronto is a leader in North America in the field of sustainable design. The purpose of the studio is to encourage students to study sustainable communities in Toronto. I realized the wonderful opportunity that the studio gave me. I decided to use Toronto as a case study within my thesis. Studying Toronto’s communities taught me a lot about sustainable techniques and design concepts. I decided to use Toronto’s sustainable communities as a model for developing a zero community at Shanghai World Expo Park.

My research led me to realize that two people had a profound effect on Toronto’s urban planning: Jane Jacobs and Christopher Alexander. Their books proved to be of great value. The book, Carfree Cities by J. H. Crawford’s was also a strong influence on me. The Carfree
model discussed in this book is quite similar to Europe’s urban format. The book is targeted mainly for small cities with small population densities. I adapted the model to apply to Shanghai’s World Expo Park—an area designated for heavy population density.

I confess writing in English is a challenge for me. When writing my thesis, I was forced to consult dictionaries frequently. I used the internet to help me find the correct words to express my ideas. My writing process was very slow. Using citations properly was also a big challenge for me. In China, citation rules are much looser than they are here. Including a bibliography is sufficient citation by Chinese standards. American citation standards are far more rigorous: it is necessary to make citations at the sentence level. I admit cultivating a good citing habit is very important. Clear citation not only facilitates research for future readers; it also gives the appropriate respect and recognition to the person being cited.

The last two years went by quickly for me. I still remember the first day I arrived at school. The memory is so fresh that it feels as if I had arrived only yesterday. As the time to leave approaches, I have become aware of a deep love that I have for this amazing school, particularly my beautiful department. I am proud that I have studied here and am grateful; it is one of the greatest opportunities of my life.
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