CLIMATE CHANGE AND URBANIZATION: CHALLENGES AND PROGRESS IN CHINA

Environmental Defense Fund
Energy Foundation China
Institute for Sustainable Communities
Natural Resources Defense Council
World Resources Institute

(in alphabetical order)

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Environmental Defense Fund (EDF)

EDF is a leading nonprofit environmental organization headquartered in the US, representing over 1 million members. Since its founding in 1967, the group has linked science, economics, law and innovative private-sector partnerships to create innovative, equitable, and cost-effective breakthrough solutions to the most serious environmental problems. In 1997, EDF began developing programs in China and exploring new methodologies that benefit both environmental protection and economic development. EDF has achieved notable progress by cooperating with the Chinese government, institutions and other industries.

Energy Foundation China (EF China)

EF China, established in Beijing in 1999, is a grant-making philanthropy organization dedicated to China's sustainable energy development. EF's mission is to assist in China's transition to a sustainable energy future by promoting energy efficiency and renewable energy. EF supports policy research, standard development, capacity building, and best practices dissemination across eight sectors: buildings, electric utilities, environmental management, industry, low-carbon development, renewable energy, sustainable cities and transportation.

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The Institute for Sustainable Community (ISC) has worked more than 20 years in low carbon, sustainable development and has led 91 sustainable community-driven projects in 25 countries across the globe. It started working in China in 2007, and has offices in Guangzhou, Beijing and Shanghai. It works with local partners, including governments, private sector, academies and NPOs to address the challenges of environmental protection, reducing carbon emissions, and creating low-carbon developments mainly in Pearl River Delta and Yangzi River Delta.

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WRI is a global research organization that spans more than 50 countries, with offices in the United States, China, India, Brazil, Indonesia and more. Our more than 450 experts and staff work closely with leaders to turn big ideas into action to sustain our natural resources—the foundation of economic opportunity and human well-being. WRI China focus on four priorities: Cities and Transport, Climate, Water and Energy.

(In alphabetical order)

TABLE OF CONTENTS

ACKNOWLEDGEMENT I

EXECUTIVE SUMMARY II

1. CHINA'S URBANIZATION AND CARBON EMISSIONS 1

2. URBAN LAND USE 6

2.1 Land Use and Carbon Emissions 7

2.2 Key Issues 8

2.3 Good Practices in China 10

1. Shanghai: "Landless investment" in property development 10
2. Chenggong, Kunming: Practicing "New Urbanism" 11
3. Hong Kong: Compact high-density development 14
4. Tianjin Binhai New Area: Integrated planning for new development 16
5. Wuxi: Building an integrated and green industrial park 17
6. Zhongshan: Old city regeneration 17

2.4 Conclusion 18

3. URBAN TRANSPORT 19

3.1 Transport and Carbon Emissions 20

3.2 Key Issues 21

3.3 Good Practices in China 24

1. Guangzhou: BRT leading the charge 24
2. Beijing: Considering low-emission zones 25
3. BYD: Frontrunner in electric vehicles 26
4. Hangzhou: World's largest bikeshare program 27
5. Promoting walkability in Chinese cities 27
6. Shanghai World Expo: Making green transport fashionable 29
7. Wuhan: Community carpooling initiative 29

3.4 Conclusion 30

4. URBAN ENERGY USE 31

4.1 Urban Energy Use and Carbon Emissions 32

4.2 Key Issues 32

4.3 Good Practices in China 34

1. National low-carbon cities program 35
2. Rapid renewable energy deployment 36
3. "Passive House" pilot 38
4. Exponential growth of green buildings 39
5. Large-scale energy retrofits in residential buildings 40

6. Yangzhou: Revitalization of an ancient city *41*
7. Shanghai: Real-time energy monitoring in commercial buildings *42*
8. Improving energy efficiency of household appliances *42*
9. Foshan's green lighting initiative *43*
10. "Cool China": Inspiring individual low-carbon actions *44*

4.4 CONCLUSION 44

5. RECOMMENDATIONS 45

5.1 RECOMMENDATIONS FOR CHINESE CITIES: LAND USE 46

1. Adopt the "smart growth" concept to increase land use intensity *46*
2. Encourage compact mixed land use *47*
3. Coordinate planning between all government levels and departments *47*
4. Strengthen land use management *47*

5.2 RECOMMENDATIONS FOR CHINESE CITIES: TRANSPORT 48

1. Implement differentiated strategies to optimize public transport *48*
2. Focus on decreasing the demand for private vehicles *48*
3. Accelerate the development of smart public transport systems *49*
4. Increase the quality of public transportation services *49*
5. Integrate multiple modes of transport *49*
6. Encourage green commuting and travel *50*

5.3 RECOMMENDATIONS FOR CHINESE CITIES: URBAN ENERGY USE 50

1. Develop and improve low-carbon urban planning *50*
2. Promote widespread green building development *51*
3. Disclose urban energy data statistics *51*
4. Invest social capital into energy-saving building renovations *51*

5.4 STRENGTHENING COOPERATION BETWEEN CHINESE CITIES AND THE INTERNATIONAL COMMUNITY 52

1. Introduce best practices and share knowledge *52*
2. Adapt international experiences to suit local conditions *52*
3. Focus more on small- and medium-sized cities *53*
4. Improve the governing capacity of Chinese cities *53*

REFERENCES 54

LIST OF FIGURES

Figure 1: Population Growth Projections (left) and Forecast of Carbon Dioxide Emissions (right) for China and India 2

Figure 2: Comparison of Superblock on the Original Plan (left) and Smaller Mixed Neighborhood Design in the New Plan (right) 4

Figure 3: Changes in China's Arable Land Area from 1979-2008 7

Figure 4: High-Density Development Near a Subway Station in Hong Kong 15

Figure 5: Yearly Growth of Private Car Ownership in China 20

Figure 6: Yearly Changes in Passenger Volume of China's Urban Rail Transit 22

Figure 7: BYD's Market Share in New Energy 26

Figure 8: NRDC Top 10 Walkable Cities in China 28

Figure 9: 2009-2011 Renewable Energy Demonstration Map 37

Figure 10: Growth of Certified Green Projects in Recent Years 39

LIST OF ABBREVIATIONS

BRT	Bus Rapid Transit
CO_2	Carbon dioxide
EDF	Environmental Defense Fund
EDZ	Economic Development Zone
EF China	Energy Foundation China
GDP	Gross Domestic Product
ISC	Institute for Sustainable Communities
MEP	Ministry of Environmental Protection
MLR	Ministry of Land Resources
MoHURD	Ministry of Housing and Urban-Rural Development
NDRC	National Development and Reform Commission
NMT	Non-motorized Transportation
NRDC	Natural Resources Defense Council
SO_2	Sulfur dioxide
WRI	World Resources Institute

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EXECUTIVE SUMMARY

This report underscores the connection between China's urbanization and global action on climate change by examining the lessons learned from Chinese cities and the latest best practices observed in China. It is our hope that this report will help the international community develop a more comprehensive understanding of China's efforts in addressing climate change and rapid urbanization, and put forward suggestions on how the international community can help China achieve its green and sustainable urban development goals.

The authors did not intend to comprehensively cover all issues related to urbanization and sustainable development in China. Rather, the report is focused only on three areas that we believe are of great importance for China's urban sustainability: land use, transportation, and energy. We highlight key issues in each of the three areas that Chinese cities need to pay attention to and provide suggestions for how to effectively address them. We also present encouraging cases from the field that showcase locally appropriate best practices in applying the principles of smart growth and low-carbon development to contribute positive impact to climate mitigation.

Challenges of Rapid Urbanization

The rapid urbanization process in China has created both opportunities and challenges. Low density land development, rapid motorization, and low energy efficiency have greatly contributed to China's huge carbon footprint. Between 1978 and 2013, China's urban population rose from 18 percent to 53.7 percent. The growth of the urban population has brought about massive economic growth, poverty reduction, and living standard increases, but has also created many environmental problems.

Unwise land use practices such as low-density urban development, excessive zoning, and massive urban expansion have resulted in large investments in infrastructure and motorization, creating a "lock-in" effect on carbon emissions. Studies show that carbon emissions from developed land represent 96 percent of the emissions from all types of land use.

Once a famous "bicycle kingdom", China has already transformed to a "car kingdom", ranking first in the world on both personal car sales and production. Now on average, one in every 13 Chinese citizens possesses a private car. In 2013, car sales in the United States surged to 15.6 million, but still lagged behind China's 20 million. The transport sector has become a major source of China's carbon emissions, responsible for approximately 23 percent of the total CO_2 emissions in 2010. From 1991 to 2009, the carbon emissions from this sector grew rapidly at 15.6 percent per year.

Energy use efficiency is another key area for carbon emissions reduction in cities, and the building sector takes a lion's share (when excluding industrial energy consumption), accounting for about one third of the total energy consumption, globally and similarly in China. The 287 large Chinese cities – those administratively at prefecture level or above – currently consume 56 percent of the total energy used in China.[I]

China's leadership has recognized these challenges and problems. In March 2014, the Chinese government formally rolled out a plan to pursue a "new type of urbanization" that will be a departure from past patterns of wasteful and unsustainable urban growth. The government pledges to take a new urbanization pathway that features placing people at the center of development; seeking concurrent "four modernizations" (of industry, agriculture, cities and information system); striving to optimally plan urban growth; ensuring eco-friendly development; and preserving cultural heritage.

Local Practices and Experiments

Some successful cases of efficient **land use** in Chinese cities are emerging. For example, Shanghai has been promoting "landless investment" to increase land use intensity; the city of Kunming is building a transit-oriented mixed land use area in its Chenggong New Town; Hong Kong has rich experience in high-density development through vertical design; and Tianjin's Binhai New Area has adopted an integrated planning process that ensures coordination among economic, land use, spatial, transport, and other planning exercises.

In recent years, many Chinese cities have stepped up efforts to develop low-carbon/**green transport** systems. Some examples of front runners are: Guangzhou's Bus Rapid Transit (BRT) system, which started operation in 2010 and boasts to be Asia's first and the world's second largest – now over 20 Chinese cities have BRT in operation and more are building it; Shenzhen-based automaker BYD, which is a world leader in manufacturing electrical vehicles and enjoys 37 percent of China's new energy vehicle market; Hangzhou's public bicycle rental system, the world's largest rental system with 78,000 bikes, over 2000 rental stations, and 400,000 users per day in some peak times; Shanghai's 2010 World Expo that broadly and rapidly popularized the concept of green travel among citizens, raising the public recognition rate on the term from 67.7 percent in 2009 to 98 percent by 2010 when the Expo ended; and Wuhan's innovative community project on carpooling for low-carbon commuting, which attracted 300 participants in the beginning year of 2009.

An increasing number of Chinese cities have begun to talk about low-carbon development, while some are already taking concrete action, especially on **energy use** efficiency. China's National Development and Reform Commission launched a low-carbon cities pilot program in 2010, which has selected 42 cities to participate. The development of green buildings has been adopted as a national strategy and many demonstration projects on near-zero energy buildings and "passive houses" have been carried out with government support, which are helping raise building energy efficiency standards. A large number of existing residential buildings have been successfully retrofit for energy efficiency in northern China where room heating is a major source of energy use. Shanghai is taking the lead in constructing a central data platform to monitor energy use in real-time by the city's

[I] This percentage number includes energy consumption from the industrial facilities belonging to cities.

large commercial and public buildings. There are also various public education programs in China, such as the one named "Cool China" that educates and encourages the public to practice easy-to-follow low-carbon behaviors.

Recommendations

The cases described in this report illustrate China's great efforts made in recent years to transition the country's development mode towards a low-carbon and environmentally sustainable one. However, given China's size and its speed of development, changes will not be quick and easy; big challenges still lie ahead. China should enhance international cooperation and can use help from the international community. The author organizations of this report have long been supporting China's sustainable urban development and thus accumulated good understanding and first-hand expertise of China. Based on collective experience, the authors put forth a number of recommendations to Chinese policy makers and implementers as well as to the international community, with the goal of boosting China's green urbanization.

Land Use

To reverse inefficient and unwise land use practices in Chinese cities, the authors stress to the importance of land use density and urban planning coordination. The existing tax policy also needs reformation to remove unwanted incentives for land conversion, while rewarding compact urban land use. The authors provide the following recommendations for Chinese cities to improve urban land use efficiency:

- Adopt a "smart growth" concept to increase land use intensity by ensuring high density development and minimizing conversion of arable land.
- Encourage compact mixed land use by implementing appropriate policies and zoning rules, and fully utilizing spaces above and below ground.
- Coordinate planning between all levels and departments and operate under consensus starting from the initial stages of development.
- Strengthen land use management through reforming tax policies and new construction approval processes.

Transportation

To turn the strong tide of increasing car use in Chinese cities, the authors stress the importance of not only expanding public transit systems, but also travel demand management and non-motorized travel modes. The authors provide the following recommendations for Chinese cities to enhance green urban transportation:

- Implement differentiated strategies to optimize public transport based on the size and development stage of a city.
- Focus on decreasing the demand for private vehicles to reduce private car use, as opposed to increasing paved roads to temporarily alleviate urban congestion.
- Accelerate the development of smart public transport systems which are information-based, real-time, and people-centered.

- Increase the quality of public transportation services by improving network density, carrying capacity, reliability, and convenience.
- Integrate multiple modes of transportation with emphasis on linking public transport, cycling, walking, and other green transport methods.

Encourage green commuting and travel among citizens through public education and civil society engagement.

Urban Energy Use

Energy use is mainly concentrated in cities – especially electricity consumption, therefore cities are the main "battlefield" for energy conservation and emissions reduction. To harvest deep energy efficiency in cities, the authors stress the importance of conducting low-carbon energy planning, managing energy consumption in building operations, disseminating distributed renewable energy applications, and continuously promoting energy conservation behavior. The authors provide the following recommendations for Chinese cities to increase urban energy use efficiency:

- Develop and improve low-carbon urban planning by evaluating demonstration projects and pilot programs, creating policies and guidelines, and monitoring for continual improvement.
- Promote widespread green building development with unified standards, certification, energy measurements, and integration into conventional architectural designs.
- Disclose urban energy data statistics to enhance energy data analysis, establish benchmarks, and allow public scrutiny.
- Invest social capital into energy-saving renovation of existing buildings and large-scale urban energy facilities.

How the International Community Can Help

The international community maintains a high interest in China's sustainable development and green urbanization pursuits because mitigating global climate change and protecting planet Earth are among the world's top challenges. Under the last 35 years of open-door policy, China has maintained a welcoming attitude towards international cooperation. Therefore, the authors see great potential for international collaboration as China strives to implement a "new type of urbanization." The authors believe the international community can make especially valuable contributions in the following areas:

- Introduce best practices and share knowledge to inform Chinese urban planners of the beneficial and detrimental effects of different urbanization practices. Integrating international experiences with local Chinese conditions is crucial.
- Avoid mechanical implementation of international examples by incorporating China's unique characteristics into the plans. Only then will planners garner enthusiasm for sustainable urban development from city governments and citizens.

- Focus on increasing international cooperation with and assistance for small and medium-sized Chinese cities. Since these cities represent the nation's largest urban population, improving urban sustainability there will reap the greatest benefits.
- Increase the governing capacity of Chinese cities. The international community has rich experience in public management and governance of cities that China lacks. Chinese cities can gain such experiences through international cooperation on urbanization projects.

1 CHINA'S URBANIZATION AND CARBON EMISSIONS

Birdview Landscape of Shanghai ©Gin Gong

The five international organizations that co-authored this report have long been working on clean energy development and environmental protection in China. They have carried out numerous sustainability projects in many Chinese cities and have gained considerable first-hand experience. By focusing on urbanization in China in this report and examining the past positive and negative experiences, we present how China's rapid urbanization can play an active role in global climate action.

Cities have long been the world's economic hotspots, and the process of urbanization has been closely associated with economic and social transformations, bringing about greater geographic mobility of resources, higher literacy levels, better life quality and longer life expectancy[1]. Since 1950, the world's urban population has grown rapidly from 746 million to 3.9 billion, which accounts for more than half of the total world population[2]. Urban areas generate 80 percent of global GDP and more than 90 percent of global gross value[3]. While rapid urbanization brings large economic opportunities, it also poses challenges for climate change mitigation. It is estimated that urban energy consumption represents more than 70 percent of global final energy use and CO_2 emissions[4].

As the global population is expected to increase by 2.5 billion by 2050, urbanization rate is expected to reach 66 percent[5]. The majority of urbanization in the future is expected to occur in Africa and Asia, with the largest growth to take place in India, China, and Nigeria[6]. These three countries alone will account for 37 percent of global urban population growth from 2014 to 2050[7]. Even considering a conservative population growth model, China's carbon dioxide emissions will grow rapidly up until 2040 (Figure 1).

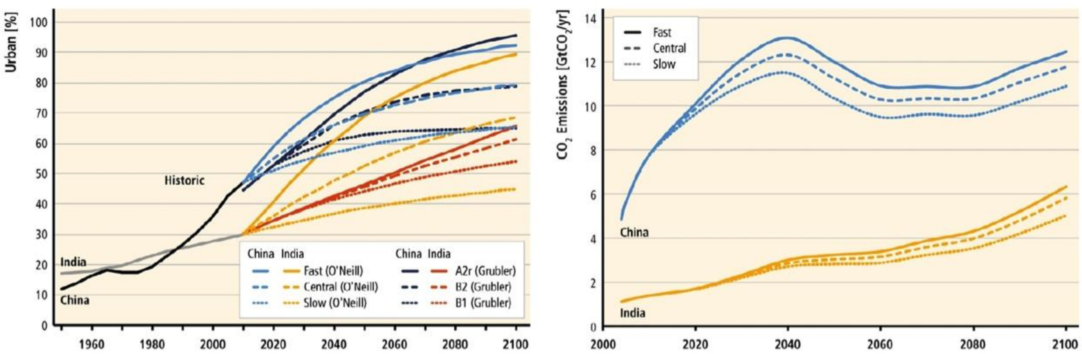


Figure 1: Population growth projections (left) and forecast of carbon dioxide emissions (right) for China and India

(Source: O'Neil et al.[8], 2012; Gruber et al. 2007[9])

Most urban carbon emissions come from energy consumption in buildings, transportation, industry, and the service sector. In most industrialized countries the high quality of environmental surroundings, developed service industry (including financial and trade), and relocated basic industry have made buildings and transportation the primary sources of urban carbon emissions. In developing countries, industry is the primary source of urban carbon emissions, but emissions from transportation and buildings are increasing rapidly in large and medium sized cities of emerging economies. China is a telling example of an emerging economy with an increasingly large share of emissions from transportation and buildings.

The speed of China's urbanization is unprecedented. The Chinese urban population rose from 18 percent to 53.7 percent of the total population between 1978 and 2013[12]. On average, 15 million Chinese rural farmers become urban residents every year. This trend of rapid urbanization will likely continue for several decades due to China's ambitious economic development goals and relatively low urbanization rate. Currently, China is already home to the world's largest urban population of 758 million[13], which is 2.4 times the population of U.S., or nine times that of Russia. Of the 658 cities in China, 16 of them have populations greater than 5 million[14]. China's urbanization rate is expected to reach about 60 percent in 2020, which means more than 100 million peasants will immigrate to city in the next 6 years.[15] It is predicted that China's urban population will reach 1 billion by the year 2030[16].

While China's rapid urbanization has brought about massive economic growth, poverty reduction, and living standard increases; it has also created many environmental problems. Low density land use, low energy efficiency, and rapid motorization have contributed to China's considerably large carbon footprint. China has already become the largest carbon emitter. In 2013, 9.5243 billion metric tons of carbon emissions were produced by China[17], with cities contributing 70 percent of total energy-related carbon emissions[18]. Energy consumption per capita in urban areas is 3.9 times greater than in rural areas[19].

If China is to embark on a low-carbon development path, besides vastly improving industry energy efficiency, China must focus on three crucial areas: increasing intensive and efficient land use, developing sustainable urban transportation, and improving urban energy efficiency.

Unwise land use strategies such as urban density reduction, excessive zoning, and urban sprawl result in massive investments in infrastructure and motorization. Such investments are the foundations for building and transportation energy use, thus unwise land use can "lock-in" carbon emissions into urban infrastructure[20]. In just ten years from 2003 to 2012, the amount of land undergoing construction in Chinese cities increased by 60 percent. This expansion has consumed large amounts of arable land equivalent to 20 times the size of New York and 10 times the size of London[21]. From 1979 to 2008, China's total arable land area decreased by 13 million hectares, which amounts to about 328 times the size of Beijing's urban area (Figure 2). Additionally, China's urban expansion rate has exceeded the need of population growth rate over the past few years, and the average urban population density has decreased by about 25 percent in the past ten years[22]. The transition of large amounts of relatively lower carbon emitting agricultural land into urban areas has not only removed the carbon sink created by the original vegetation and soil, but also enhanced carbon emission intensity largely due to construction of road and building facilities.

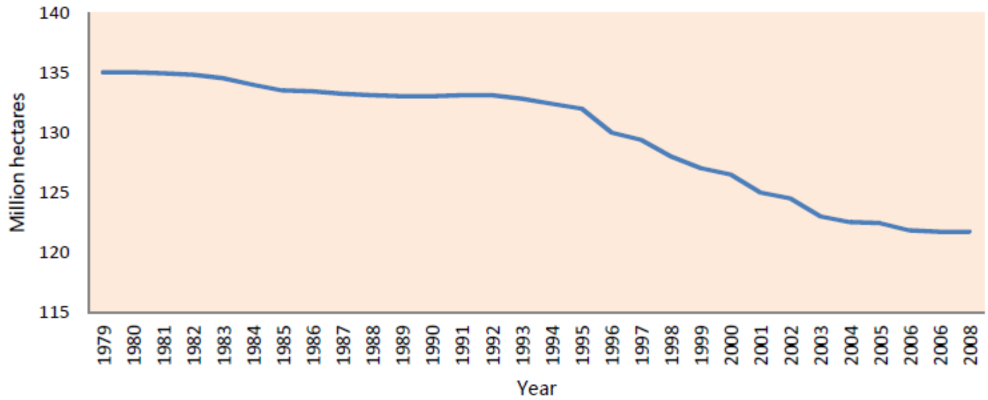


Figure 2: Changes in China's arable land area from 1979-2008
(Data source: Annual Communiqués on Land and Resources of China, Ministry of Land and Resources)

Urban land use is highly related to urban transportation. The transport sector was responsible for approximately 23 percent of total CO_2 emissions in 2010 and around 40 percent of the transportation sector's total energy consumption was used in urban spaces[23]. Automobile-dominated development and road construction have encouraged urban sprawl; resulting in the rapid increase of automobile use and ownership, and the decline of NMT in many Chinese cities. From 1980 to 2010, the number of registered vehicles in China rose 100 times, reaching 250 million in 2013[24]. By 2009, China became the country with the highest automobile production and sales[25]. Motorized transportation has become a major source of China's carbon emissions.

As urbanization progresses, carbon emissions from energy services required for lighting, heating, and cooling will grow[26]. The building sector accounts for about one third of total global final energy use[27]. Hence, urban energy use efficiency is another key area for carbon emission reduction. Over the past decade, an average of 260 million square meters of newly built housing areas have been added to China's urban landscape every year, the equivalent of rebuilding the Empire State Building in New York City 1280 times every year. Most new Chinese buildings still have low energy efficiency[28].

Experts say that if China's rapid urbanization rate continues, China will reach 76 percent[29] urbanization rate by 2050, increasing the urban population by 292 million[30]. If such intense urbanization continues, China's urban land area is expected to expand by almost 220,000 square kilometers by 2030[31]. Moreover, it is predicted that China's energy demand will roughly double in the next 20 years[32]. How China decides to urbanize will greatly affect the global response to climate change.

In the past few years, the Chinese government has begun to reflect on its unsustainable urban development mode. In 2012, the Central Economic Work Conference advocated for "improving the quality of the urbanization, seeking advantages, avoiding disadvantages, and actively guiding healthy urbanization". In March of 2013, the Premier Li Keqiang proposed the "new type of urbanization", a plan that emphasizes people-oriented urbanization and urban disease prevention. The Central Economic Work Conference then clarified in December of 2013 that urbanization must follow the laws of development and adapt to different situations to facilitate a smooth and natural urbanization process. In March of 2014, the State Council issued the *National Plan on New Type of Urbanization (2014-2020)*, determined to embark on a "people-oriented, optimally planned, four modernizations (industrialization, informatization, urbanization, and agriculturalization) synchronized, and ecologically civilized" uniquely Chinese urbanization path[ii].

Critical questions remain about how and when China can transition to more low-carbon development. The opportunities and challenges that Chinese governments face, and the roles of non-governmental forces and the international community are not always clear. This report will examine experiences from Chinese cities in three major areas of urban carbon emissions – land use, transportation, and energy efficiency – to summarize local practices as well as lessons learned and provide recommendations for China's low-carbon urbanization.

[ii] In addition to "human centered", "spatially balanced" and "eco-friendly" urbanization, this document also emphasizes "synchronization of urbanization with industrialization, information technology development, and agricultural modernization"

2 URBAN LAND USE

Rendering of Chenggong Low-Carbon Town
©Energy Foundation & Calthorpe Associates

2.1 Land Use and Carbon Emissions

Arable land is limited and extremely precious for China and its staggering 1.3-billion denizens. Arable land per capita in China is only one tenth that of the US and less than half of the world average. However, China's inefficient land use over these past three decades of urbanization has significantly decreased China's arable land area. Between 2003 and 2012, land expropriated for city development amounted to 15,588 square kilometers, 15 times the urbanized area of Beijing, or equivalent to over 20,000 Forbidden Cities[33]. China now has 121 million hectares of arable land, only slightly higher than the central government's target of 120 million hectares of protected farmland. Enthusiasm regarding development of various kinds of industrial parks is seen in almost every city; these are areas with drastically lower building and population densities compared to old urban areas. Since 2006, the central government has started to designate economic development zones (EDZs) across the nation, with increasingly more rigorous control over the newer EDZs. However, demand for land remains overwhelming and inefficient land use is still prevalent.

How land is used determines how much carbon is emitted. The level of carbon emission from land is directly correlated to the type of organic matter and vegetation growing on it. A forest serves as a carbon sink to absorb and capture CO_2. Crops also absorb CO_2 through photosynthesis, but high intensity industrial agriculture that uses fertilizers and machinery also generate greenhouse gas emissions. Thus, the agriculture sector becomes a source of carbon emission, but on a much smaller scale than the industrial sector. Academic studies show that emission generated from China's farmland represented only 1.84 percent of China's land-based carbon emission in 2008. The carbon emission intensity of land used for residential and industrial/mining purposes in addition to transport purposes are 33.64 tons per hectare and 47.81 tons per hectare, respectively; this is much higher than farmland emission, which sits at only 0.03 tons per hectare[34]. Another study from Jiangsu on carbon emission from land conversion suggests that developed land represents 96 percent of carbon emissions. This finding is also supported by another research project suggesting that carbon emissions increase dramatically when farmland is converted for construction. [35,36]

In the long run, carbon emissions are also affected by how efficiently land is used during construction. If urban infrastructure such as roads and buildings are built without considering long term results and costs, construction materials and long-term use could potentially become large sources of carbon emissions. For example, while the construction process and materials required for a wide road produces carbon emissions, the same road will allow for more motorized vehicles to travel and thus generate more carbon emission from vehicle exhaust. Using the findings of an Asian Development Bank-funded project on carbon emissions from highway development, we can roughly estimate how much CO_2 has been emitted by road construction in China[37]. Nearly 13,600 kilometers of city roads were built annually from 2003 to 2012. If one third of these were four-lane highways and two thirds were two-lane highways, then construction of these roads would have been responsible for 380 million tons of carbon emissions. A total of 5 billion tons of CO_2 could have been emitted during this decade if emissions of induced motorized traffic were to be included as well (excluding emissions from existing motorized traffic)[38]. If these cities had used their land more efficiently and reduced road construction by just 10 percent, they could have spared China 500 million tons of carbon emissions.

2.2 Key Issues

As mentioned before, more efficient land use in urbanization has dual implications for China: 1) mitigating climate change, and 2) ensuring food security. Generally, high-density development is needed to **achieve efficient land use**. If the density of urban construction is too low, the expansion of urban land will happen too rapidly. However, high-density land use is not synonymous with increasing building densities and erecting skyscrapers. Rather, key indicators including volume ratio, building density, building height and urban green space ratio must also be considered. Reasonable land use should take transportation conditions, market demand, infrastructure capacity, urban landscape as well as ecological and environmental carrying capacity into consideration. The ultimate goal is for social interactions and exchanges to become easier and more efficient.

In addition to economical and intensive use of land resources, it is also critical to ensure compact development of urban construction areas in order to avoid disorganized sprawl. After developing for several decades, many Chinese cities experience rapid population growth. Since capacity of the existing town is limited, this rapid population growth generates demand for constructing new towns. If the new downtown is constructed far from existing urban areas, not only will it waste resources from construction of duplicate structures, but also cause inconvenience for urban residents. Therefore, building compact sub-centers within regions neighboring existing urban areas should be a top priority for city planners. This not only minimizes reduction of arable land, but also reuses existing public facilities and services, making people's lives more convenient. Additionally, long-distance commutes between the old and new areas are reduced and thus energy consumption and pollutant emissions are decreased.

Mixed land use is also important for improving land use efficiency. Residents' daily work and living needs can be met in a smaller area by implementing moderate mixed land use. This improves land use intensity while making infrastructure utilization more efficient, reducing traffic pressure as well as improving urban vitality and overall attractiveness[39]. Mixed land use can be divided into horizontal mixing and vertical mixing. Level mixed land use refers to the act of not relentlessly pursuing strict zoning, but to achieve a reasonable mix of residential, commercial, office, and public facilities and services. This will reduce traffic demand and increase living and working standards, while also avoiding the production of dark zones, which is an area of land that has very limited and singular functions, and at any given moment is not in use. Vertical mixing refers to the development and mixed use of land and the space above and below it. This way, commercial, office and residential functions are separated by assigning them to lower, middle and upper levels. By placing subways, parking lots, shopping malls and other service facilities underground, we can achieve a multi-functional use of space. In addition, buildings and public spaces can provide different functions at different times, but this practice is still relatively limited in Chinese cities.

Tax regime reform is another pivotal determinant of land use efficiency in China. China's economy has become increasingly market-driven since 1978. In 1994, the central government divided its taxes into central and local, with three types of taxes shared between the corresponding governments. Central taxes include those with stable sources, wide tax foundations, and are collected easily. Local taxes, on the other hand, have scattered sources, are difficult to administer, and more costly to collect. As a result, tax revenues for local governments are limited. However, local governments are authorized to convert rural collectively-owned land into urban construction land. Local governments can sell the land rights to developers in exchange for land concession revenues[III]. Thus, local governments are appropriating rural land for urban construction and using the land concession revenues to address their fiscal deficits. From 2001 to 2003 China's land concession revenues amounted to a massive 910 billion RMB, or 35 percent of local revenues. In 2010, this figure rose to 69 percent of local revenues. In 2012, land concession revenues climbed to a whopping RMB 2,690 billion RMB[40].

Dependence of local governments on land concession revenues is one of the main culprits behind low-density and wasteful land use during these past two decades. Fortunately, the central government has initiated tax system reforms this year. The National Audit Office launched a nationwide campaign targeting the finances and debts of local governments. Moreover, the politburo just passed the General Plan for Fiscal and Tax Reform. Although the details of this plan have not been disclosed yet, China's minister of finance indicated that one objective of this reform is to create a tax regime that will level the playing field and unify the market environment.

For the longest time, uncoordinated spatial planning in Chinese cities has resulted in inefficient use of land and a huge waste of resources. Unlike streamlined planning systems used in most Western countries, China's spatial planning system is a more complex, "multi-regulation" parallel planning system: China's National Development and Reform Commission (NDRC) leads planning and regional planning of main functional areas; Ministry of Housing and Urban-Rural Development (MoHURD) leads system planning and urban planning at all levels; Ministry of Land and Resources (MLR) dominates land use planning; Ministry of Environmental Protection (MEP) dominates ecological function zoning. Since the origins, objectives, methods, standards, and implementation periods, etc. of these different programs differ, there are often overlapping, contradictory and even conflicting issues that detract from effective allocation of resources and management, and ultimately affect coordination of intensive land use efficiency. With China's recent rapid

[III] There is no private land ownership In China. Rural land is owned collectively by local farmers, while urban and industrial land (as well as all natural resources) belong to the nation. Local governments can authorize the use of a particular section of land in their respective jurisdictions for certain purposes within a specified period.

urbanization, an urgent need for rational allocation of space resources and integration, unified planning, and rational development has emerged. **Spatial planning coordination and the goal of a streamlined planning system** is gradually gaining more attention in the eyes of the government. In August 2014, four ministries jointly issued the *Notice For Cities and Counties To Merge Regulations*. Jiaxing, Huai'an, Yulin, Xiamen, Hezhou and 28 other cities were used as pilot cities. Prior to this, Tianjin, Shanghai, Chongqing, Guangdong, Beijing and other cities already merged regulations as a trial run, and in the process gained valuable and practical experience.

2.3 Good Practices in China

1. Shanghai: "Landless investment" in property development

Shanghai is a populous city facing natural resource shortages and a limited carrying capacity. Land constraints ultimately influence its sustainable development. Therefore, promoting intensive land use should be a priority when implementing sustainable development strategy. As the manufacturing industry developed, Shanghai's land availability declined. Since 2004, some districts have adopted the "landless investment promotion" to develop even where additional land was unavailable. One of the major initiatives of the promotion was to improve the downtown economy and usher in new land use intensities for high rise buildings and the modern service industry. Secondly, renovation and transformation of industrial areas increased capital, technology advancement, intensity per unit area of utilized land and other factors, all while preventing increases in land inputs. In industrial park transformation, more investments were added to old companies with excess land. On the other hand, enterprises with low output per unit of land, high energy consumption as well as heavy pollutions were shut down, thereby freeing up the land. Comprehensive assessment of industry orientation, environmental protection, land demand and other indicators were conducted for enterprises intending to enter the industrial park. Therefore, enterprises with intensive land use enterprises were introduced. Reasonable land replacement improves the efficiency of land use and also promotes the upgrading of industrial structures. This will ultimately result in overall economic benefits.

From 2004 to 2005, Shanghai Qingpu was one of six districts that removed 250 enterprises that had high energy consumption, low output, and heavy pollution, which freed 6,875 acres of land. Meanwhile, Qingpu Industrial Park has regulations that prevent new investments less than 300 million USD per square kilometer from establishing, and requires the expected output to be no less than 3 billion RMB per square kilometer. These regulations clearly define the minimum standards for building density and floor area ratio of land for each project. In Jiading district, 72 prospective projects were assessed, and 32 of the candidates were approved with the average investment per acre at $312,300. Similarly, the original Nanhui District assessed the status of all its enterprises. It encouraged enterprises of high economic quality to increase investment, merge with smaller enterprises to increase production scale and improve yield per unit of land, without using additional land. Sluggish, inefficient enterprises were replaced with better, more efficient companies.

With Shanghai leading the way, the Yangtze River Delta region has raised the minimum capital intensity of land and therefore increased land use efficiency. Each region vigorously promoted the construction of multi-standard factories. In Suzhou Industrial Park, the investment of projects worth less than $10 million were only admitted to standard production buildings, thus greatly improving the capital intensity of land. Zhejiang Xiangshan Economic Development Zone reclaims land from idle production plants that have been inactive for six months. The reclaimed land is transferred to enterprises with more intensive investment and higher land use efficiency.

2. Chenggong, Kunming: Practicing "New Urbanism"

Chenggong New Town began construction in 2003, with a planned area of 160 square kilometers. The original plan adopted the use of superblocks and single land use patterns, the most popular and most widely used strategy in China. The superblock development model is an urban road network consisting of broad-based streets. Access control systems are placed at an average of 500 meters apart, with each 500 meter area serving a single function. The entire area is usually packed with buildings of similar appearances with similar uses. This development model uses a wider road to improve traffic efficiency, with the additional cost of decreased pedestrian safety and bicycle accessibility. To solve noise and pollution issues, buildings need to be built further from the streets, thus increasing the distance that pedestrians must walk to enter buildings. In the Chenggong New Town superblocks, these factors were obstacles for people who walk or ride bicycles. These obstacles not only undermined street retail prices, but also reduced transit accessibility.

In 2011, the US Energy Foundation and MoHURD collaborated to redesign core areas and launched a low-carbon urban construction pilot project. Smaller neighborhood blocks replaced the superblocks, and a transit-oriented, mixed land use development pattern was used. Unlike superblocks, small-scale neighborhoods offered rich flexibility. They included a blend of residential buildings and structures for various functions, thus avoiding dark zones. This mixture of high-rise and low-rise buildings allowed a floor area ratio higher than that of a typical one. In addition, small-scale neighborhoods favor cycling and walking, thereby reducing the demand for motor vehicles; increasing the efficiency of buses and private cars. Transit-oriented, mixed use development patterns allow for transit density to be highest at the town center. Starting from this central transit node, comprehensive development of offices, retail, entertainment and residential areas have been developed within walking distance. Finally, mixed use neighborhoods encourage walking, which is beneficial for the local economy since walkable cities ultimately increase vitality of local businesses[IV].

[IV] Energy Foundation has recommended eight principles for urban planning: 1. build neighborhoods that promote walking; 2. prioritize bicycle network development; 3. create dense road networks; 4. support high-quality public transportation services; 5. zone for mixed-use, multifunctional neighborhoods; 6. Increase land

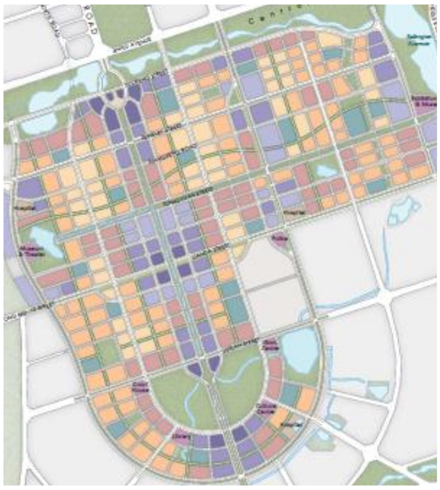
 

Figure 3: Comparison of Superblock in the original plan (left) and smaller mixed neighborhood design in the new plan (right)

Challenges and solutions of the "New Urbanism" practice in Chenggong are as follows. First, the original Chenggong New Town plan was partially completed and many projects were under construction. The new plan therefore needed to cooperate with already constructed roads, existing sites, local culture and lifestyle as well as existing norms and regulations so it could be implemented successfully. Second, the inherent requirements of the new plan conflicted with the existing Kunming city planning technical regulations. This challenge was solved when Chenggong became a low-carbon pilot area within Kunming and was given special implementation rights. Specific changes are as follows:

Breakthrough Indicators	New Plan	Existing Standards
Road network density	13.7 km/km^2	5.1 km-7.4 km/km^2
Building distance from street	1-3 m, 3-5 m	10-50 m
Neighborhood scale	100-150 m	300-500 m
Parking	Reduced parking supply	Minimum
Volume rate（FAR）	1.5 times around metro station	No requirements
Road width	No more than four lanes	Up to ten lanes
Mixed use	15%-20% commercial in residential area	Not encouraged

intensity and match it with appropriate transit capacity; 7. ensure compact development that supports short commutes; 8. increase mobility by regulating parking and road use.

In China, the government retains ownership of all land, and can transfer this ownership to development enterprises at a price. Under this model, the government benefits more from a larger area available for sale. Chenggong's small plot development model greatly increases the government's proportional management and administrative costs. To address this challenge, the Kunming Planning Bureau, Chenggong New Town Administrative Committee (Chenggong District Government) and EF China jointly established the Kunming Chenggong low-carbon pilot office, which is responsible for the management and coordination of development projects and provides technical support.

The redesigning of Chenggong's core areas transformed a network of superblocks into a compact grid of smaller neighborhoods. The new design, with a multi-modal transportation infrastructure, greatly improved land use efficiency and created a more convenient, user-friendly urban living environment. Through the "New Urbanism" core area transformation, the environmental benefits expected include reductions in vehicle emissions by 72 percent, greenhouse gas emissions by 59 percent, and total motor vehicle kilometers traveled by 67 percent.

It is undeniable that there are still issues at this stage of Chenggong New Town development. Chenggong is rather far from the central district of Kunming. Infrastructure and commercial facilities are still not mature. Therefore, although the new plan emphasizes a balance between residential and commercial structures, and offers residential areas for government workers and college dormitories, the actual residential occupancy rate is still low, and traffic volume between the old and new towns is high. In addition, since the subway between Chenggong and the main district has not been fully constructed, a high proportion of round-trips rely on private vehicles. According to 2012 statistics, the population density in the central district of Kunming has reached at least 2,200 people per square kilometer, while the population density of Chenggong District is only 631 people per square kilometer. Due to the small population, the "New Urbanism" plan for the city has not reached its highest potential for convenience and vitality. Other new urban areas in China must also be aware that new areas have profound impact on sustainable development. To avoid sprawl, a new sub-compact central area should be set up within or adjacent to an existing urban area. Not only will this protect arable farmland, but also greatly reduce the cost of transportation, utilities, and services within the new district; ultimately reducing daily commute time for residents.

Although the issues mentioned above mean that Chenggong New Town will probably not experience great prosperity in the short run, low-carbon planning in "New Urbanism" is a fundamental guarantee for a vibrant and eco-friendly city. As urbanization continues, the old urban areas will become increasingly crowded, which will gradually cause more people to move to the new town. The supporting facilities of Chenggong will also be constantly improved. With a great balance of residential structures and offices, a walkable and transit-oriented infrastructure, and wide social diversification of economic activities, Chenggong's future development and vitality is worth the wait.

3. Hong Kong: Compact high-density development

Hong Kong is a prime example of compact high-density land use. The intensive land use patterns in this city include the following five areas:

(1) Compact building layout: In Hong Kong, the linear or spatial distance between any two buildings is relatively short, thus reducing the need for transportation. Hong Kong's Central CBD, for example, covers 152.97 hectares, and since the horizontal distance between buildings is very short, you explore the entire CBD area on foot. In contrast, the size and land usage of Beijing Chaoyang's CBD is about 399 hectares and Shenzhen's CBD is about 607 hectares.

(2) High-density land use: Hong Kong promotes high-density development, buildings are generally at least 200 meters tall. Increasing vertical height, also increases land use intensity, thereby reducing the area of land occupied by a building

(3) High-density land use: Typically, land use is divided into 3 levels: above ground, ground level and below ground. Ground level is mainly used for the city's primary traffic. Above ground is mainly used for the construction of pedestrian bridges and public facilities, such as schools, galleries, etc. Finally, below ground is mainly used for the construction of subways and surrounding shopping areas.

(4) Utilization of lower levels: In Hong Kong, most buildings are higher than 200 meters, and the underlying architecture of the lower levels is often open-open or semi-open. Lower levels are usually built into a common platform, connecting different buildings. These platforms feature parks, entertainment, medical facilities, etc., effectively connecting the entire community. These platforms also connect with ground transportation passages and underground subways to ensure communities are integrated into the surrounding transportation systems. Lower levels in universities are connected to public transit, and are not private spaces within the school. For example, Hong Kong Polytechnic University in West Kowloon has a lower level revolving door that connects with two main roads. Due to rational planning and effective sealing, public transportation does not affect the school's normal operations.

(5) Community integrated land model: All residential, commercial, recreational, and public facilities are rolled into one area, and this total area is not allowed to exceed two-thirds of the entire community. All communities are used three-dimensionally. Private spaces are above ground, while the ground and below ground levels are usually public spaces. This open design is primarily for connection to public transport and placement of public facilities. For example, Kowloon City community has a total land area of 135403 square meters, and volume ratio of 10. The different usage proportions are 42.87 percent residential, 13.13 percent commercial (including five-star hotels and office buildings), 32.9 percent public land (including green land, and main roads within the community), 1 percent for entertainment purposes, and the remainder for other uses. Due to rational planning and convenient transportation, Hong Kong property prices have reached record highs.

Input and output capacity of the land increases when science and reason were used in urban planning. Specifically, Hong Kong uses legal and supporting regulations, legal procedures, and professional bodies to ensure detailed and reasonable planning. Adhering to the belief that no land shall be developed without proper planning, Hong Kong not only improves the enforcement of urban planning, but also prevents irresponsible and low-density development.

Second, it supports high-density mixed use models through increased investments in infrastructure. Typically, transportation systems are divided into three layers: above ground, ground level and below ground. Skywalks are everywhere and in all directions, connecting to almost all municipal facilities. Through this, Hong Kong has achieved real separation of pedestrians and vehicles. Ground level is used mainly for motor vehicles; while below ground, Hong Kong's subway system reaches just about every possible location. A powerful transportation system ensures that Hong Kong has an orderly and highly dense development model. Take communities for example; any multi-purpose community has many different modes of transportation set in place: community portals connect with subways; community roads are wide and connect to main roads, allowing minicabs, taxis and private vehicles to commute with ease. Above ground, platforms and pedestrian bridges that connect to the city's main public facilities. In Hong Kong, all communities have no less than five modes of transportation: subway, buses, minicabs, taxis and private cars, and all transit facilities are within walking distance. The importance of transportation in Hong Kong is evident in the total public transport area. For example, Hong Kong's famous Central CBD has a total area of only 152.97 hectares, yet about one third of that land area, 51 hectares, is used for transportation. Convenient transportation provides a basis for ensuring the effectiveness and intensity of urban land use.

Hong Kong's compact high-density land development model enhances the economic value of land, improves working conditions and living environment, and increases social benefits, ultimately making it a truly comprehensive utilization of land.[41]

Figure 4: high-density development near a subway station in Hong Kong
(Source: http://www.daodao.com/Tourism-g294217-c1-n1224-o10_Lvyouluxian.html)

4. Tianjin Binhai New Area: Integrated planning for new development

The cost of new construction sites in cities is higher than ever, so planning and developing low-carbon models with efficient land use is becoming more important. Tianjin Binhai New Area used an integrated planning model and has created a template for the development of new districts. Tianjin Binhai New Area has a total area of 2270 square kilometers, and a population of 2,630,000. In 1994, the Tianjin Municipal Government decided to build upon the foundation of the Tianjin Economic and Technological Development Zone and the Tianjin Free Trade Zone. The completion of Binhai New Area was expected to take 10 years. Currently, the Binhai New Area has become the gateway to northern China's open development. It is a base for high level modern manufacturing and R&D, a northern international shipping and logistics center, and an ecological city for residents; it is known as "China's third economic growth pole".

Binhai New Area's success was largely due to its efficient and pragmatic planning and implementation system. Binhai New Area boldly developed a path in line with its own characteristics, consistent with integrated planning. First, Binhai New Area established a first class unified planning system. With functional area planning, urban planning, and land use planning as its main objectives, the Binhai New Area created the *Binhai New Area Urban and Rural Development Master Plan*. This would become a program for the development and construction of new areas, with a planning period of 20-50 years. Secondly, it established a unified technical standard planning system. This designated unified planning area, land size and standards, and basic planning details. The planning system also kept statistics on the basis of consistency and forecasting.[42] Third, it was equally important that the planning was implemented by the Binhai New Area Administrative Committee (sub-provincial administrative level), as it made the coordination of various departments possible.

Integrated planning in Tianjin Binhai New Area has revealed useful and practical knowledge described in the following two points:

First, one of the unique characteristics of Binhai New Area is that it introduced environmental planning into the spatial planning system. This practice allowed for functional positioning, and established the basic principles of environmental priorities. In the past, it was common practice to emphasize spatial planning layout and allocation of space resources, while ignoring the protection of the ecological environment. The Binhai New Area Master Plan stresses the equal importance of environmental protection and urban planning within overall land planning of functional areas. This has created a spatial planning system that is more organic, scientific, and closer to perfection.

Secondly, Binhai New Area successfully implemented integrated planning. One of the reasons for its success is because Binhai New Area belonged to a national comprehensive reform pilot area, which was tasked with reform and innovation and therefore enjoyed special policy privileges. The new district administrative system, with its spatial layout and coordination mechanisms, was more appropriate for the new model than the old systems were. Other cities, especially those under renovation, should not blindly pursue this model until equity sector coordination mechanisms have been stabilized; otherwise, these cities could run the risk of spatial planning errors and contradictory land use. The integrated planning model is an ideal goal. Local governments should establish multi-planning collaboration as a short-term goal, and then steadily move toward a planning convergence agenda before finally adopting integrated planning as an end goal.

5. Wuxi: Building an integrated and green industrial park

The Wuxi-Singapore Industrial Park, established in December 1993, is a provincial-level economic development zone. It was developed and managed by Wuxi-Singapore Industrial Park Development Co., Ltd. (WSIP), a joint venture between the Economic Development Group Corporation of Wuxi New District and Singapore Sembcorp Industries. As an independent legal entity and investor, WSIP purchased raw land from the local government for the purpose of industrial development. The plan was for WSIP to make the most out of every inch of land while satisfying investor needs. In the scheme for the industrial park, WSIP first set aside a one square kilometer plot, of which a smaller area was reserved for a green residential community. This community included amenities such as an international elementary school, a clinic, apartments, dormitories, bank outlets, convenience stores and clubs; of course, the planned infrastructure and industrial activities were still the primary job. Land resource authorities had veto power on granting land use rights for any investment projects. They reviewed every project, and vetoed indiscriminately if it failed to meet local land use criteria[43].

6. Zhongshan: Old city regeneration

The town of Xiaolan is one of three pilots chosen by the city of Zhongshan, Guangdong. Xiaolan began to transform some of its old settlements, factories and city areas in the mid-1990s. In 1997, Xiaolan developed a renovation plan for its old city areas to improve road networks, repaire historical buildings and renovate areas like the creative industry park and Jianghuayuan Community. Moreover, Xiaolan converted an original granary site into an affordable housing site to accommodate those who wished to relocate from old city areas. In 2002, Xiaolan developed a plan to rezone its urban spaces by relocating all industrial activity to the north, while forcing pollution prone enterprises to the industrial park south of town.

In 2003, Xiaolan built new residential communities in the town's northern and western areas. Support from professional property management services resulted in 30 percent of land savings. Xiaolan also introduced a policy in 2009 which encouraged residents to exchange their land for apartment ownership. This further centralized local residents and dramatically improved land use efficiency. Xiaolan successfully enhanced its land use intensity and reaped better economic benefits by re-zoning its urban territory, adopting zone-based management and introducing property management services to rural residential areas.[44]

2.4 Conclusion

China's arable land per capita is already extremely limited, yet three decades of fast urbanization and irresponsible land use has significantly reduced this valuable resource even more. If this trend is not reversed, China's food security will be threatened and adverse effects on global climate change will continue to increase. Key steps for China include: 1) universalizing high-density land development; 2) adjusting tax policies to encourage land conservation and intensive utilization; and 3) promoting integrated and coordinated government administration on spatial planning. The central government has already launched its fiscal and tax reform, and there is already coordination in efficient land use practices and spatial planning in several Chinese cities. However, China will need to go above and beyond on a much larger scale and use more diversified methods to avoid unsustainable land use.

Compact and efficient use of urban land is the foundation for sustainable transport development and efficient energy use. The following chapter will present issues within China's urban transportation system, which are intrinsically closely associated with land use.

3 URBAN TRANSPORT

Guangzhou BRT ©ITDP-China

3.1 Transport and Carbon Emissions

Urban transportation includes public, private, non-motorized and goods transportation. Oil represents 94 percent of fuels consumed by urban transportation, which has made transport one of the leading causes of greenhouse gas emissions[45]. In 2010, the transportation sector emitted 6.755 billion metric tons of CO_2, or 22 percent of global CO_2 emissions from fuel combustion[46]. This year, China's transportation sector emitted 769 million metric tons of CO_2, or 11 percent of the national total. If this trend continues, it is estimated that by 2020, CO_2 emissions from China's transportation sector will reach 1.463 billion metric tons, or 14.6 percent of the national total[47].

China has witnessed explosive growth in urban transportation demands; driven by rapid economic growth, urbanization and industrialization. As a percentage of national total oil consumption, the combined oil consumption by travel, transportation, warehousing and postal services totaled 14.7 percent in 1990, 28.4 percent in 2000 and 34.4 percent in 2010[48]. An academic analysis revealed that oil consumption and CO_2 emissions by China's road transit in 2008 was 20 times that of 1978, a growth from 119 million to 377 million metric tons of CO_2 emissions[49]. Another Chinese study showed that CO_2 emissions from China's transportation sector grew from 151.6 million metric tons in 1991 to 602.3 million in 2009, representing a 15.6 percent compound annual growth rate (CAGR)[50]. An investigation by the World Bank between 1993 and 2006 also found that energy use and CO_2 emissions of urban transit grew at a CAGR of 6 percent from 2002 to 2006, for a combination of 17 World Bank-selected Chinese cities; while the growth rate of individual cities ranged from 2 percent to 22 percent[51].

Exponential growth of carbon emissions from urban transportation is also reflected by China's phenomenal growth in private car ownership. In 1978, China had just initiated economic reforms and almost no one owned private cars. In 2013, private car ownership numbered over 100 million nationwide (figure 7)[52]; meaning one out of every 13 Chinese people owned a private car.

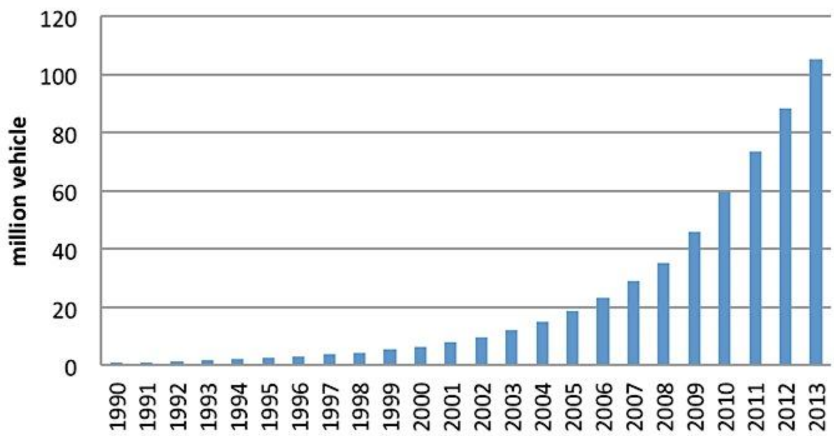


Figure 5: Yearly growth of private car ownership in China
(Source: China Statistical Yearbooks)

China's continual motorized vehicle explosion has caused traffic congestion and air pollution to increase at an alarming rate. The *China New Urbanization 2010* report published by the Chinese Academy of Social Sciences shows that of 50 sample cities, Beijing ranks first in terms of longest average commute time at 52 minutes, followed by Guangzhou (48 minutes), Shanghai (47 minutes) and Shenzhen (46 minutes). Serious traffic congestion is no longer exclusive to the mega cities, but has become the daily norm in many large and even medium-sized cities as well. The environmental health data released by China's MEP this past August shows that of the 161 cities that adopted the new air quality standard, 152 of them, or more than 90 percent, failed to meet the criteria[53].

Increased motorization in China has not only adversely affected mitigation efforts for global climate change, but has also resulted in a deterioration of urban traffic and air quality. Motor vehicle-centered development strategy is not sustainable, thus must transition to relying more on low-emission alternative travel modes, which can offer multiple benefits, from reducing energy consumption and carbon emissions to improving people's health, road safety, and social interactions.

3.2 Key Issues

It is encouraging to note that in recent years, the Chinese government and a great number of Chinese cities have placed the development of public transportation high on their agenda. This is a critical step in the right direction. As China continues a rapid urbanization process for another two or three decades, urban transport systems will need expansion and people's lifestyle and travel behaviors will inevitably change. Whether or not Chinese cities continue to motorize or are able to restructure the transportation systems to reverse the trend and increase green travel, will ultimately make a great impact on China's low-carbon vision and global carbon emissions. Moving forward, three aspects are worth high and sustained attention in China:

First, make **public transportation development** a long-term priority and encouraging large-capacity public transit systems for big cities. Public transportation is a very energy efficient and low-carbon option thanks to its adaptability and large capacity. Public bus commutes require only one eighth of the per-capita energy use and carbon emissions of private car commutes; while subway commutes require only one sixteenth of the latter[54]. Prioritized development of public transportation will help alleviate city traffic congestion, improve air quality and reduce energy use and carbon emissions.

The Chinese government has introduced a number of policies recently to encourage cities to prioritize public transportation in budgeting, city planning and development. The Chinese government legally defined urban public transportation as a social program in 2006; requiring the government to increase public transit expenditure, incorporate it into public finance, and establish lower fares. In 2012, the number of public transportation vehicles doubled from that of 2000, and ownership of public vehicles per 10,000 people grew 128 percent[55]. Among the total trips taken within large cities, the share of these trips using public transportation has grown dramatically.

Large-volume public transit modes such as rail transit and bus rapid transit (BRT) have experienced considerable growth given support from government policy. In 2012, China's urban rail transit systems reported 8.7 billion rides, 6.7 times as many as in 2004[56] (Figure 8). By the end of September 2013, 37 cities had approved or formulated rail transit development plans. More than 90 percent of provincial capitals[57] had developed rail transit plans, and the total length of built rail transit systems nationwide had reached 2,300 kilometers[58]. Moreover, more than 20 cities in China already have BRT systems in place, with many other cities in the process of either planning or constructing their own BRT systems. The BRT systems in Chongqing and Zhengzhou alone are capable of reducing 218,000[59] and 170,000 metric tons[60] of carbon emissions, respectively.

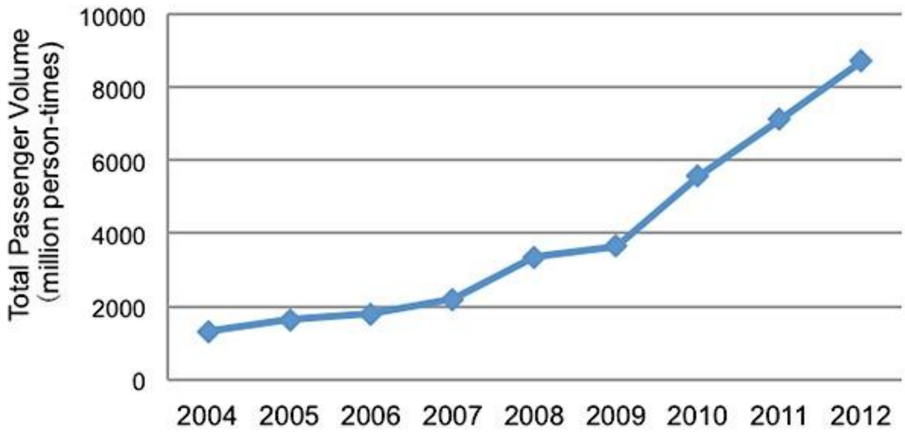


Figure 6: Yearly changes in passenger volume of China's urban rail transit
(Source: China Statistical Yearbooks)

Second, discourage and **suppress private car usage**, while supporting the replacement of gasoline and diesel vehicles by low-emission and clean-energy vehicles. Cars in China are used six times as often as in the US, and three times as often as in Tokyo[61]. Although absolute car ownership in Chinese cities is lower than foreign cities, more frequent car use has led to increased traffic in China.

To address this issue, many Chinese cities have resorted to car use control through demand management. Beijing, Chengdu, Hangzhou and Guangzhou have successively introduced policy measures to control car use through license plate end number restrictions. Beijing and Shanghai even went a step further by auctioning and distributing license plates through a lottery, which has greatly slowed the growth of private car ownership. In terms of parking space supply, several cities have plans in place to develop parking facilities and differentiated parking fees. Moreover, rapid development of public transport and NMT systems has further reduced dependence on privately owned cars.

The Chinese government has issued incentives to encourage the use of low-emission and clean vehicles to promote fuel technology transition on a national level. In 2008, the

Chinese government increased its excise tax for high-emission cars by 10 percent to 20 percent, and reduced excise tax for low-emission cars from 3 percent to 1 percent[62]. In 2009, the vehicle acquisition tax for low-emission cars was halved[63]. The Chinese government incorporated three types of electric vehicles into its 863 Program in 2001 to drive the development of new-energy vehicles; they began offering tax incentives for environmental-friendly vehicles such as hybrids. In 2009, the State Council allocated billions of RMB through grants and loans to support the new-energy auto industry; selecting 20 pilot cities to promote energy-saving and new-energy vehicles, and provided subsidies to consumers who purchased all-electric cars. That same year, the State Council also reformed its oil tax, which increased the tax burden for oil-guzzling car users. New-energy cars were exempted from the excise tax as of July 2014. Spurred by these policy actions, Chinese new-energy vehicle output has grown exponentially. The total output in 2014 is estimated to be three times as large as that of 2013[64], with a promising goal of producing and selling 500,000 units in 2015[65].

Third, manage and **reduce transport demand growth** by developing non-motorized transport systems and influencing citizen travel behaviors toward low-carbon options. As the greenest of all among the transport modes, non-motorized transport[V] (NMT) does not consume fossil fuel or discharge exhausts, and requires very limited space.

In recent years, some Chinese cities have started to bring NMT back into its city planning, management and development. In 2005, the State Council promulgated the *Opinion on Prioritizing Public Transport Development in Cities*, followed by the *Opinion on Economic Policies for Prioritizing Public Transport Development in Cities*; these were jointly released by the Ministry of Construction, NDRC, Ministry of Finance and Ministry of Labor and Social Security. In 2007 and 2008, China organized a nationwide "Public Transport and Car-less Day". In 2012, the *Guideline on Development of Pedestrian and Bicycle Systems in Cities* pointed out that large and mega cities should encourage NMT as the dominant mode of transportation for short and medium-length trips, as well as for connection to public transit systems; meanwhile, small and medium-sized cities should promote NMT as the main form of travel. The Guideline also sets the target for NMT percentage within the total number of trips in cities of all different sizes, and requires completion of NMT planning before 2015. In 2013, MoHURD issued the *Guide for Planning and Design of Urban Pedestrian and Bicycle Systems*, which offered specific guidelines for NMT planning and design. Thanks to these joint efforts, 106 cities in China have working pedestrian and bicycle systems by 2014, with many other cities following suit. Furthermore, cities like Guangzhou and Ningbo have introduced sidewalk management regulations to combat sidewalk encroachment and improve pedestrian environments. Cities like Hangzhou, Shanghai, Beijing and Zhuzhou even have public bicycle networks in place to encourage their citizens to travel by bus and cycling.

[V] Non-motorized transportation usually refers to a form of transit powered by humans, which mostly includes walking, cycling and riding other low-speed, environmental-friendly vehicles whose maximum speed is lower than 20 kilometer per hour, with very little noise and effective braking systems.

As of September 2012, 153 Chinese cities have joined "No Driving Day", resulting in a total of 200 to 300 million people participating. The public awareness of this campaign has been growing across the country, reaching 78 percent in 2012[66]. The National Resources Defense Council released a report in August 2014 that evaluated 35 Chinese cities on their walking friendliness, creating a lot of media coverage to help promote NMT options.

3.3 Good Practices in China

1. Guangzhou: BRT leading the charge

Guangzhou's BRT is the largest BRT system in Asia, and second largest world-wide. It is a collaborative project including the Institute for Transport & Development Policy (ITDP) and the Guangzhou Municipal Engineering Design & Research Institute. Guangzhou's BRT system is also China's first BRT system to be awarded the ITDP's Gold Standard status[67]. In 2012, it was also designated a United Nations' Response to Climate Change Lighthouse Project. In addition, the BRT system uses innovative specialized lanes & flexible routes model; with 86 functional capabilities, it is the most complex and advanced intelligent dispatch and control system in the country. By integrating more than 80 bus lines, and ensuring rapidity by separating BRT buses from other vehicles, Guangzhou's BRT system has metro-like large capacity, while retaining the flexibility of conventional bus system. This BRT system also holds multiple world records: it has the world's highest BRT bus flow, is the first high-capacity BRT system world-wide to operate direct service routes, is the first BRT system to adopt the reversible lane control system, and is the world's first BRT system to be highly integrated with a compatible bikeshare network.

What is also worth noting is that during the location selection and surrounding environment design process of the BRT stations, special attention was paid to the integration of BRT system, subway systems, pedestrian facilities to make passenger transfer convenient and user-friendly. Specifically, Zhongshan Avenue's BRT line is the first in the world to achieve physical integration with a subway system. The entire subway line 6 will eventually realize seamless connection with BRT stations. During construction of the BRT, transit-oriented development was incorporated into the surrounding land. In addition, other cities should learn from its cooperative operating model that focuses on operation efficiency and quality of service. Guangzhou's BRT is managed by Guangzhou BRT Operation Management Group as a whole and collaboratively operated by 8 different bus companies. These various groups are all represented within the control center. Fares are assigned based on kilometers traveled rather than number of passengers, and fare allocation is adjusted based on the level of service.

Since the grand opening of Guangzhou's BRT in 2010, it has been constantly optimizing its routes and operation levels. The system has exceeded the capacity of other systems in Asia by more than three fold. One-way passenger traffic stands at 30,000 passengers per hour; resulting in more than 850,000 passenger trips per day[68]. This kind of capacity is greater than the majority of Chinese subway lines. For Guangzhou, this calculates into at least

86,000 tons of CO_2 emissions and 14 tons of particulate matter emissions avoided every year[69]. The opening of the gold standard BRT system has increased average bus speeds from 15 kilometers per hour to 22 kilometers per hour, while at the same time improving other vehicle speeds by 15 percent[70].

2. Beijing: Considering low-emission zones

A low-emission zone (LEZ) is a geographically defined area that restricts access of specific polluting vehicles or only allows access by low polluting vehicles with the ultimate aim of improving air quality. Data shows that motor vehicle emissions in Beijing account for about 22.2 percent of the city's total PM2.5 emissions. Establishing low emission zones will effectively improve the air quality in Beijing. In actual practice, LEZs have been adopted by many countries and regions as an important tool to address air pollution caused by transportation.

Greenhouse gasses like CO_2 and air pollutants are emitted simultaneously during fossil fuel combustion. Decreased fossil fuel consumption not only reduces greenhouse gas emissions, but also provides the co-benefit of reducing primary air pollutants. LEZ is just one example of how low-carbon planning has the added co-benefit of improved air quality. Based on practical experience of other countries, LEZs will reduce a city's carbon dioxide concentration by 10 percent, nitrogen oxide emissions by 15 percent and will be able to effectively decrease PM10 concentrations. Even taking air quality out of the equation, the benefits are worth it; LEZs effectively decrease traffic by 19.2 percent, while significantly increasing traffic speeds. A case study in Milan showed an improvement of 11.3 percent on traffic speed[72].

In terms of public health, the establishment of LEZs will make substantial contributions to a city's livability by increasing road safety, reducing traffic noise and decreasing environmental pollution. As to the economic benefits, we will see a gradual withdraw of high-polluting and high-emission vehicles from the automotive market, and the promotion of a clean, energy-saving transportation sector.

As designated in the newly enacted *Beijing Clean Air Action Plan 2013-2017*, the Beijing Transportation Committee and Beijing Environmental Protection Agency are responsible for developing the above mentioned low emission zones and set traffic congestion fees. The plan to implement these low emission zones required research on LEZ congestion charge mechanisms such as levied electronic toll collection policies and intelligent vehicle identification systems. In early 2014, the World Resource Institute began collaboration with the Beijing Municipal Commission of Transport on traffic congestion alleviation, transport sustainability, greenhouse gas emission control and the promotion of green transport. LEZ is currently a priority on Beijing's policy agenda. With London, Milan and Berlin as mainstream models worthy of reference, Beijing will carefully consider the relationship between the establishment of low emission zones and the collection of traffic congestion fees, gradually phase out motor vehicles exceeding emission standards through economic levers, and enact concerned LEZ policies when the time is right.

3. BYD: Frontrunner in electric vehicles

BYD Company Limited (BYD) is a domestic Chinese brand that leads the electric vehicle market worldwide. Established in 1995, BYD specializes in IT, automobiles and new energy. BYD is also the world's largest supplier of rechargeable batteries, with the largest market share of nickel-cadmium batteries and handset lithium-ion batteries.

China's electric passenger car sales have seen explosive growth, with 45.6 percent (2013) increasing to 68.6 percent (2014)[73]. This is directly entwined with China's three part strategy for the electric vehicle industry. As the frontrunner in electric vehicles and rechargeable batteries, BYD holds the key to the future success of electric vehicles; that is, battery technology that powers electric cars. BYD introduced both the world's first electric car driven by a Dual Mode system and an electric car powered by a proprietary degradable battery; the latter of which can power more than 500,000 kilometers of travel, the longest battery-powered travel distance ever known. In January 2013, BYD was honored with the Zayed Future Energy Prize to celebrate its accomplishments in renewable energy. Although in 2014 BYD accounted for nearly 37 percent of the new energy vehicle market share, new energy vehicles only accounted for 0.4 percent of the entire automotive market. The promotion of new energy vehicles still has much potential, and it is estimated that in 2020, the market share will rise to 1.6 percent[74].

BYD has seen explosive growth in the new energy vehicle market since 2010, and has excellent cooperation with the Government (a number of its brands will be exempt from the new energy automobile acquisition tax list). If BYD can improve its R&D at the same time, it would go a long way to broadening its future development prospects.

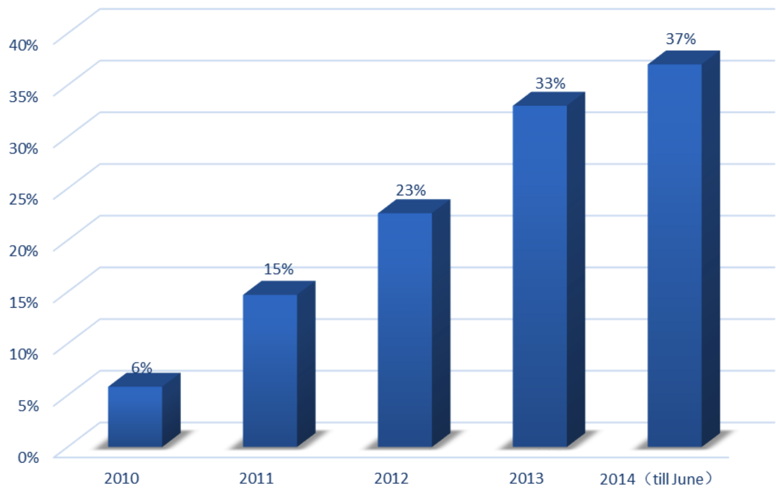


Figure 7: BYD's market share in new energy
(Source: BYD Annual Report)

4. Hangzhou: World's largest bikeshare program

Covering an area of 16,000 square kilometers, Hangzhou, the capital of Zhejiang Province, is home to 8.85 million people. Modeled after successful international and domestic practices, Hangzhou's strategy aims to create a new NMT system that is aligned with the city's needs, integrated with its public transit systems and is overall safe, convenient, efficient and low-cost. In time, these features will become an international model of its own.

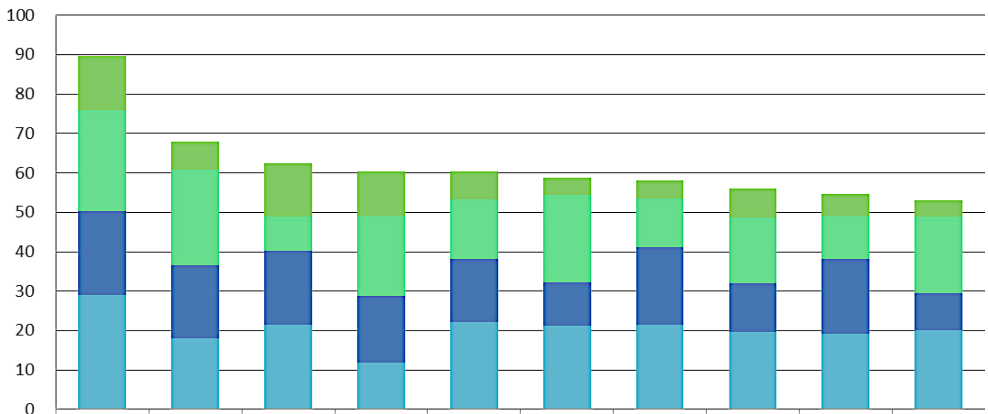
Hangzhou has divided the city into 47 NMT zones in order to guide non-motorized traffic to these areas. Also, the city area is grouped into eight categories based on land use purposes, pedestrian traffic levels and citizen activities. Based on these categorizations, measures were introduced to satisfy the different needs of various pedestrian units. Hangzhou has also introduced design guidelines for its NMT and pedestrian systems, which offers guidance for future planning and development of NMT systems. In addition, Hangzhou has completed the compilation of the *Hangzhou Non-motorized Transport Development Strategic Plan* that intends to complete construction of 125 bike corridors within the city by 2020.

Also worth mentioning is Hangzhou's bikeshare program. This public project is supported by the Hangzhou government, with responsibility for operations given to Hangzhou Public Bicycle Transportation Services Development Co., Ltd. During the early stages, financial support was given from the government, and later kept going mainly through leasing kiosk business development and advertising investment operations. There are currently 78,000 public bicycles available[75], and more than 2000 bicycle rental sites[76], with daily rental volumes reaching 400,000[77]. Under this program, bike rentals within one hour are free. Public biking has now become a hallmark for the city of Hangzhou. Its success is not only attributed to government guidance, market operations and public participation, but just as importantly to its reasonable planning. The decision of where to place the rental sites was jointly decided by bus companies, the Traffic Police and the Urban Administration Office. In 2009, the Hangzhou Planning Bureau finally completed the *Hangzhou Public Bicycle Transportation System Development Plan*. The size and location of their rental stations are still constantly improved through public participation on the Internet, hotlines and other platforms. Finally, the Hangzhou government also places great importance on the city's bike culture. It not only combines tourism industry, city branding with the development of the bikeshare system and urban bicycle land systems, but also adopts the communication strategy to promote cycling as a city style. The mottos "care for the environment, travel green", "improve quality of life for our city" and other slogans printed on the public bicycles and rental station billboards have long been popular and deep-rooted, making cycling an urban trend and a fashionable lifestyle.

5. Promoting walkability in Chinese cities

Walking is the healthiest and most low-carbon, green travel mode. Walkable cities increase the convenience of daily life and enhance the quality of life for residents. If residents can walk and public transit or just walk to satisfy basic daily travel needs, much of a family's economic cost can also be reduced. Walking can increase opportunities for exchange and communication between people, resulting in a higher sense of belonging. More pedestrian-friendly streets increase economic performance of surrounding businesses and raises land values; this type of urban development delivers direct economic benefits to the community. Increasing the proportion of walking among total urban commutes can reduce energy use and carbon emissions, thus improving air quality, mitigating global climate change, and easing urban traffic congestion. The design and construction of walkable cities requires more compact spatial layout and efficient land use patterns to help restrict urban sprawl. Therefore, promoting cities to improve their walkability is an important strategy for easing pedestrian – vehicle conflicts.

To raise city governments' and the public's awareness of the importance of walkability, the Natural Resources Defense Council (NRDC) released in August 2014 the results of an original Walkability Index that ranked 35 Chinese cities of different sizes and from different regions based on their urban walkability. The top ten cities are presented below in Figure 8.



	Hong Kong	Shenzhen	Shanghai	Guangzhou	Dalian	Qingdao	Xiamen	Jinan	Haikou	Jiujiang
Policy/management	14	7	14	11	7	4	5	7	5	4
Functionality	26	24	9	20	15	22	12	17	11	20
Comfort	21	19	19	17	16	11	20	12	19	9
Safety	29	18	21	12	22	21	21	20	19	20

Figure 8: NRDC Top 10 walkable cities in China
(Source: Walkability of Chinese Cities, NRDC[i])

NRDC ranked the walkability of cities' core urban areas in four aspects. The first aspect was functionality, which represents the degree to which residents can rely on walking to complete daily tasks, for example attending school, going shopping, engaging in society, seeking medical attention, etc. This requires good road connectivity, and road network density and scale of city roads to make the transportation system more pedestrian-friendly. The second aspect is comfort, such as whether sidewalks and pathways are kept clear, roads are bordered by trees, etc. The third aspect is pedestrian safety, primarily traffic safety, designated space for pedestrians, etc. Lastly, the fourth aspect considers how municipal governments advocate for walking and how well pedestrian infrastructure is managed.

Hong Kong, with its high road network density, accessible pedestrian walkways (including overhead walkways), excellent transportation management, and good air quality, ranks first as the most walkable city. Narrow streets in Shenzhen's core urban area make walking more convenient. Shanghai and Guangzhou municipal governments have relatively clear policies for NMT system construction and pedestrian walkway management. For example in 1985, Guangzhou implemented the *Guangzhou Interim Provisions for Sidewalk Management*. Then in 1999, Guangzhou issued the *Guangzhou Regulation for Temporary Occupation of City Streets*. In 2000, Guangzhou also released the *Notice for Reducing Illegal Vehicle Parking on Sidewalks in Urban Areas*.

6. Shanghai World Expo: Making green transport fashionable

The green travel initiative with EDF as an active participant during the Shanghai Expo in 2010, is a large-scale campaign influencing more than 10 million people, and the long-lasting and most attended single low-carbon event in the world.

During the time before the Expo, the project aimed to first enhance the public's awareness of green travel through exhibitions, competitions and training. It released its *EXPO Green Travel Guide* to visitors as a reference for how to travel more sustainably, and at the same time educated people on how to reduce carbon emissions caused by transportation and provide the relevant guidance. During the actual Expo, enterprises were encouraged to grow a "Expo Green Travel Forest", and people were encouraged use low-carbon transportation through the issuance of low-carbon travel cards that provided visitors with carbon neutralizing tools. They also offered online carbon calculator services to guide the public on how to select low-carbon lifestyle and way to travel, and to lead a carbon-neutral way of life.

Thanks to this initiative, public awareness of green travel increased drastically. In 2009, only 67.7 percent of respondents said that they had heard of green travel; after the Expo, this figure jumped to 98 percent, with 79 percent expressing their willingness to travel green. The *2010 Shanghai World Expo Green Travel Report* showed that during the Expo, this campaign helped Shanghai reduce approximately 830,000 metric tons of CO_2 emissions. This figure is equivalent to saving 350 million liters of gasoline. Intensive travel modes including rail transits, buses, coaches, and taxis accounted for 92 percent of total mode share, while the rate of green travel went up as high as 94 percent.

7. Wuhan: Community carpooling initiative

A residential community called Changqing Huayuan (Evergreen Garden) in Wuhan has introduced a carpooling program for community residents. This program intends to mitigate traffic congestion, reduce energy use, lower carbon emissions and to improve community rapport. A survey showed that 80 percent of people commuting by car at peak hours only have one person in the car. Organized by the community, the program encourages all car owners in the community to offer free rides for other residents if their schedules and routes match. For carpool purposes, community residents can either share cars or take turns driving. In October 2009, the community chose its second block as a pilot, with 20 car owners registering the day the program was launched. In October, the program was scaled up to include the whole community, with registered car owners increasing to 162. By the end of December 2009, more than 300 car owners had joined this low-carbon lifestyle carpooling program.

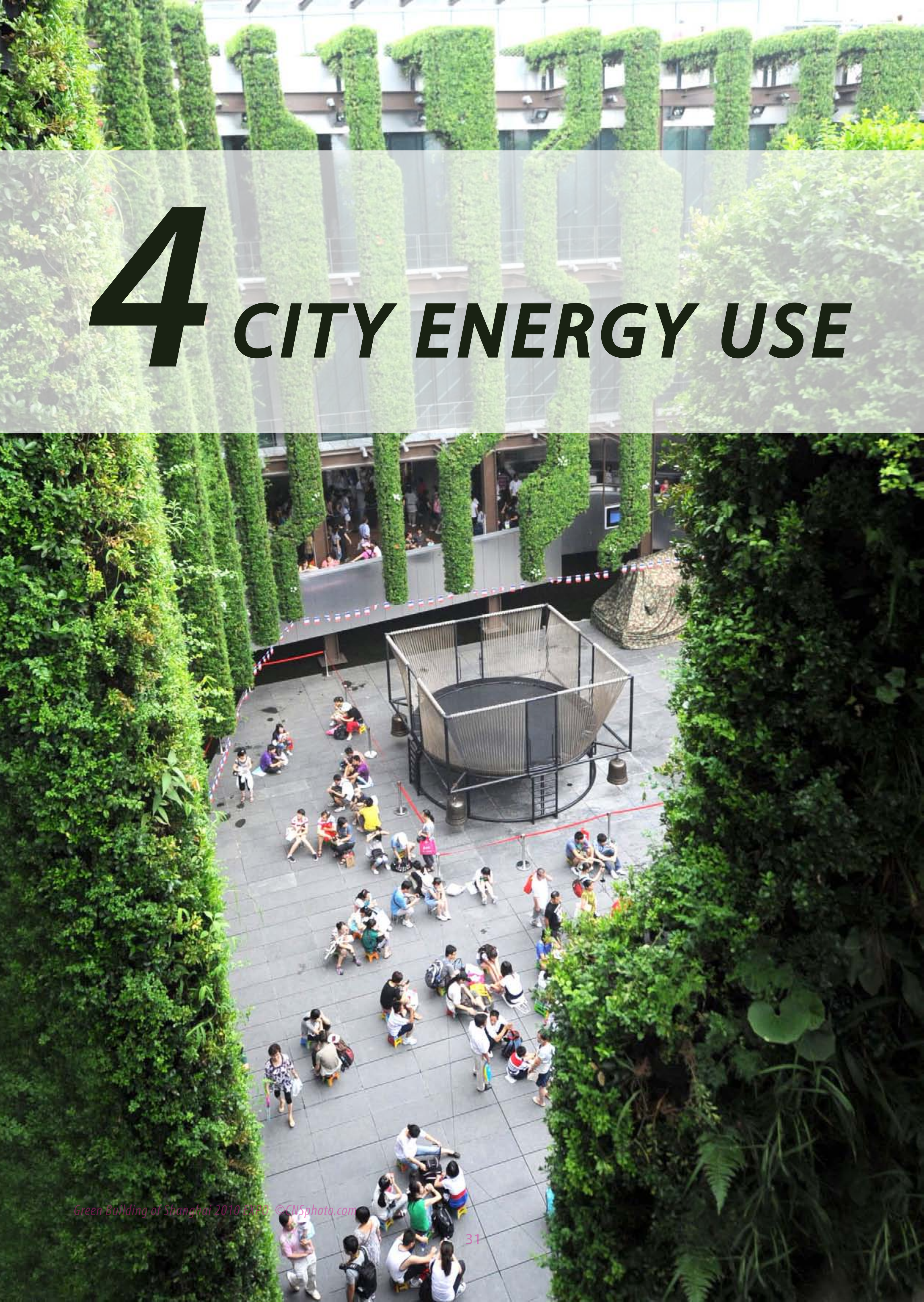
Although neighborhood carpools have good social, environmental and economic benefits, this policy gradually faded out after two years. This is mainly due to the fact that carpools, in accordance with current laws, cannot charge any fees; so eventually many people became embarrassed with long-term use of a free ride. Those that were eager to pass out free rides in the beginning became less willing to consistently pay for gas out of their own pockets, and didn't want to ask for money to avoid becoming a suspect for illegal "black car" operations.

So the issue became a question of how to give car owners incentive, while giving passengers peace of mind. This is now a key factor for the continued implementation of this project. One idea is to provide the community with parking subsidies and discounts on car washes for car owners. In addition, the city of Wuhan is also actively exploring a number of different ways to improve the legal system, so that it can continue to promote this new environmentally friendly travel model.

3.4 Conclusion

Chinese cities have paid a high price for rapid urbanization in the past three decades. Domination of motor vehicle-oriented cities is partly to blame. However, increasing urban traffic congestion has also presented a unique opportunity for China to shift to a low-carbon development model. Over the past decade, Chinese cities have been steadily moving towards low-carbon transport development, with three main aspects for intervention: 1) priority on public transportation during the planning and funding of urban transit development; 2) restrictions on privately owned cars through demand management measures, including limitations on car access and purchase, differentiated parking charges and tax policy adjustments as well as incentives to encourage the use of low-emission and clean vehicles; and 3) focus on integrating NMT systems into city planning while building awareness and encouragement of low-carbon travel. To expand the portion of low-carbon modes of transportation, Chinese cities will have to provide convenient, comfortable public transit systems and NMT facilities, as well as promote a low-carbon environment and healthier lifestyles, while controlling private car use. Only when this holistic three-pronged approach has been implemented, will the general public have incentives both internally and externally to choose greener transportation modes. However, China still has a long way to go on its low-carbon transition journey, and whether China can ultimately reach this destination or not will be greatly affected by urban land and energy use. The following chapter will introduce the latest actions taken by Chinese cities to improve their energy efficiency.

4 CITY ENERGY USE



Green Building of Shanghai 2010 EXPO. ©CNSphoto.com

4.1 Urban Energy Use and Carbon Emissions

Energy consumption – in particular, fossil energy combustion -- is considered the main source of carbon emissions worldwide. In the energy consumption process, emissions are released into the atmosphere in various forms, and have physical and chemical effects on air quality and climate change. These effects affect the use of energy sources and the supply of energy in a negative feedback loop. CO_2 emissions from energy use comprise of an overwhelmingly large share of human greenhouse gas emissions. Research shows that CO_2 emissions from energy use increased at a compounded annual growth rate (CAGR) of 1.5 percent from 5.5 billion metric tons in 1990 to 7 billion in 2005[78], making them key research topics in climate science.

Cities are the primary consumers of energy and thus the main source of carbon emissions. Urban areas represent only 3 percent of the world's total land, but account for 75 percent of the world's energy consumption, producing 60 percent to 70 percent of CO_2 emissions. These figures are even higher in developing countries. Statistics show that energy used by 287 of the 600 prefecture-level cities in China comprises 55.48 percent of the national energy total and 58.84 percent of total CO_2 emissions. In other words, less than 300 cities have contributed more than half of China's total carbon emissions. If the remaining cities and towns are included, the combined energy use may exceed 80 percent of the national total[79]. Under China's rapid development, cities face many prominent energy issues. Some of these issues are similar to those of other cities around the world, but more have to do with China's unique urban characteristics. First of all, China's urban development is occurring at the same time as its industrialization, and not as a post-industrial product of a developed country. Thus, to develop cities with intelligent and intensive energy use is an even greater challenge. Secondly, urban development is extremely unbalanced, with equally large differences in energy structures. Large cities are home to more educated residents, while medium and small cities face talent shortages. The same could be said of capital, technology, policies, and attention. Furthermore, the Chinese market is far from perfect since China is still transitioning between a planned economy and a market economy. All of these factors make urban energy issues all the more complicated.

4.2 Key Issues

Urban energy is defined as energy consumed by cities and primarily includes energy used by three sectors: industry, transport and buildings. Some researchers divide energy into energy used for production of goods and services, and energy consumed in households; while a more common practice separates energy use by sector. During China's rapid urbanization process, buildings and transportation have become, and will continue to be, the fastest-growing users of energy. Since the previous chapter discussed energy use by transportation, this chapter will mainly focus on the energy consumption of buildings. To address these issues, there are several strategies China can adopt:

First, require **city-level energy planning**, so as to control emissions at their source. Urban energy is an intertwined issue involving multiple fields so the issue cannot be addressed by any individual department; it requires coordination at a higher level. The key to sustainable urban energy is to devise energy plans at the city-level and optimize energy allocation and utilization in city development[80]. Only when energy conservation is incorporated into city planning and top-down designs consider both supply and end-use efficiency, can cities fundamentally reduce energy use[81]. New York and Greater London both serve as paradigms for coordinating energy use and reducing urban carbon emissions at the macro level.

China's City and Countryside Planning Act is lacking in content when it comes to energy-related urban planning, especially in local awareness of general energy conservation issues and related understanding of the development status. It also lacks basic data needed for improving energy efficiency of buildings. A city-level systematic planning guide does not exist, and therefore cities do not have a guide for saving energy. The current emphasis on energy conservation focuses on industry, transportation, and construction. However, the intrinsic links between these three main energy fields are sorely lacking. There is no systematic guidance for cooperation between these different departments, and the result is a very limited urban energy plan. Cities' existing individual plans for energy, such as electricity, gas, and central heating are planned with supply as the main factor. This approach may be effective, but in the case of rapid urbanization, the initial population and size of the planned area is much smaller that maximum capacity of energy facilities, allowing low capacity facilities to operate inefficiently in the long-term. Overall, supply-side planning lacks coordination and does not address energy saving measures.

Governments must formulate a comprehensive energy strategy for future urban planning, and follow strict implementation. Based on China's current situation, governments should focus particularly on improving energy plans for new cities. To alleviate the pressures of an increasing urban population, many cities are building satellite towns. It was estimated that China will build about 200 of these towns, with average populations of over 200,000, within the next 30 years. These new cities and urban areas should develop detailed energy plans in accordance with industrial and land use planning. Strict implementation and adjustments based on changes and regular updates are more important than the plan itself. Of course, no plan is perfect and urban development is a moving target, so planners must have a dynamic and open-minded approach in order to succeed.

Second, boost alternative energy and **renewable energy use** in various city applications. China's energy mix is the reason behind the over-dependence of Chinese cities on fossil fuels, especially on coal. Coal accounts for 70 percent of China's primary energy consumption, which has negatively impacted urban air quality. Clean energy accounts for only a small share of the energy mix. Therefore, China should place reducing coal use at the heart of its urban energy strategy. China needs to restructure its fossil energy supply to further reduce the share of coal in energy consumption, especially consumption by end users, and encourage cities to use clean energy from sources outside of these cities -- hydropower, wind power, etc.; and reduce the direct combustion of coal (for example, the direct combustion of coal used in space heating). In addition, China should emphasize long-term development of renewable energy for the future, such as promoting distributed generation of renewable energy, large-scale use of renewable energy in buildings, and geothermal energy development.

Third, focus on key areas for **energy conservation**, particularly building energy efficiency. Generally, the more developed the service sector, the higher the share of building energy use in total energy consumption. In the developed world, this share is around 40 percent. In such cities as New York and Tokyo, the share can be as high as 75 percent. Statistics for China have long been lacking; official sources say that buildings contribute 27.5 percent[82] of China's total energy use, while university sources claim this figure is 20.7 percent[83]. Nevertheless, there is unanimous agreement that the share of urban energy used by buildings will continue to increase rapidly. China is still industrializing, and the vast majority of Chinese buildings have lower energy consumption than buildings in developed countries' cities due to reduced thermal comfort; The majority of Chinese buildings are maintained at warmer temperatures than those in developed countries in the summer, and maintained colder temperatures in the winter. However, the potential for growth is very high. Construction of new buildings has been growing rapidly at a yearly pace of more than two billion square meters. This figure means that half of all new buildings in the world are built in China each year. Domestic energy use has also been on the rise. Moreover, there is growing demand for winter heating in northern China and for summer cooling in southern China, resulting in surges in electricity use during these two seasons. In the Central Yangtze River Basin area, the summers are hot and winters are extremely cold. However, this area is not been provided with heat in the past, so the demand for heat has increased at a rapid rate along with resident's incomes. In southern China, demand for air conditioning has also seen similar outcomes. In addition, China's fast urbanization and industrialization will inevitably drive up building energy consumption. To reduce urban energy use and emissions, China must adopt more rigorous energy performance standards for newly added buildings, while conducting energy retrofits for existing energy-inefficient buildings. China may also develop energy-saving green buildings to create low-carbon communities and urban areas to spur the low-carbon transition of cities. Finally, energy efficiency of household appliances and energy savings in city lighting, among many other energy saving methods, should not be ignored.

Finally, **encourage citizens to conserve energy**. Building a low-carbon city requires the support of all citizens and communities. A low-carbon city would be impossible without people changing the way they live and use energy.

4.3 Good Practices in China

To improve the sustainability of urbanization and address climate change, governments, enterprises, NGOs and other stakeholders have all established urban energy issues as one of their priorities. They have achieved substantial results, but must also confront many new challenges, which will require the joint effort of both China and the international community. To continue making progress on its low-carbon journey, China needs to learn from both lessons and success stories from home and abroad.

1. National low-carbon cities program

With rapid economic development comes ecological deterioration. Thus, China has voiced desire for low-carbon eco-city construction. In recent years, the Chinese government has conducted research and experimental work to solve urban energy problems. These projects include eco-cities, green cities, livable cities, new energy cities, low-carbon cities, and so on. Despite different emphases, they all revolve around the same objective of low-carbon and energy conservation.

In 1986, Yichun City, Jiangxi Province proposed the goal of eco-city development, and is considered China's first eco-city construction. In January 2008, the global conservation organization World Wildlife Fund (WWF) officially launched its *China Low Carbon City Development Project* in Beijing. It used Shanghai and Baoding as pilot cities to seek low-carbon development solutions. In 2010, the NDRC began to organize national low-carbon city pilot provinces. Low-carbon urban planning and specialized urban energy planning were the main focuses of these pilot projects. In January 2013, MoHURD approved the first batch of eight green demonstration eco-cities. This batch consisted of Guiyang Ecological District, Chongqing Ecological District, Changsha Meixihu Eco-city, Shenzhen Guangming Ecological District, Tangshan Bay Eco-city, Tianjin Eco-city, Kunming Chenggong Ecological District and Wuxi Taihu Ecological Park. The same month, MEP launched its fifth national ecological civil construction pilot. According to statistics, as of April 2014, China had 29 provinces (excluding Hong Kong, Macao, Taiwan, Tibet and Qinghai) that have proposed green demonstration projects (including eco-cities, ecological parks and ecological districts. The number of projects under construction or in the planning process has reached 217, and are mainly located in the more developed economies of China's eastern and central regions. The national *12th Five Year Green Building and Green Eco-City Development Plan* will usher in the construction of 100 green eco-cities, with 19 already approved, green eco-city demonstration projects. In addition, MoHURD has met with Singapore, Sweden, the United States and other countries and local governments to seek cooperation for building low-carbon eco-cities.

Although the country's eco-city development is still in the exploration and trial stages, the benefits are already apparent. In 2010 and 2012, the NDRC named a total of 42 pilot provinces and cities. Preliminary evaluations have yielded positive results. Guided by low-carbon planning and other measures, pilot areas have significantly reduced their greenhouse gas emissions. In the first half of 2013, the carbon intensity of 10 pilot provinces and cities dropped by an average of 9.2 percent, greater than the national average of 6.6 percent[84].

In order to ensure the healthy development of ecological city planning, we need to strengthen guidance, screen appropriate local technologies and models, and gradually improve the accountability system. It is also just as important to promote governments, enterprises, and the public to take actively participate in eco-city construction and management. Government departments must place deep consideration onto the planning stages of implementation and management, and the introduction of appropriate incentive policies and measures. Businesses have the responsibility of actively pursuing technological innovation to guarantee smooth continuation of low-carbon eco-building operations. The public must adopt low-carbon lifestyles and change transportation patterns. All these changes will help cities achieve their low-carbon, energy saving goals.

2. Rapid renewable energy deployment

Increasing urban clean energy and renewable energy is undoubtedly one of the most effective ways to reduce a city's carbon emissions. In September 2007, the central government proposed its *Long-term Renewable Energy Development Plan* which aimed to achieve 10 percent renewable energy as part of the total national energy consumption in 2010, and 15 percent in 2020.

Most recently, during the APEC CEO Summit in Beijing, President Xi Jinping announced China's pledge to reach peak carbon emissions by 2030, if not sooner. To reach that goal, Mr. Xi pledged that clean energy sources like solar power and wind turbines would account for 20 percent of China's total energy production by 2030. Nationally, renewable energy development has ushered in rapid development. According to data released by the National Energy Board, as of the end of September 2014, the country's total installed capacity of renewable energy generation reached 404.37 million kilowatts, with total installed power capacity ratio exceeding 30 percent; China continues to maintain its status as a leader in global renewable energy. Newly installed hydropower capacity accounted for 15.65 million kilowatts, with total hydropower capacity reaching more than 290 million kilowatts. Newly installed wind power capacity accounted for 8.58 million kilowatts, with cumulative wind power capacity reaching 84.97 million kilowatts. PV capacity added another 4 million kilowatts, with cumulative installed capacity of over 20 million kilowatts. Biomass power generation added 900,000 kilowatts, with cumulative installed capacity of over 9.4 million kilowatts. Renewable energy generated from the Yangtze River and China's northern regions, is transported to the large cities through high pressure, ultra-high voltage power transmission lines. In Shanghai, for example, renewable energy produced far from the city accounted for 13 million kilowatts in 2014, which was nearly half of the 28 million kilowatts needed for the entire summer. This is roughly equivalent to avoiding the consumption of 8.476 million tons of coal, which is roughly equivalent to avoiding 92,400 tons of sulfur dioxide emissions, 79,700 tons nitrogen oxide, and significant amounts of other harmful gases[85].

In addition to the introduction of "green" electricity, the development of city energy distribution and acceleration of renewable energy applications can help solve territorial energy issues. China is one of the world's leaders in solar energy resources, and is also rich in recoverable low-temperature geothermal energy from surface water, shallow groundwater and soil, a resource that promises huge potential for development. Solar energy and low-temperature geothermal energy are both low-grade and have low heat values. Under the graduated principles for energy use, such energy types are most suitable for buildings and domestic use. Thus, to improve energy performance, it is economically effective to increase the use of solar energy and low-temperature geothermal energy in buildings.

In this regard, MoHURD and the Ministry of Finance have jointly introduced policy incentives, launched pilot programs and appointed pilot cities (Fig. 11). To promote the use of solar energy, 22 cities from 13 provinces have introduced policies mandating the promotion of solar thermal installation. Jiangsu, Anhui, Shandong, Nanjing, Shenzhen and other cities have all proposed that new commercial and residential buildings twelve stories or lower shall be built with unified designs for solar hot water systems. Ningbo requires integrated building design for utilizing solar energy in all new residential buildings above the sixth floor if the buildings have more than 12 stories. Shanghai has a clear mandate for using solar hot water systems in residential buildings 6 stories tall or less. By the end of 2012, solar energy and low-temperature shallow geothermal energy were respectively supplying energy to 2.46 billion square meters and 300 million square meters of built-up urban areas, while the capacity of already installed or currently being installed solar PV reached 1,079MW[86].

During the formulation of the renewable energy construction plan, provinces (including autonomous regions and municipalities) such as Chongqing, Anhui and Beijing have all introduced the *12th Five Year Renewable Energy Development Plan* or proposed targets for the construction of large-scale renewable energy sources. Chongqing's proposed target for renewable energy construction was 4.5 million square meters. Qingdao proposed that by 2015, geothermal energy would cover an area of 10 million square meters, while solar thermal application would cover 13 million square meters. Shandong Province stated that by the end of the *12th Five-Year Plan*, the area supplied with renewable energy within Shandong Province would account for 50 percent of all newly constructed area, and that the renewable energy used in the process would account for 12 percent of the total. Zhejiang province will add approximately 50 million square meters of area supplied by renewable energy, and Fujian advertises that it will add over 30 million square meters.

Figure 9: 2009-2011 Renewable Energy Demonstration Map
(Source: Center of Science and Technology of Construction, MoHURD)

Earlier this year, the National Energy Administration and the MLR jointly issued the *Guide to Promoting the Development and Utilization of Geothermal Energy*, setting clear goals for geothermal development. The goals state that by 2015, national geothermal heating area shall reach 500 million square meters, with geothermal power capacity reaching 100 trillion kilowatts, and for geothermal energy output to be equivalent to the energy from 20 million tons of standard coal. By 2020, geothermal energy output will be equivalent to that of 50 million tons of standard coal. On June 25th, the two ministries issued *Notice on the Preparation of Geothermal Energy Development and Utilization of Organizational Planning*, which required provinces' (including autonomous regions and municipalities') Development and Reform Commissions to collect data on the exploration results of their regions' geothermal resources, obtain statistics on the demand for heating and electricity, and organize preparation for the development and utilization of geothermal energy plans.

3. "Passive House" pilot

China's building energy efficiency work is a collection of experiences from learning and international examples. For example, the initial building energy efficiency standards are borrowed from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards. Building insulation and energy-saving technologies also take a European approach. The "passive house" concept originated in Germany, and uses innovative thermal insulation, thermal windows and thermal doors to provide efficient heating and ventilation of buildings with very little energy consumption. Germany currently has 32,000 "passive houses", and is growing at a rate of 3000 per year. Compared with these passive low-energy buildings, China's own low-energy buildings are lagging behind. German buildings require only one fourth to one fifth of the energy Chinese buildings in the same climate and latitude consume. Therefore, in order to improve China's new building standards, MoHURD has been cooperating with Germany since 2009 in constructing demonstration buildings in China.

Zai Shui Yi Fang (literally meaning "waterside") in Qinghuangdao is a pilot passive house program carried out according to German standards. Testing shows that apart from the 65 percent increase in energy efficiency currently required, heating alone has raised energy efficiency by an extra 30 percent. The additional cost per square meter was only 627.8 RMB ($100 USD).

Up until now, 37 projects are underway with a total construction area of about 330,000 square meters. Building types include residential, industrial, offices, schools, memorials, student dormitories, etc., and two projects have already been awarded the *Passive House Quality Label*[87]. Shandong, Hebei and other provinces have also set targets for demonstration areas.

For example, in northern China, if the region's annual new residential construction area is 500 million square meters of which 10 percent of new residential buildings have reached the passive low energy standard, the region can achieve annual savings of about 8.5 billion kilowatt hours of primary energy. These savings are equivalent to about 1.05 million tons of standard coal, and carbon dioxide emission reductions of about 2.83 million tons[88].

Finally, with the support of the US-China Clean Energy Research Center, a near-zero energy building demonstration was launched in various climate zones. Based on these model buildings, even higher requirements for building energy efficiency standards are in the works.

4. Exponential growth of green buildings

Green buildings are essentially an upgraded version of energy efficient buildings with more stringent environmental requirements. In the early 1990s, NRDC began introducing China to the concept of green buildings through Leadership in Energy and Environmental Design (LEED), a US green building certification system. In 2006, China inaugurated its own green building design standards and certification system. In 2013, the State Council released the *Green Building Action Plan* as the system's first document in 2013. China has since witnessed an exponential increase in green buildings. By December 31, 2013, 1,446 projects had passed green building certification, covering a total area of 162.7 million square meters[89]. Both the number and built-up area of green buildings have doubled over these years.

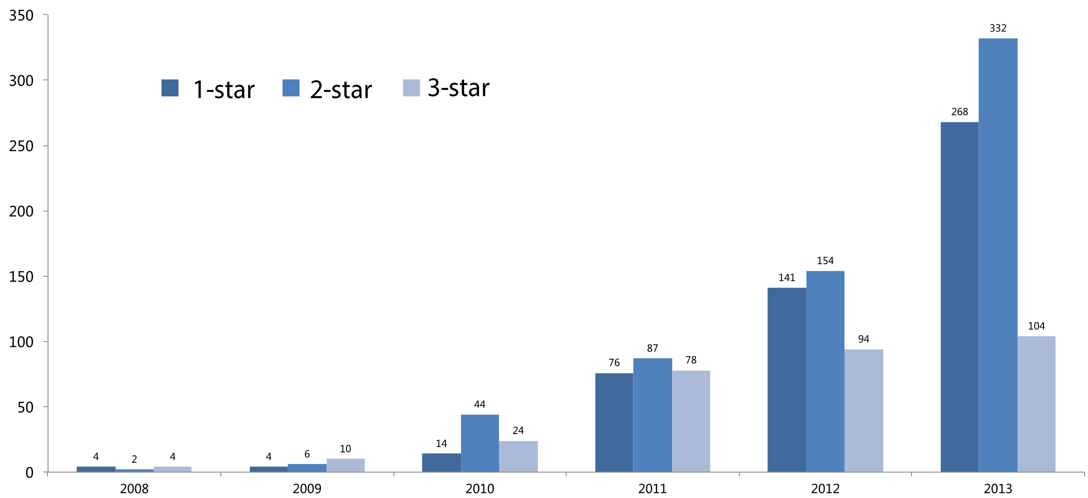


Figure 10: Growth of certified green projects in recent years
(Source: MoHURD)

The development of green buildings has branched off in two new directions: enforcement, and expansion into various regions. Enforcing implementation is an important direction for the future development of green buildings. According to the requirements set by MoHURD in 2014, all newly constructed government buildings such as office buildings, schools, hospitals, airports, museums, etc. must take the lead in enforcing green building standards. At the same time, government construction of affordable housing was also asked to do the same. Since June 2013, all new buildings under construction in Beijing must achieve the minimum green building standards (one star) in order to receive approval. Meanwhile, there has been a shift to continuously reduce the energy consumption of green buildings. Jiangsu, the province with the largest number of green buildings, proposed the concept of constructing energy-saving green building demonstration zones in 2010. In July 2010, the Suzhou Industrial Park New Eco-Technology City and Kunshan Huaqiao International Financial Services Area became a demonstration zone for the first batch of green buildings. As of the end of July 2014, there were a total of 54 Jiangsu green eco-integrated demonstration project areas, including 37 green building demonstration areas, 5 regional integration demonstrations and 12 green building model cities. The total comprehensive coverage will include 13 provincial cities. This green building demonstration project is expected to include more than 90 million square meters of building area[90].

5. Large-scale energy retrofits in residential buildings

In northern China, where heating is provided in winter, urban residential buildings that need retrofitting for energy performance improvements represent a total built area of 3.5 billion square meters. These buildings, which are mostly 20 to 30 years old, are energy inefficient and less comfortable when compared to modern buildings. In cold seasons, the room temperature in such buildings is below 10 degrees Celsius. Condensation, mildew and disrepair are prevalent, making these buildings uncomfortable to inhabit[91]. For years, heating fees have been charged by floor space rather than by the amount of heat consumed, discouraging energy conservation. Moreover, the widespread use of coal for heating in this region has not only produced enormous carbon emissions, but also worsened winter air pollution in northern China.

To address this issue, the central government began energy retrofits of these buildings in the early 1990s. In collaboration with France and Germany, China unveiled a number of demonstration projects to explore retrofitting models and technologies for residential buildings in north China. Those model projects greatly catalyzed the development of energy-saving technologies and the establishment of energy performance standards for buildings. In 2007, 15 provinces and municipalities in northern China launched heat meter installation and energy retrofits, which were subsidized by the government based on total retrofitted floor space. During the *11th Five-Year Plan* period, 180 million square meters of floor space was retrofitted. The purpose of saving energy is not only to reduce energy consumption from heating, but also to greatly improve indoor comfort. In Hebei Province, Tangshan City's energy-saving renovation of existing buildings totaled an area of 24.45 million square meters by the end of 2013. This accounted for 70 percent of all renovated areas in the city. After this implementation, indoor temperatures during the winter increased from 15 degrees Celsius to above 20 degrees Celsius, and the rate of energy savings for these renovated buildings was as high as 70 percent.

In May 2012, the *12th Five-Year Plan for Building Energy Conservation* released by MoHURD set the target of installing heat meters and completing energy retrofits of 400 million square meters of residential buildings in northern China. Furthermore, such energy retrofits will be scaled up for cities in the Yangtze River Basin, which experiences hot summers and cold winters.

Furthermore, on July 21st 2014, the State Council issued an *Opinion of the State Council on Improving Shantytowns.* This called for strengthening improvements to the shantytown, which mostly consisted of urban low-income groups; and the strict enforcement of energy efficiency standards. In 2013, more than 3.2 million households benefited from this transformation, and in 2014 it is expected that more than 4.7 million households will benefit. Overall, approximately 100 million people will be affected by this policy. Shantytowns have poor living conditions, and are not connected to the central heating system of cities. The residents usually use a small coal stove for self-heating in the winter, a practice that emits pollution that is hard to control. The effective implementation of this policy will help reduce nonpoint pollution sources in cities.

6. Yangzhou: Revitalization of an ancient city

Existing energy saving plans for buildings should gradually scale up to par with overall urban community development to assist carbon emissions reduction in the city.

Comprehensive transformation of communities and cities, especially older cities, is difficult. It is important to consider the protection of historical and cultural heritages of the city, while trying to improve living standards of residents and keep carbon emission levels from increasing. Based on these principles, Yangzhou Municipal Government worked with ISC to construct low carbon community pilot projects. The goals were to explore and demonstrate low-carbon transformation plans, abandon traditional urban development patterns, improve resident's awareness of low-carbon lifestyles, and introduce the feasibility of low-carbon technology investment in Chinese cities.

In July 2011, Yangzhou Municipal Government and the ISC signed an agreement to transform 4,134 square meters of an old factory area in the old part of Yangzhou into a set of plots for the demonstration of a low-carbon community. Yangzhou Municipal Government attached great importance to this cooperation, and allocated more than 20 million RMB as special construction funds. ISC funded and organized a team of American experts to provide full technical support, including participatory planning and design. They reached agreed to create a low-carbon project with the aim of maintaining the old town's low carbon emission levels while significantly improving living standards for its residents.

During the project implementation process, ISC invited an expert from the United States who was familiar with the LEED for Homes certification to carry out on-site training and guidance for Yangzhou local designers. This led to implementation of residential LEED certification standards, and ultimately contributed to the birth of China's first LEED for Homes certification program. ISC also worked with the government to hold community workshops, where they listened to the suggestions and ideas of surrounding residents, developed and designed action plans, and consulted jointly with stakeholders to ensure optimal implementation of the project.

All the low-carbon technologies in the project were verified by international standards. These affordable, mature, low-carbon solutions have maximized the whole community's efficiency in energy recovery and utilization and water recycling, while minimizing the community's carbon emissions. With such integration of technologies and land redevelopment, this project has aligned well with economic and ecological benefits, turning the project into a practical and inspiring example[92]. Though there is no evidence yet that the project has been directly replicated by other cities, the Yangzhou project has helped put China on the international radar for sustainable urban development and has significantly raised local residents' awareness of urban development issues.

7. Shanghai: Real-time energy monitoring in commercial buildings

China's focus on energy saving for buildings started later than most western countries. However, in 10 years' time, China has achieved substantial progress in building energy saving equivalent to the 30 to 40 years invested by western countries. On one hand, we have made remarkable progress, but at the same time, the rapid absorption of western energy-saving technologies has not allowed time for China to properly understand the technologies. This lack of deep understanding will become an obstacle for further energy efficiency upgrades.

The building sector in Shanghai consumes much more energy than that of other cities and regions. In 2012, Shanghai started to build the "1+17+1"energy use monitoring platforms to control energy use by large non-residential buildings and strengthen energy use oversight. For government buildings whose area exceeds 10,000 square meters and non-residential buildings whose area exceeds 20,000 square meters, energy use will be sub-metered and energy use data transmitted online. The goal is to complete the "1+17+1" monitoring platforms (1 at the city level, 17 at the district level and 1 for municipal government buildings), which will cover all the government and large non-residential buildings, by the end of 2015. In 2013, sub-meters that allow online data transmission were installed at approximately 1,400 government and large non-residential buildings in Shanghai. By the end of 2014, all government and large non-residential buildings will be covered, with digital energy performance management applied to primary energy-consuming buildings.

To help Shanghai better utilize building energy use data, EF China and NRDC shared U.S. best practices on building energy performance benchmarking and information disclosure. Moreover, NRDC also partnered with stakeholders such as power grid companies to pilot demand response measures in Shanghai to address summer peak demand.

8. Improving energy efficiency of household appliances

Studies show that by improving the energy efficiency of nine categories of home appliances, China can cumulatively reduce carbon emissions by nearly one billion metric tons by 2030[93] and save one trillion kilowatt hours of electricity, an amount equivalent to the combined power generation of 403 medium-sized thermal power plants.

To make home appliances more efficient, China has introduced mandatory energy efficiency standards and labeling. The *Energy Conservation Law (Revised)*, which went into effect on April 1, 2008, requires energy-consuming products and equipment to comply with new energy efficiency standards and also requires energy-intensive products to abide by energy use limits. By December 2011, China had enacted 46 mandatory energy efficiency standards, covering 6 categories: home appliances, enterprise equipment, lighting, industrial machinery, office equipment, and transport vehicles. Statistics show that by the end of 2011, 19 product categories following improved efficiency standards had cumulatively saved 687.8 billion kilowatt hours of power, or the equivalent of 248 million tons of coal, thus avoiding 640 million metric tons of CO_2 emissions and 2.82 million metric tons of SO_2 emissions[94].

Currently, the NDRC is researching how to promote the development of low-carbon products. It will prioritize the promotion of low-carbon air conditioners, refrigerators, televisions and other appliances.

9. Foshan's green lighting initiative

China's rapid urbanization, rise in economic prosperity and increased living standards have made citizens more demanding of their environment. Improving cities' street lighting and nightscapes have become an important component of city planning, development, and management. However, growing demand for lighting has also driven up energy use, requiring cities to be more energy efficient in their beautification efforts. Statistics show that lighting consumes about 10 percent of China's total power supply and promises huge energy-saving potential, since most lighting products in China are inefficient[95].

In accordance with the State Council's requirements on energy conservation, under the *11th Five-Year Plan*, cities actively promoted green lighting, and the development of urban lighting was rapid. By the end of 2010, there were 17.74 million road lights in 657 cities nationwide. The *11th Five-Year Plan* saw a net increase of 5.67 million road lights, and achieved 14.6 percent power savings, a truly remarkable feat. On November 4th 2011, MoHURD enacted the *12th Five-Year Green City Lighting Plan*. The target set for energy savings of 15 percent below 2010 levels by the end of the five years.

In the process to promote these policies, cities have led the charge. Foshan, Guangdong has requested the use of more energy efficient lighting products, such as energy retrofits of office buildings owned by government bodies and their affiliates to promote LED lighting. The local government also launched awareness-building activities for LED products and successful LED projects through seminars, media reports, exhibitions, and experience facilities in an attempt to raise public awareness of LED lighting and create a favorable market and social climate for LED lighting. By the end of April 2013, Foshan had installed 222,079 LED lights, including 50,040 street lights and 172,039 indoor lights[96].

10. "Cool China": Inspiring individual low-carbon actions

Guided by the NDRC Department of Climate Change and the MEP Department of Education and Communication (DEC), "Cool China" is a nationwide low-carbon action co-organized by the MEP DEC, the National Center for Climate Change Strategy and International Cooperation, and EDF. Implemented by the CANGO Commuting Fund, "Cool China" was designed to encourage the public to live a low-carbon life. Through schools, communities, businesses and other channels, the initiative organized individuals and families to calculate their everyday carbon footprint online. Between 2011 and 2013, more than 80,000 students calculated their family's carbon emissions and committed to make reductions. Offline, low-carbon tours, summer camps, and other activities encouraged face-to-face interaction to improve public awareness and behavior.

Funded by "Cool China", select communities from cities like Beijing, Hangzhou and Guangzhou built low-carbon facilities to promote green and low-carbon lifestyles and foster a low-carbon culture at the community level.

Thanks to the participation of five provinces and 10 municipalities, "Cool China" also received attention at the Durban Conference. "Cool China" was selected as one of China's Top Ten Climate Change and Low-Carbon Events in 2011, and was featured several times in the article, *China's Policies and Actions for Addressing Climate Change*.

4.4 Conclusion

Cities are the world's largest energy users as well as the largest source of greenhouse gas emissions. To accomplish low-carbon urban development, cities must coordinate energy use planning between departments and sectors at the city level; increase the share of renewables in the urban energy mix; mandate the implementation of more rigorous energy standards in new buildings, and adopt other energy efficiency improvement measures in the buildings sector such as carrying out energy retrofits of inefficient buildings, intensifying oversight over large non-residential buildings, and developing green building and low-carbon communities. Cities must also encourage public participation to reduce energy use and emissions. Urban energy issues have become more important to the Chinese government and international community. China has established preliminary policy and legal frameworks, accomplished positive results, and developed more successful practices. In the future, if China can scale up practices of pilot programs and further consolidate efforts in data collection, energy retrofits, energy management, and project quality, then China will elevate its low-carbon city development to a new level.

5 RECOMMENDATIONS

Beijing with Blue Sky and Green Trees ©Judy Li

China's rapid economic growth, urbanization and industrialization over the last three decades have lifted more than 600 million people out of poverty[97] and elevated China to middle-income country status. Until now, China has managed to avoid problems related to urbanization faced by other developing economies, such as high unemployment rates, prevalent urban slums, decline of city centers, and deterioration of public security. However, the reckless urban sprawl, rapid motorization, and inefficient resource and energy use accompanying China's urbanization have also left massive ecological and carbon footprints. Meanwhile, the Chinese government has drawn up an ambitious blueprint for the coming decades in which urbanization will continue to serve as an engine for growth. If China's urbanization continues to consume resources at the current rate, China will not only risk irreparable damage to environmental and human health and face a scarcity of natural resources, but will also contribute a significant negative impact to global climate change.

However, it is encouraging that China has realized its development is restricted by environmental, resource, and climate constraints and is now seriously reflecting upon its previous development model. Recently, the Chinese government has repeatedly expressed its determination to embark on a people-oriented and ecologically sound new urbanization path. The next question is how to build consensus and translate such determination into serious action by Chinese cities.

This report contends that effective land use, transportation, and energy are three key areas of emphasis to ensure China's low-carbon transition and highlights case studies of successful practices in these areas. The following chapter introduces policy recommendations for China. Based on our extensive project experience in China, we also offer recommendations on how the international community can reinforce its collaboration with Chinese cities.

5.1 Recommendations for Chinese Cities: Land Use

1. Adopt the "smart growth" concept to increase land use intensity

Disorganized development of urban areas and sprawling construction results in inefficient land use by decreasing the quantity of arable land and wasting resources. Furthermore, constructing a succession of buildings with the same function decreases the efficiency of urban infrastructure. Foremost, urban construction must ensure high density. Construction should maximize land use efficiency by skillfully considering transport conditions, market demand, infrastructure capacity, urban landscaping needs and ecological carrying capacity. Areas in close proximity to high-capacity transportation hubs should have the highest density and density should gradually decrease with increasing distance from these rail stations and public transport interchange sites. Effective land use ensures crucial availability of green spaces and public spaces within high density development areas while maintaining urban environment quality and vitality. Secondly, cities need to utilize land that has already been constructed on to address the needs of new urban construction.

Cities should redevelop inefficient urban areas and encourage the transformation, utilization and conservation-oriented development of old cities, factories and villages. Third, when there is demand for new construction sites, the priority should be to set up sub-compact urban areas near existing town centers. This development scheme not only minimizes the conversion of cultivated land, but also makes use of existing public facilities and services, increases convenience for residents and reduces energy consumption and pollutant emissions due to decreased travel distance between the old and new towns.

2. Encourage compact mixed land use

Excessive zoning of city spaces has led to traffic congestion, wasting of resources, decreased vitality and environmental pollution. Instead, cities should encourage compact and mixed land use development. First, overly strict zoning rules should be replaced with policies that allow for a reasonable mix of residential, commercial, office, public and other functional services buildings. Mixed zoning reduces traffic demand, increases convenience for everyday life and improves efficiency of land use. Secondly, the space above and below ground should be fully utilized: high-rise buildings should be divided by top, middle and bottom and assigned respective commercial, office and residential functions, while subways, parking lots, shopping malls and other service facilities should be built underground to achieve multifunctional space utilization. For land that is not planned for construction, realistic goals for landscaping, farming and green maintenance should be implemented to reduce carbon emissions to the maximum extent. Finally, it is important to test and demonstrate time as a variable of multifunctional building use. For example, different uses of public spaces could be promoted during different time periods. China's cities still lack experience in this regard and will need the government's help to overcome obstacles.

3. Coordinate planning between all government levels and departments

Urban planning in China has traditionally been carried out by various different departments. Due to contradictions among departments' objectives and means, it has often been difficult to efficiently implement plans for land use, economic and social development, urban construction and transportation infrastructure. Therefore, it is crucial for departments to coordinate and reach consensus in the initial stages of urban development. In order to achieve an effective interface for urban renewal, departments must minimize internal conflicts regarding industrial layouts, construction of urban infrastructure and spatial planning. Effective coordination is required for optimal configuration and rational use of land resources.

4. Strengthen land use management

In order to tackle the issue of urban sprawl, land management practices must be strengthened. Firstly, to effectively manage and control growth, fiscal policy must be reformed and local governments should seek other revenue sources, especially those that promote urban management and public services. Secondly, the approval process for new construction sites must be scrutinized: the number of new sites should be minimized and existing land for construction should be used more efficiently. Improving the approval process requires an increase in transparency and reliance on public approval. In addition, local governments need to prioritize urban public services and city management, while focusing less on GDP growth and attracting investment.

5.2 Recommendations for Chinese Cities: Transport

1. Implement differentiated strategies to optimize public transport

Although China mapped out a strategy for prioritizing urban public transport development as early as 2004, this strategy has been conceptually and practically misunderstood. For example, some cities overemphasized expanding public transport at the cost of neglecting efficiency improvement, structure optimization, and quality enhancement. Cities also ignored coordinating public transport with other transport modes or addressing differences between cities. Going forward, cities should prioritize development of public transport according to the following differentiated strategies.

Roadmaps for public transport development should be drafted based on local needs. Due to space, funding, environmental and other constraints, large-capacity public transport modes such as rail transit are not suitable to dominate public transport in most Chinese cities, nor can all cities implement BRT systems. According to a study analyzing factors affecting public transport development in 645 Chinese cities, different strategies should be used to improve the attractiveness and operational efficiency of public transport based on the size and development stage of a city. Large cities and mega-cities should introduce public transport services with larger capacities than those of public buses, while small- and medium-sized cities should urgently expand their bus fleet and coverage[98]. In large cities and mega-cities, public transportation systems should include large-capacity rail transit, medium-capacity BRT systems and public buses; medium-sized cities should emphasize medium-capacity BRT and public buses. Medium-sized cities may also develop low- and medium-capacity rail transit where necessary and financially possible. Small cities should focus on developing public transport systems dominated by public buses. Moreover, cities should stress optimizing the structure of public transport modes to enable transit-oriented development and achieve smart growth.

2. Focus on decreasing the demand for private vehicles

The gap between transport supply and demand drives traffic congestion across Chinese cities. Many cities believe this issue can be addressed by building and widening roads and increasing transportation infrastructure. However, such a line of thinking will not alleviate urban congestion, but will instead trap cities in a vicious cycle of more roads and more cars. Chinese cities should adopt demand management measures to reduce transport demand and narrow the demand for private cars. As opposed to increasing supply, demand management is less costly and more effective. China can adopt the following methods to reduce transport demand: adopt compact and mixed use land development; introduce economic tools (such as congestion charges, fuel taxes, public transport subsidies and differentiated hourly charges) to reduce private car use and encourage travel by public transport or non-motorized vehicles; enhance planning and management of parking facilities (abolishing requirements to build parking facilities in city centers and areas with high pedestrian traffic, distributing limited parking spaces in such areas by charging deterrent parking fees, etc.) to reduce motorized traffic; and introduce innovative programs (flextime, carpooling, etc.) to improve transport efficiency and reduce demand.

3. Accelerate the development of smart public transport systems

As a key component of a smart transport management system, a smart public transport information system is an internationally recognized means for easing urban congestion and improving public transport efficiency and service. Although some big cities have adopted such systems, China as a whole still lags behind, exhibiting limited application of information systems, poor information integration between systems, and a lack of more sophisticated uses of system data. In the future, China should implement smart public transport systems that are information-based, real-time, and people-centered. Chinese cities should consider adopting the following strategies: build a smart public transport management system that is based on public transport capacity, real-time traffic conditions, and passenger flows; expand the use of public transport IC cards on a larger geographical scale; develop smart personalized systems that can provide public transport information in real-time to inform citizens; and regionally integrate public transport vehicles on a larger scale to maximize the efficiency and utilization of resources.

4. Increase the quality of public transportation services

Whether or not public transportation can become residents' first choice depends on the quality of service provided. Rather than relying solely on expanding the geographic scope and amount of public transport, cities should first improve public transportation network density and site coverage, increase the carrying capacity of mass transit and improve the ease of public bus travel. Secondly, since time is the primary concern when people consider transportation, stability and punctuality should be enhanced to reduce time spent on public transport. Finally, transit systems should be made more convenient and user-friendly by assigning qualified personnel, maintaining clean waiting areas, creating a healthy interior environment and providing full accessibility for citizens.

5. Integrate multiple modes of transport

In many countries, citizens have the option to choose from multiple modes of travel. However, in China, pedestrians and cyclists are rarely considered in the planning of road systems. Providing adequate road spaces and a streamlined organizational relationship for different modes of transport (motor vehicles, public buses, non-motorized vehicles, pedestrians, etc.) should be considered in the planning of city road systems so that all modes operate with efficiency, order, and safety. Modes of transport should be seamlessly connected to enable easy inter-modal transfer and road planning should reflect ideal designs with an emphasis on public transport, cycling, walking and other green transportation methods. Currently, transit interchange sites are a bottleneck for the development of urban public transport, so cities should also focus on building a better bus transfer system. Furthermore, to make public transport more attractive, cities will have to set low fares, construct integrated hubs and provide parking at interchange sites.

Integrating the development of public transport and NMT is also important in attracting more people to take public transportation, especially when it comes to the last leg of a commute. Currently, the lack of support for walking or biking the last leg of a commute is a huge issue in Chinese cities, and has become a hindrance to the development of public transport. Walkability and bikeability around bus stops is sorely lacking, and the bicycle park and ride (B + R) model has yet to be widely promoted. For existing bus stops, the focus should be on constructing more bicycle parking facilities, promoting the integrated management of bicycles and public transport systems and improving sidewalks and pedestrian crossings to ensure public safety and convenience around these sites. For new sites, cities should implement a model standard that integrates public transport and NMT and form guidelines for future development.

6. Encourage green commuting and travel

Adopting policy measures to restrict private car use and encourage green travel is far from enough. Policy measures should be complemented by awareness-building activities to increase public understanding of low-emission cars, emissions standards, demand management policies, and the benefits of green travel. In addition, cities should incorporate feedback from citizens, media studies and psychological principles to improve communication activities and promote participatory activities. Improved public communication will help publicize the concept of green travel and encourage citizens to be actively involved in China's green transition. International organizations should introduce successful public engagement and green transport education programs to Chinese cities.

5.3 Recommendations for Chinese Cities: Urban Energy Use

1. Develop and improve low-carbon urban planning

Starting from existing demonstration projects, various pilot programs encouraged by different central government bodies for low-carbon cities, ecological cities, and livable cities should be evaluated to identify issues and good practices. This information should be used to create a systematic framework based on these scattered experimental attempts. The focus should be shifted from form, design, and quantity; to substance, implementation and quality. Successful practices of pilot cities can be translated into implementable policies and technical guidelines. Research should be conducted on the replication of these practices in more cities and urban areas. Particularly, these practices should be expanded in the urban areas of existing pilot cities to assess and monitor the mechanisms established and continuously push implementation and improvement forward. This will help enhance low-carbon development plans, design better low-carbon development roadmaps and encourage sharing experiences between cities in order to determine the most suitable plan and strategy.

2. Promote widespread green building development

Green buildings should be encouraged at a larger scale, with priority given to the development of green buildings in low-carbon cities and industrial parks. Publicly financed projects such as affordable housing and municipal buildings should also prioritize green building techniques. We need to encourage the expansion of green building demonstration areas, and establish model success stories in different climatic zones. At the same time, we must always strive to improve operation and maintenance of standards, so that a unified consensus can be reached on green building evaluation criteria. The quality of green buildings should be ensured by strengthening supervision throughout the whole construction process, especially during the later stage and into building operation. After passing green design certification, building owners should be encouraged to apply for green operation certification. Energy savings should then be quantitatively measured, so that the growth of green buildings can be converted into the growth of energy savings and emissions reduction. Finally, to implement passive design techniques, we need to integrate universal green building knowledge and technology with conventional architectural designs.

3. Disclose urban energy data statistics

Energy use data already owned by government bodies should be fully disclosed. Lack of access to basic information like energy use data has become one of the major barriers to participation for market players and international stakeholders. To overcome this, full monitoring of urban construction departments is needed and statistics should reflect all relevant information. This should include periodic reports to the community and acceptance of social supervision. The result will not only be improved city energy data analysis, but also increased information for benchmarking results and public inquiries.

4. Invest social capital into energy-saving building renovations

In order to realize the depth of energy efficiency in cities and to reduce urban energy demand, it is necessary to continuously improve energy standards for new buildings, and to encourage large-scale development of green buildings and low-energy buildings; especially when it comes to the transformation and renovation of existing buildings.

China cannot continue to rely on government subsidies to renovate its massive stock of existing buildings as it would require investment in the trillions of RMB. For public buildings, there are no model cases available yet for large-scale energy-saving funding plans. This type of missing information, along with financial difficulties, is the main obstacle for change. In order to mobilize social capital we need to show investors case studies and the energy-saving benefits it can bring. Furthermore, we need explore the establishment of standardized processes to ensure regulation adherence and risk control.

These would include: building a reference to determine energy consumption, energy-savings estimates, design and construction calculations, measurements, verifications, and so on. By establishing uniform rules and developing ancillary security policies, we can boost investor confidence in the market, and gradually guide social forces to participate in large-scale urban renewal of existing buildings and facilities.

5.4 Strengthening Cooperation between Chinese Cities and the International Community

In a globalized world, China's urbanization – historically unprecedented in both size and speed – cannot be addressed by China alone. China's urbanization has spurred the nation's economic growth while revitalizing the global economy. More importantly, China's pursuit of low-carbon, sustainable urbanization will help the rest of the world confront climate change and play a crucial role in allowing humankind to preserve our planet. Consequently, China's urbanization increasingly demands the world's attention. Rather than focusing on how international markets seek to benefit from China's urbanization, we prefer to share our observations and recommendations on how the international community can help China make its urbanization more sustainable.

1. Introduce best practices and share knowledge

China should learn from the urbanization trajectories of industrialized and Latin American nations and the related consequences of urban sprawl, including excessive motorization, air pollution, wasted energy, environmental degradation, urban slums and social inequity. Although these issues are widely understood within expert circles, China has more than 600 prefecture-level and 2,000 small cities, so it is unlikely that the management of every city can effectively identify which international practices are worthy of study or imitation. Furthermore, many local jurisdictions still regard certain ineffective practices as models due to a lack of exposure to international experiences. Sharing international success stories, lessons and best practices – especially with smaller cities -- should be an ongoing process. Cities often applaud international outreach activities and training programs, but at the same time, the following recommendations must also be considered.

2. Adapt international experiences to suit local conditions

As a result of its long history, deep-rooted culture and political systems, China has developed into a nation with many unique characteristics. Hence, before being applied in China, foreign concepts and practices must be integrated with Chinese characteristics to ensure their relevance. Foremost, international concepts must be implemented based on a full understanding of the issues unique to Chinese cities, the constraints of China's existing administrative and policy frameworks, and the central government's short- and medium-term reform and development plans. One must also consider differences in perception and knowledge of such practices as well as gaps in public awareness. Nevertheless, Chinese characteristics should not be deemed an excuse for environmental misconduct in city development, but instead as locally relevant designs based on a true understanding and objective analysis of special situations and issues in China's urbanization. Integrating Chinese characteristics may mean that cities will be selective about their partners and the means of cooperation; it may also mean that a project must be carried out in phases in accordance with China's unique system, and that local culture will play an important role in the project's vitality so that the city and its residents can demonstrate more initiative.

3. Focus more on small- and medium-sized cities

Small and medium-sized cities are home to the largest sector of China's population and comprise the largest share of cities in China. The Chinese government's latest policies aim to strictly control the development of large, metropolitan cities, while focusing on the development of smaller towns as a major area of future migration. These small- and medium-sized cities have a strong desire to grow and elevate their status as part of China's economic miracle. Quite a few small- and medium-sized cities respectively aspire to become regional centers and international cities; in turn, many towns wish to be officially recognized as cities. Although such lofty goals and visions should not be ridiculed, small- and medium-sized cities frequently lack a deep understanding of international practices, direct policy guidance and oversight, and concepts and methods for sustainable urbanization. Moreover, these cities oftentimes fail to implement effective positioning and planning, blindly replicating the practices of large cities without considering local conditions and needs. To help China's rapidly sprawling cities transition toward green and low-carbon urbanization, international cooperation and assistance must focus attention on China's small- and medium-sized cities.

4. Improve the governing capacity of Chinese cities

In the process of pursuing investments, new economic development zones and GDP growth, many Chinese city governments have achieved impressive economic development and gained valuable experience. But when the "new type of urbanization" requires them to shift their focus to people- and quality-centered development, they find themselves at a loss. Highly livable cities require excellent public management and governance, including the capacity to find innovative systems for investment and finance, the ability to obtain public-private cooperation, and effective information disclosure, communication, public engagement and feedback management. In these aspects, Chinese cities can learn from foreign cities' extensive experience, solutions, processes and skills, as well as international organizations' expertise in implementing cooperative projects with local governments, thus helping to build the capacity of local governments.

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Environmental Defense Fund - Beijing Office
C-501, East Building, Yonghe Plaza, 28 Andingmen Street, Beijing 100007
Phone: +86-10-6409-7088
Fax: +86-10-6409-7097

Energy Foundation China - Beijng Office
Room 2403, CITIC Building, No. 19, Jianguomenwai Dajie, Beijing 100004
Phone: +86-10-5821-7100
Fax: +86-10-6525-3764

Institute for Sustainable Communities - Guangzhou Office
Room.1811, R&F Profit Plaza, No.76 West Huangpu Blvd, Guangzhou 510623
Phone: +86-20-3839-1669
Fax: +86-20-3810-3771

Natural Resources Defense Council - Beijing Office
Suite 1706, Taikang Financial Tower, No. 38 Dongsanhuan Bei Road, Beijing 100026
Phone: +86-10-5927-0688
Fax: +86-10-5927-0699

World Resources Institute - Beijing Office
Room K-M, 7/F, Tower A, The East Gate Plaza, No.9 Dongzhong Street, Beijing 100027
Phone: +86-10-6416-5697
Fax: +86-10-6416-7567