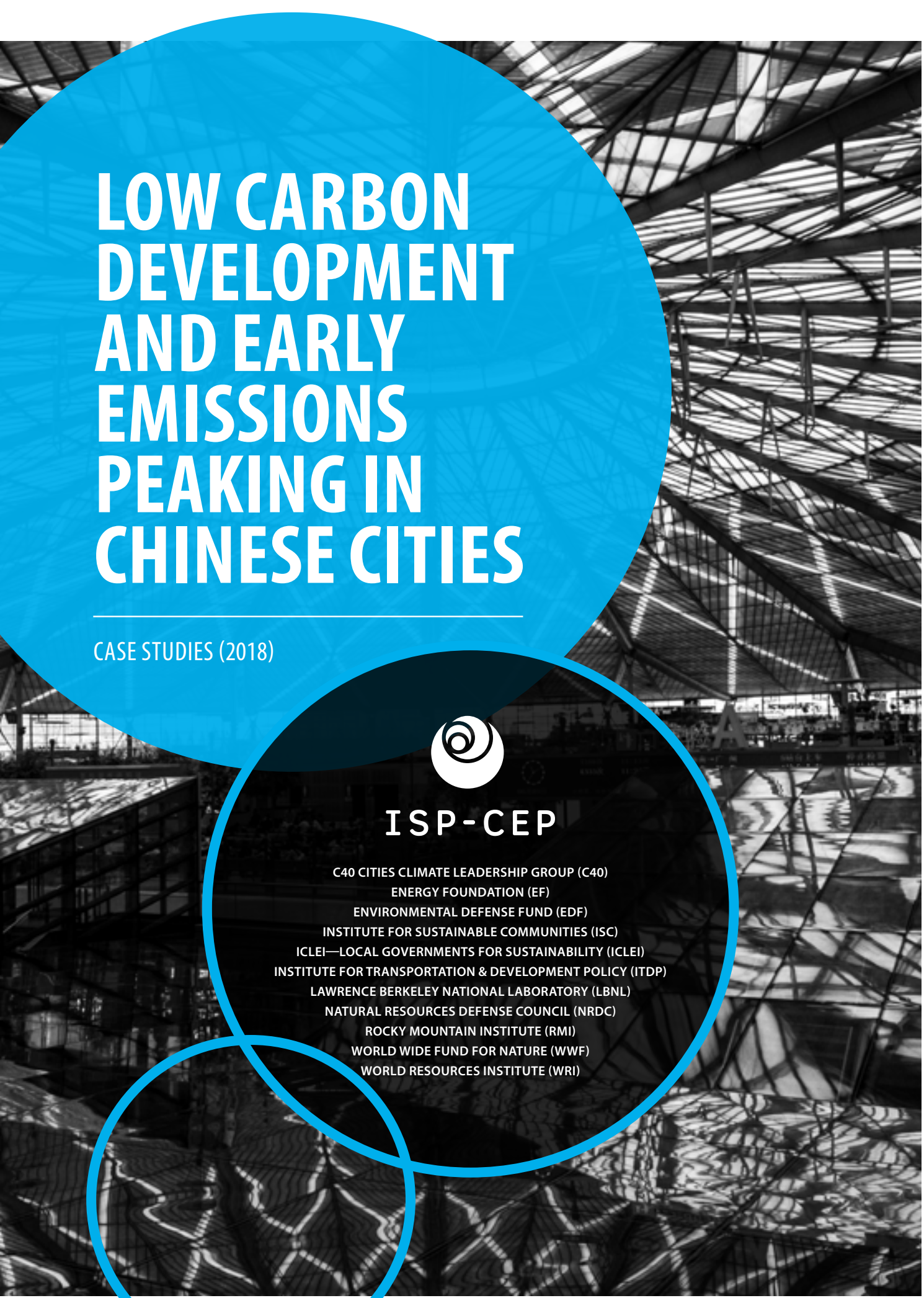
SEPTEMBER 2018

LOW CARBON DEVELOPMENT AND EARLY EMISSIONS PEAKING IN CHINESE CITIES

CASE STUDIES (2018)



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PREFACE

Climate change poses a fundamental risk to the livelihood and future of all humankind. In response to the increasingly hazardous threats of climate change, the Chinese government made a public commitment in 2014 to peak carbon dioxide emissions around 2030—ideally even sooner. Believing in the urgency of action, the government will decrease carbon dioxide emissions per unit of GDP from 60% in 2005 to 65% in 2030. Cities play a critical role in this effort, not only because they are particularly vulnerable to climate change, but also because energy-related carbon dioxide emissions from cities account for more than 70% of global emissions. Several leading cities already took action at the first "U.S.-China Climate-Smart/Low Carbon Cities Summit" in September 2015, where they promised to peak their carbon emissions ahead of the 2030 national goal. Since then, even more cities have joined in this endeavor.

In order to help Chinese cities successfully achieve their carbon emissions peaking goals, several international organizations in China have come together to establish the International Technical Supporting Platform for City Emission Peaking (ISP-CEP). Among its many aims, ISP-CEP intends to share effective cases to encourage peer learning amongst Chinese cities. To that end, this report collates the best low carbon development and emission peaking practices. In selecting the cases, we researched the cities' most recent actions and/or progress and marked a highlight of each. As this is a broader, case studies report—not for technical purposes—our goal is to tell a story, rather than list information, in an effort to be concise, refreshing, and easy to read.

We coordinated several meetings in the first six months to identify potential cases and selected eight on which to conduct further studies. The process involved collecting information from ISP-CEP members and interviewing experts, both of which provided valuable insights into the challenges and obstacles faced by each case study city. Although each city has its own unique characteristics, we have seen a common, serious commitment to combatting climate change. The shared ambitions and innovations of these cities greatly encouraged us with our own research; therefore, it is our greatest hope that we can pass on the voices and rigor of these leading cities to their neighbors in order to inspire more low carbon solutions. Going forward, we plan to both continue collecting data on current carbon peaking cities as well as keep track of emerging players in low carbon peaking efforts.

This report was a collective contribution from members of ISP-CEP and thus belongs to all platform members. We would like to extend our appreciation to all the members of ICP-CEP for their support. Many thanks especially to the Energy Foundation's China Low Carbon City Project Project Manager, Mr. Weiwei Lin for the help in data collection. Our gratitude goes to Dr. Ji Zou and Dr. Zhigao Wang from the Energy Foundation, Dr. Lei Zeng and Dr. Tao Pan from the Institute for Sustainable Communities, Mr. Daizong Liu and Ms. Su Song from the World Resources Institute, Dr. Ke Wang from Renmin University, and Mr. Xing'an Ge from the Shenzhen Emissions Exchange. To our experts, Mr. Zetao Xiang from the Chenggong Kunming District Planning Land Service Center and Mr. Dingxian Xiang from the Wuhan Energy Conservation Supervision Center, thank you for patiently taking the time to discuss your studies with us. The passion and dedication of the aforementioned individuals for urban transformation, as well as their perseverance and resolve is inspiring, for it shows us that the road to low carbon development in each of our cities is full of promise and prospects.

Case Studies Report Writers, September 2018

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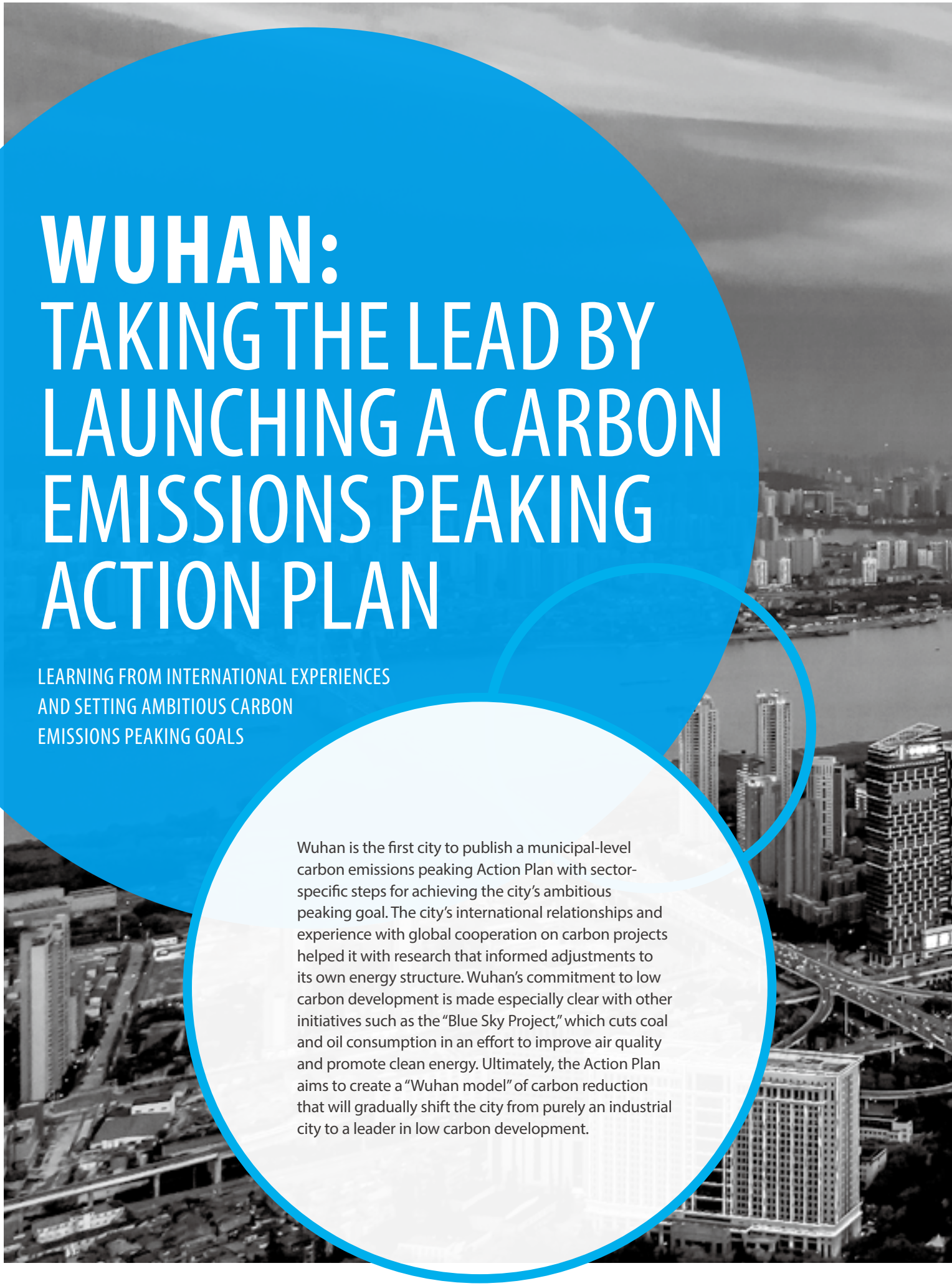


WUHAN: TAKING THE LEAD BY LAUNCHING A CARBON EMISSIONS PEAKING ACTION PLAN

LEARNING FROM INTERNATIONAL EXPERIENCES AND SETTING AMBITIOUS CARBON EMISSIONS PEAKING GOALS

Wuhan is the first city to publish a municipal-level carbon emissions peaking Action Plan with sector-specific steps for achieving the city's ambitious peaking goal. The city's international relationships and experience with global cooperation on carbon projects helped it with research that informed adjustments to its own energy structure. Wuhan's commitment to low carbon development is made especially clear with other initiatives such as the "Blue Sky Project," which cuts coal and oil consumption in an effort to improve air quality and promote clean energy. Ultimately, the Action Plan aims to create a "Wuhan model" of carbon reduction that will gradually shift the city from purely an industrial city to a leader in low carbon development.


dfz.wuhan.gov.cn

Wuhan is an industrial city whose economic development is dominated by iron, steel, petrochemical, and thermal power industries. The annual GDP growth rate during the 12th Five Year Plan period (2011-2015) was 10.4% accompanied by a 6.11% increase in energy consumption. In addition to a rigid demand for energy, the city faces natural constraints on coal, oil, and gas as well as insufficient wind, solar, water, biomass, and other low carbon resources, making it difficult to find alternative clean strategies. These factors, combined with Wuhan's new trillion-fold multiplication plan to double its GDP from one trillion RMB to two trillion RMB by 2021, pose huge challenges in continuing economic development while simultaneously controlling energy consumption and honoring early emissions peaking goals.

Figure 1 Wuhan Carbon Emissions Peak Action Plan (2017-2022)

Image source: Wu Zeng [2017] No. 36, Notice of the Municipal People's Government on Printing the Wuhan Carbon Emissions Peak Action Plan (2017-2022).

Nonetheless, in September 2015 at the first US-China Climate Summit in Los Angeles, California, the city of Wuhan made a public commitment to reach its carbon emissions peak by 2022—eight years before the national goal. A year later, the municipality proved its intentions by dictating these commitments in the "Thirteenth Five-Year Plan for National Economic and Social Development in Wuhan" and in the "Thirteenth Five-Year Development in Wuhan." In December of 2017, the "Wuhan Carbon Emissions Peak Action Plan (2017-2022)*" set forth more specific measures to peak emissions by 2022 (Figure 1). How did Wuhan propose such ambitious emissions peaking goals given the apparent conflict with its economic development plan?

Learning from International Experiences

Through active participation in low carbon cooperation projects and international conferences, the Wuhan Municipal Government realized the importance of sustainable development. This international exposure prompted it to adjust its development ideas in a timely manner. Since 2012, Wuhan has launched a number of international cooperation projects, such as the Wuhan Sino-France Carbon Assessment and the Sino-French Ecological Wuhan Model City. Wuhan has also participated in numerous international meetings such as the "China-U.S. Climate Smart/Low Carbon Cities Summit," "C40 Urban Sustainable Development Forum," "China-EU Low Carbon Cities Conference," and other related platforms. Its international reputation and participation in cooperative, low carbon

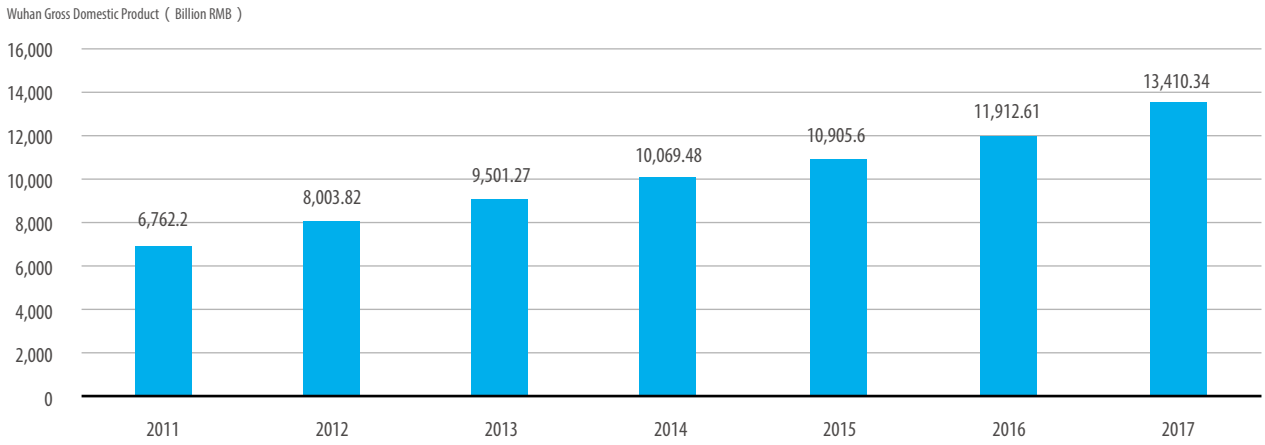


Figure 2 Wuhan GDP from 2011 to 2017

Image Source: http://www.whtj.gov.cn/newslist.aspx?id=201211101045426 2

* The Wuhan Municipal Government issued the "Wuhan Carbon Emissions Peak Action Plan (2017-2022)," which specifies that the city will peak its carbon emissions by 2022, where the amount will be controlled at 1.73 billion tons.

development projects have helped the city win many international awards, such as the "C40 (City Climate Leadership Group) 2015 Urban Award," the "United Nations Development Programme: 2015 China Sustainable Cities Award," and the 2017 C40 "The Future of the City" Award.

International Cooperation in Low Carbon Research

Wuhan's participation in international low carbon cooperation projects enabled it to establish many relationships with various international organizations. When the State Council approved Wuhan as a low carbon pilot city in 2012, Wuhan started preparing greenhouse gas emission inventories in the following year and completed its list of greenhouse gas emissions for the years 2005, 2010, and 2012. From 2013 to 2016, Wuhan selected more than 30 low carbon development-related topics and commissioned various professional organizations and academic institutions to conduct research for its peaking plans.

Using its international and domestic partnerships, Wuhan formed a joint task force with the Energy Foundation and Innovative Green Development Program, Wuhan University, and Huazhong University of Science and Technology during the data collection and investigation phase. Further input from the Lawrence Berkeley Laboratory, Rocky Mountain Institute, Energy Foundation, and Innovative Green Development Program helped Wuhan's Municipal Development and Reform Commission analyze the data.

Wuhan also completed a study of its coal consumption in collaboration with the Natural Resources Defense Council during the 13th Five-Year Plan period. In an effort to push its industrial sectors to meet carbon emissions peaking goals by 2022, Wuhan has been adjusting its energy structure. In the 13th Five-Year Plan, Wuhan put a cap on total coal consumption, intending to decrease coal consumption to less than 41% by 2020.[1] Wuhan also proposed to drop the proportion of coal in total energy consumption from 50.03% in 2015 to 36.58% in 2020 as well as maintain zero-growth in crude oil consumption from 2015 to 2020.[2] Controlling coal and oil consumption would limit the development of traditional, high-energy industries such as steel, petrochemical, thermal power, and building materials, further encouraging industrial transformation in Wuhan.

The "Blue Sky Project"

Wuhan has been engaged in many ongoing local low carbon programs such as the "Blue Sky Project," which was launched in 2013. Requiring an investment of 28 billion RMB, the "Blue Sky Project" aimed aimed to improve air quality. Major milestones of the project included the withdrawal of chemical companies from the Third Ring Road in 2014 and a 65% increase in new energy vehicles in 2014. By 2016, Wuhan eliminated all yellow-standard vehicles* and a year later, installed fume purification equipment across all vehicles. Subsequently, Wuhan formulated an annual implementation plan to increase the city's clean energy supply by controlling its use of polluting fuels and coal.

Under the "Blue Sky Project," Wuhan issued the "Embracing the Blue Sky Plan 2017," setting a goal of cutting 1 million tons of coal equivalent from 2016 to 2017. Wuhan expanded the bounds of an area that prohibits material-burning facilities, including coal-fired boilers and oil shale, crude oil, heavy oil, residual oil, coal tar, and petroleum coal burning facilities (Figure 3). This plan also gave various deadlines to coal and oil facilities to switch to clean energy.

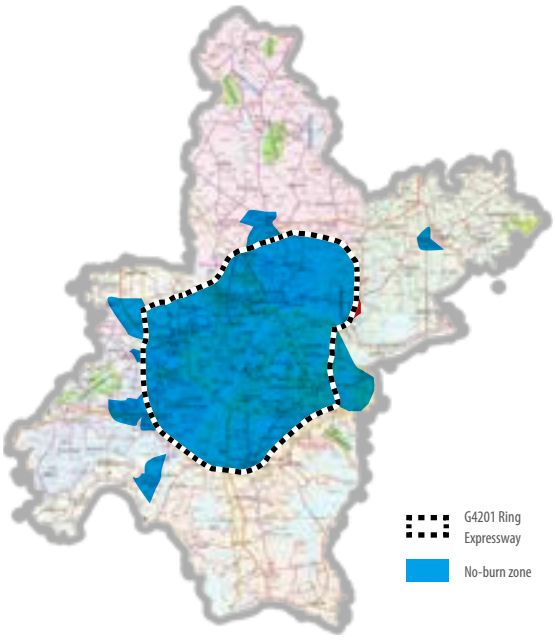
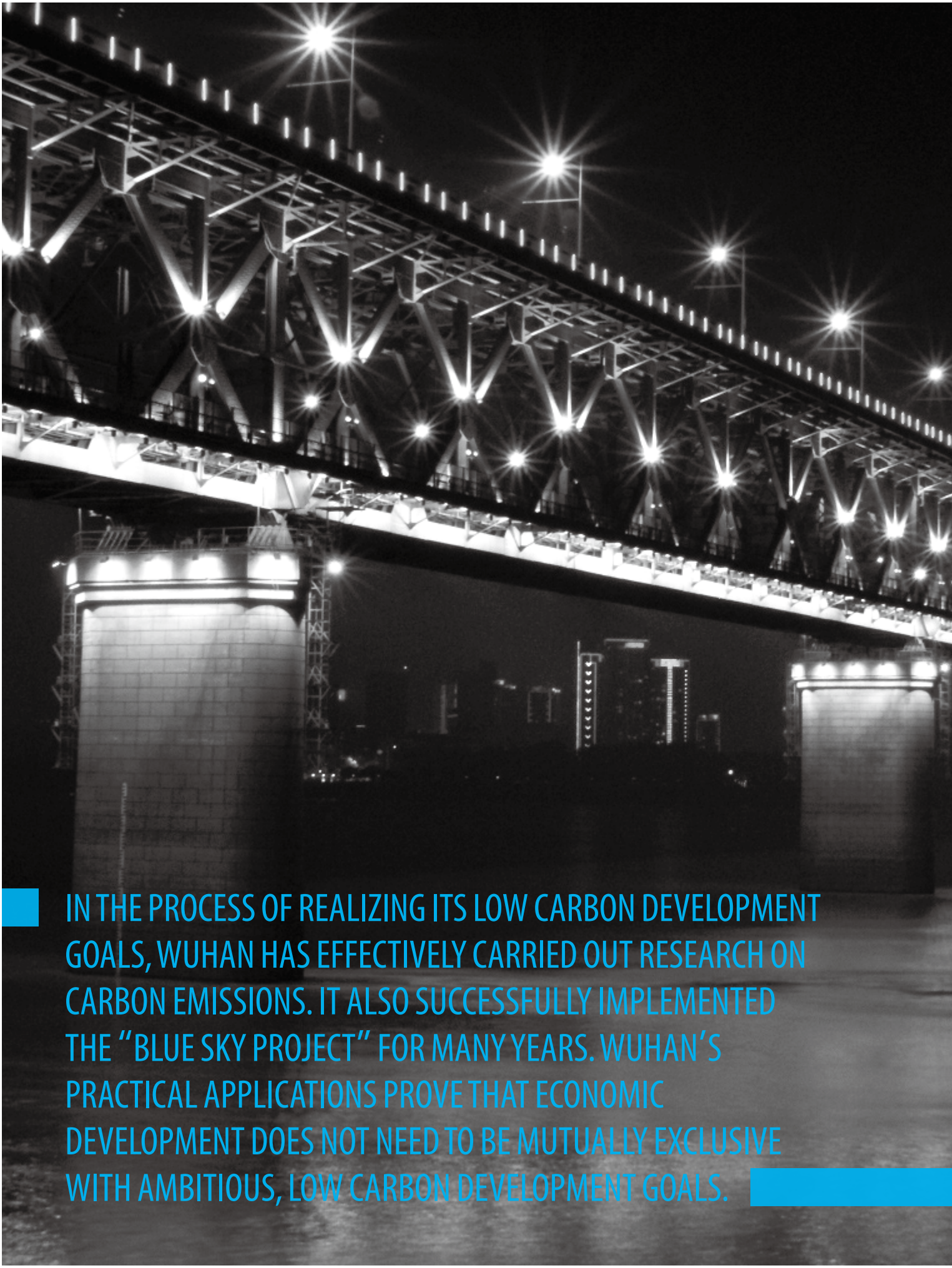


Figure 3 | Map of area that prohibits material-burning facilities

Image Source: http://www.ctdsb.net/html/2017/1030/hubei118093.html

* Classification of cars with relatively high polluted emissions



IN THE PROCESS OF REALIZING ITS LOW CARBON DEVELOPMENT GOALS, WUHAN HAS EFFECTIVELY CARRIED OUT RESEARCH ON CARBON EMISSIONS. IT ALSO SUCCESSFULLY IMPLEMENTED THE "BLUE SKY PROJECT" FOR MANY YEARS. WUHAN'S PRACTICAL APPLICATIONS PROVE THAT ECONOMIC DEVELOPMENT DOES NOT NEED TO BE MUTUALLY EXCLUSIVE WITH AMBITIOUS, LOW CARBON DEVELOPMENT GOALS.

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Wuhan's Action-Specific Carbon Emissions Peaking Plan

While many Chinese cities have proposed a goal of achieving carbon emission peaks, Wuhan is the first city to both complete its research and publish an official action plan: the "Wuhan Carbon Emissions Peaking Action Plan (2017-2022)" (hereinafter referred to as the Action Plan). This document proposes a long-term goal that limits Wuhan's total energy consumption to 19.5 million tons of coal equivalent by 2022 and sets 16 million tons as its more ambitious target. In addition to clarifying a goal, the Action Plan also identifies technical steps for different sub-sectors in the 14 districts: industrial (non-energy), construction, transportation, energy, and household. By making low carbon the primary feature in development projects across all sectors and regions in the city, the Action Plan is helping the city develop a "Wuhan model" of carbon reduction.

The five key mechanisms to ensure the sustainability of the Action Plan are as follows. First, it proposes high standards for project permitting, requiring a strict "energy and carbon assessment" to control the number of high pollution and/or high energy consumption projects. Second, it promotes low carbon marketization. Third, the Action Plan aims to develop a green finance system. Fourth, it encourages the implementation of relevant fiscal policies and tax incentives that support low carbon projects from capacity-building to construction. For example, the Action Plan requires municipal and district governments to increase capital investment, integrate existing low carbon related financial funds, and provide incentives and discounted loans to low carbon projects. Lastly, the Action Plan also stipulates multiple monitoring policies for longer-term carbon control efforts.

The Action Plan defines its target by breaking down goals per sub-region. It plans to conduct project completion assessments every two years, and these results will then be used in evaluations for relevant government officials' performances. To further collaborative efforts, the Action Plan emphasizes strong ties with international organizations by deepening Sino-U.S. and Central European climate cooperation mechanisms as well as by using the C40 urban climate leader platform.

CHANGSHA: LEVERAGING DATA AND ECONOMICS TO DEVELOP A CARBON PEAKING ROADMAP

EXPERT KNOWLEDGE AND DATA SCIENCE HELP DRAW PLANS FOR A LOW CARBON FUTURE

As the "Big Brother" in the Hunan Province, the capital city Changsha pioneers efforts in low carbon development by collaborating with international organizations and local experts. This cooperation eventually resulted in a practical roadmap with specific action points. The project team of local and international experts overcame problems of low-quality data and a lack of basic carbon emissions data. By conducting the original "carbon economic value" analysis, the project team helped Changsha understand its low carbon development investment costs and payback period, as well as the efficiency of major investments in carbon emissions reductions.

cs.loupan.com/photo/6192536/tu4-2076158.html

In July 2010, after the National Development and Reform Commission (NDRC) issued the "Notice on Conducting Pilot Projects for Low Carbon Provinces and Low Carbon Cities," most municipalities responded positively by making carbon emissions a key development indicator. As one of the major central provinces, Hunan had the determination to implement low carbon development and issued the "Five Year Action Plan for the Implementation of the Low Carbon Development in Hunan Province (2016-2020)," but this was only comprised of general objectives and deadlines.

The Institute for Sustainable Communities (ISC) proposed to partner with the Hunan Provincial Development and Reform Commission to introduce domestic and foreign technical experts who would help Changsha, Zhuzhou, and Xiangtan with carbon emissions peaking research. In June 2016, these two organizations signed a memorandum of understanding. Under this agreement, the Shanghai Institute for Sustainable Global Research (ISEE) and Hunan Innovative Low Carbon Center (HILCC) were brought in to offer external advice and assist with local coordination and technical support. The project team first began by researching and creating a carbon emissions peaking roadmap with Changsha, which maintains the best data of the three cities. The research of carbon emissions peaking and low carbon development would be drawn from Changsha's experiences and further extended to Zhuzhou, Xiangtan, and more cities in Hunan.

The Changsha carbon emissions peaking roadmap involved the help of domestic experts for technical support as well as of local agencies and stakeholders to ensure that the work was efficient and feasible. In Changsha, where the low carbon development practices were still relatively new, how did this team overcome existing difficulties in the most time-efficient way to create effective, Changsha-specific solutions?

Overcoming Problems of Working with Simple Data

A systematic, scientific process guided the making of the Changsha carbon peaking roadmap, which consists of the seven steps listed in Figure 4. The first of these steps was to create a carbon inventory; however, ISEE's Dr. Tao Pan and his team immediately ran into problems of a lack of reliable data sources and poor data quality. Changsha didn't have a complete, publicly available energy balance sheet, and some of the data required for energy consumption was missing. The project team split up, going to different sectors (transportation, education, power, etc.) to collect data. Moreover, data quality presented a challenge, as 50% of the data collected failed to match data from the Bureau of Statistics. After consulting with these sectors and conducting a rough analysis of the data, the team determined a protocol for data processing. If the data they collected had clear sources, the team would use the data directly. For data with unclear sources, they would first look at historical data and then calculate and adjust it according to the city's overall economic development trends.

In addition to these measures, the project team cross-validated the top-down and bottom-up results from different sectors. For example, the project team calculated traffic energy data of personal use cars based on the annual average mileage data of privately-owned cars from the Changsha Statistical Yearbook. The comparison of the calculated data to the data included in the Changsha Energy Balance Sheet showed that there was less than a 5% difference in the two sums. Once the team adjusted some of the parameters in their analysis, the data finally matched. While the traffic emissions data quality of personal use cars was considered reliably sourced, 50% of the operational traffic emissions data on buses, taxis, subways, and freight vehicles from

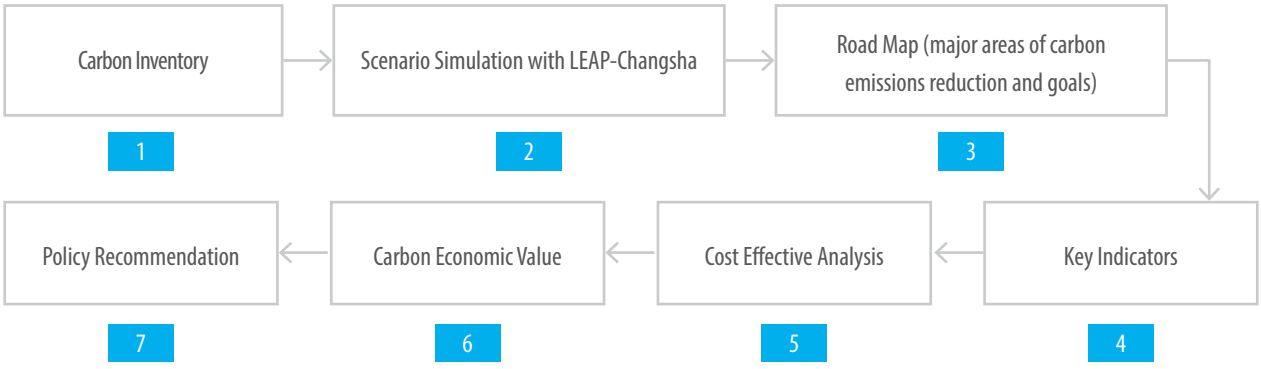


Figure 4 Peak road map and peak analysis path steps

Image Source: Study of greenhouse gas emissions peaking in Changsha

the Department of Public Transportation came from unidentified sources. This may be due to the absence of some large, non-corporate cargo statistics; therefore, more empirical research must be done to improve the data quality.

After overcoming initial problems of data sources and date quality, the project team utilized these results to input into LEAP-Changsha (a carbon emissions analysis model) based on the GREAT* model. According to local policies and government reports such as the "13th Five-Year Plan for National Economic and Social Development," the "City Master Plan for Changsha (2003-2020) (Revised in 2014)," and the "Low Carbon City Implementation Plan," the model simulated the following scenarios (Figure 5):

- Baseline scenario (possible outcomes under existing policies)
- Energy-saving scenario (above the baseline scenario, emphasizes energy efficiency improvement for each sector)
- Emissions reduction scenario (based on energy-saving scenario but with added emphasis on public transportation- and clean energy-use)
- Peak scenario (based on the emissions reduction scenario but also increasing the proportion of clean/new energy vehicles and industrial restructuring while simultaneously maintaining appropriate economic growth)
- Low carbon scenario (the most optimal scenario)

Under the baseline scenario, Changsha's carbon emissions would not reach its peak before 2030. Under peak scenarios, the amount of carbon emissions in 2025 would be 72.54 million tons, which is 30% lower than the baseline scenario. The project team then created a number of sub-scenarios based on different carbon reduction measures. Using a combination of different subscenarios, the team simulated and calculated the potential emissions reduction of each carbon reduction measure. These assessments identified seven major areas of carbon emissions reduction: energy structure optimization, energy efficiency improvement, industrial structure adjustment, moderate economic growth, low carbon transportation, waste resource utilization, green carbon sinks, and climate change adaptation.

After considering the synergies between Changsha's economic development goals, its concept of a livable

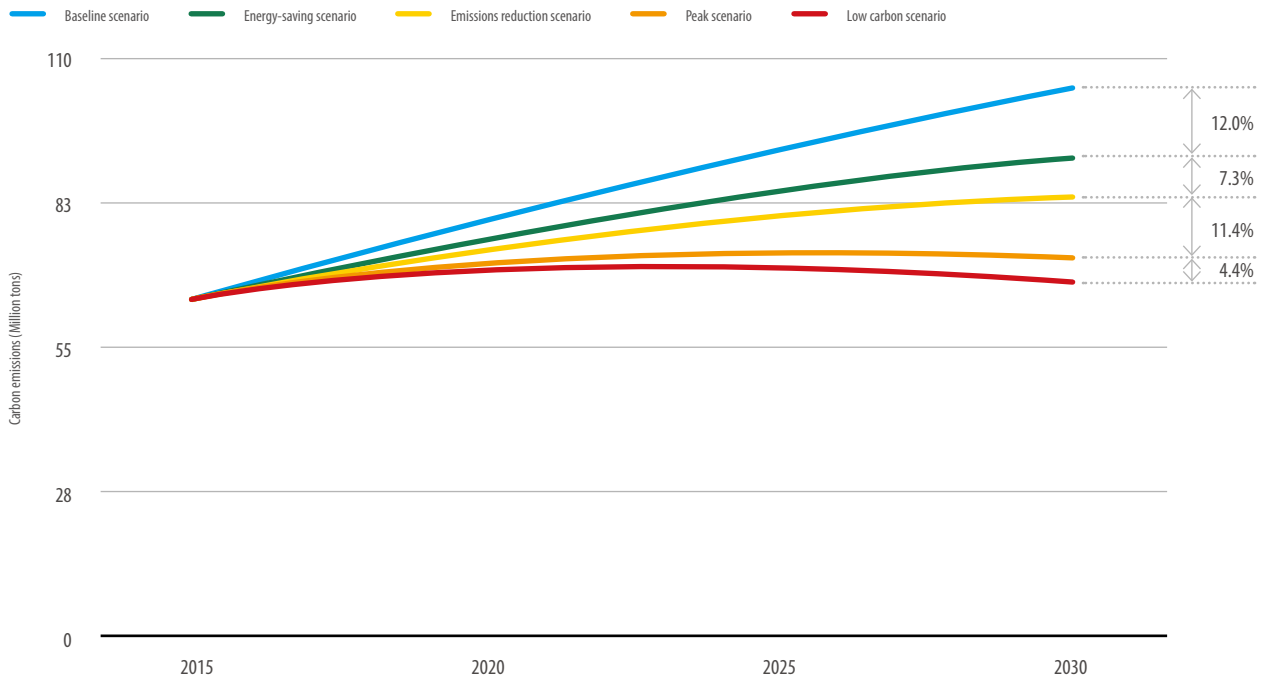
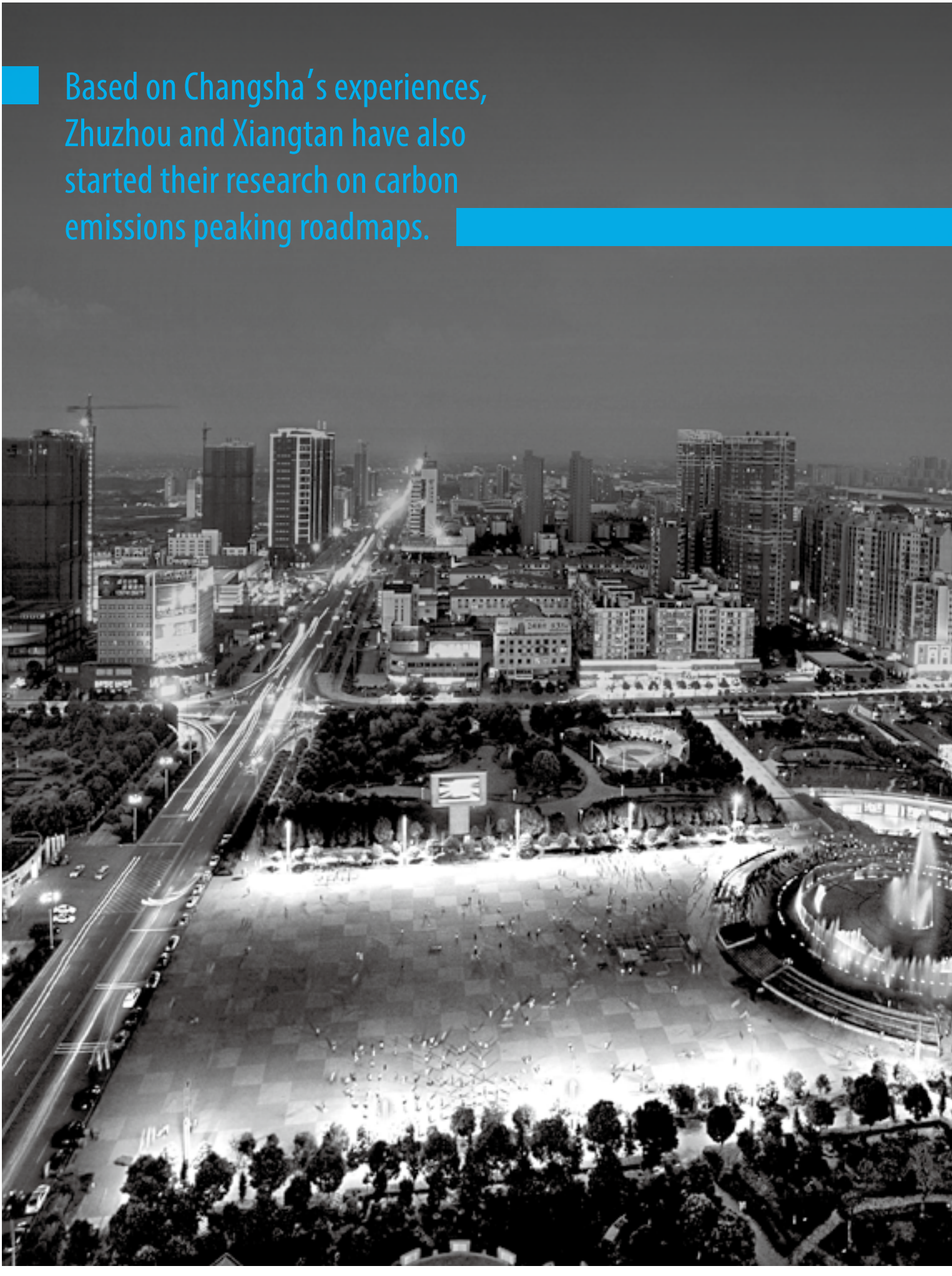


Figure 5 Scenario analysis of carbon emissions in Changsha

Image Source: Study of greenhouse gas emissions peaking in Changsha

* The Green Resources and Energy Analysis Tool (GREAT) is an integrated, bottom-up, and energy end-use based modeling and accounting tool to help local governments identify potential energy and emission reduction opportunities. It tracks energy consumption, production, and resource extraction in all economic sectors on city, provincial, and regional levels by using the Long-range Energy Alternatives Planning System (LEAP) software developed by the Stockholm Environmental Institute. LEAP includes a national average dataset of energy input parameters for residential, commercial, transport, industry, and agriculture end-use sectors and is aimed at integrating resource planning and GHG mitigation assessments.

Based on Changsha's experiences, Zhuzhou and Xiangtan have also started their research on carbon emissions peaking roadmaps.



city, and its air pollution control target, the project team engaged relevant sectors and stakeholders to formulate 19 actions items and 23 key indicators to specify goals of the seven major carbon peaking action areas as well as their corresponding measurements. The 23 indicators were designed to help policymakers quantitatively evaluate the progress of the policies and adjust accordingly.

Financing Carbon Emissions Peaking

While scientific and technical knowledge is necessary to ensure that carbon emissions goals are achieved, there also needs to be an understanding of the economic implications of carbon peaking. For many Chinese cities, its carbon emissions are correlated to its current economic development model. Under this assumption, a common understanding is that carbon emissions peaking would harm economic growth; the best case scenario for Changsha is to decouple carbon emissions from economic growth as soon as possible in order to steer development in a more strategic and sustainable way. With its carbon emissions peaking goal set in 2025, Changsha has 8 years to make this optimal scenario a reality.

Since there would be a medium- to long-term return on investment, the government needs to understand necessary investment costs before deploying large-scale, low carbon projects. The project team thus set out to understand how much of the investment should come from the government, and what the guarantees of economic returns in the medium- and long- term would be.

The results show that by 2025, the cumulative investment will reach 326.17 billion RMB. The savings and direct economic benefits from reaching the peak will be 22 billion RMB each year, which is about 10% of the city's fiscal revenue. The overall investment payback period is close to 15 years. Therefore, the project team advised Changsha to put aside a capital of 1 billion RMB each year to support continuing research, planning, policy-formulation, and implementation of low carbon city development projects involving concepts such as the circular economy, eco-cities, sponge cities, transit-oriented development, and new energy resources. According to the results, Changsha should also plan and guide funds between 30 and 50 billion RMB each year toward low carbon-related projects.

More specifically, based on the "Guidelines for the Issuance of Green Bonds" issued by the NDRC, the Changsha Circular Economy Project Table, the Ecological Construction Planning Project Table, and the Sponge City Project Table, the project team selected and ranked the carbon economic values* of 50 projects that met the green financing requirements. This analysis and ranking would help relevant departments adopt carbon reduction projects while staying within budget.

Most recently, the Changsha Low Carbon Pilot Task Force has issued the "2018 Action Plan for Low Carbon City Construction in Changsha" to ensure the implementation of low carbon projects. The project team recommends that in the next phase, an in-depth research of the carbon emissions peaking roadmap in key industries such as construction and transportation should be conducted. At the same time, Zhuzhou and Xiangtan have also started their research on formulating their own carbon emissions peaking roadmaps.

* The carbon economic value of the project refers to the proportion of the carbon emissions reduction of the project to the total reduction of emissions divided by the proportion of investment in the project to total investments. When the carbon economic value is greater than 1, it shows that the projects, compared with other projects, would take less money to achieve the same or a better emissions reduction goal, and vice versa. The higher the value is, the more emissions reductions can be achieved with a lower cost.

SHENZHEN: OPENING A ROBUST CARBON TRADING MARKET

ESTABLISHING ITSELF AS ONE OF THE MOST SUCCESSFUL CARBON TRADING PLATFORMS IN CHINA THROUGH INNOVATIVE POLICY APPROACHES

Shenzhen's carbon trading volume is small because its industrial structures are already relatively clean, which makes its basic carbon trading conditions comparatively weaker than those of other pilot cities. Yet, Shenzhen's carbon trading model has become a success for a variety of reasons. Its strict carbon trading laws and regulations, open and transparent carbon trading management, and expanded carbon market participation and innovation create an economically competitive carbon market, making Shenzhen a model emissions trading scheme in China.

In 2011, the National Development and Reform Commission chose the city of Shenzhen to become one of seven pilot emissions trading schemes (ETSs). After two years of preparation, Shenzhen launched the first ETS in China. Since 2015, the Shenzhen Emissions Exchange has provided emissions carbon market establishment and carbon trading consulting services to more than ten provinces and cities nationwide. As of November 30, 2017, Shenzhen's total carbon trading volume has reached 2,602,900 tons with a total transaction volume of 799 million RMB, ranking third and second, respectively, in the national rankings. The market price has remained at 25-35 RMB per ton, placing Shenzhen at the forefront of the country in carbon trading.[3] Figure 6 depicts the Shenzhen carbon trading development process.

Despite its high performance, Shenzhen may be at a disadvantage in its carbon emissions trading capacity compared to other pilot markets because of its relatively "clean" industry. Shenzhen only has eight power plants—of these, only one is coal-fired. Moreover, this plant still maintains high emissions efficiency compared to other coal-fired power plants. With a smaller carbon emissions trading capacity, how did Shenzhen's ETS achieve such success?

Strict Regulations and Enforcement

Shenzhen took the lead in forming a relatively comprehensive legal system for carbon trading in China. The local People's Congress of Shenzhen promoted the "Provisions of Carbon Emissions Management of the Special Economic Zone of Shenzhen" before starting the actual operations of Shenzhen ETS. In this regard, Shenzhen differed from other pilot ETSs that generally conducted operations first before instituting policy. The bill was also the first domestic legal document that instated carbon trading in China and has since been lauded as a leader within climate change legislation; it further resulted in the creation of "Shenzhen Provisional Regulations on Pilot Emissions Trading."

As the most detailed carbon trading management measure in China, this policy has 86 articles with detailed and strict penalties, such as monetary fines three times the average market price of allowances, suspension of concessions, and even "blacklists" for violations. Stringent rules and severe penalties for non-compliance and fraud help the Shenzhen ETS maintain high corporate carbon trading compliance rates. In the first three performance periods, the compliance rates reached 99.4%, 99.7%, and 99.8% respectively, marking Shenzhen's ETS as the one with the highest compliance rates in the country.

Impartial treatment of corporate violations in carbon trading is important for effective market management. For this reason, Shenzhen set up the Carbon Trading Office in the Municipal Development and Reform Commission. It is the first such office in the development and reform department and specializes in hiring legal consultants to deal with cases of non-compliance. The office works by calling, notifying, and working with the media to involve public opinion in punishing non-compliance enterprises

Expanding Participation and Encouraging Multiplayer Investment

Due to a series of policies encouraging participation, Shenzhen's ETS has more than 800 compliance companies, while most other ETSs have around 200. This sum makes Shenzhen the second largest of all pilot ETSs, second only to Beijing. The need for ETS expansion stemmed from the low

2011	Chosen as one of the 7 pilots to establish ETS
2012	The "Provisions of Carbon Emissions Management of the Special Economic Zone of Shenzhen"
2013	Launch of Shenzhen ETS
2014	Foreign investments allowed in the market
	The "Shenzhen Provisional Regulations on Pilot Emissions Trading"
2015	Regional cooperation
2017	Launch of the national ETS

Figure 6 | History of Shenzhen ETS

number of industrial and already relatively clean enterprises in Shenzhen, which supplied the ETS with a smaller total tradable amount of carbon emissions. Shenzhen's ETS lowered its carbon emission threshold to allow more companies and large buildings to enter the market. Today, the Shenzhen ETS includes 636 key industrial enterprises and 197 large public buildings whose carbon emissions amount to a threshold of 3,000 tons per year. This number is considerably lower than the carbon emissions thresholds of most other pilot markets, which range from 10,000 to 20,000 tons. Hubei's ETS threshold is even as high as 60,000 tons. In addition, the Shenzhen ETS was originally only open to individual and institutional investors. In order to expand and encourage multiplayer investment, Shenzhen's ETS became the first carbon market in China to open up to both individuals and foreign investors.

Open and Transparent Carbon Market Management

The Shenzhen ETS values openness and transparency. The Shenzhen Municipal Development and Reform Commission requires that each new business formally establish corresponding management systems, rules, and statutory documents before entering the market. Through a clear market-government separation as well as through a long document-making process soliciting various opinions, regulations on Shenzhen's ETS have maintained the same degree of maximum transparency since day one.

For example, the "Guidelines for Quantifying and Reporting of Greenhouse Gases" and the "Guidelines for Quantifying and Reporting of Greenhouse Gas Verification of the Organization" were issued before the launch of the Shenzhen ETS. The verification of carbon emissions data reflects Shenzhen's commitment to transparency. Under these standards, compliance companies are required to quantify and report their annual carbon dioxide emissions and then submit their analysis of greenhouse gas emissions to their supervising authorities. This analysis is then verified by independent, third-party verification agencies. In order to further promote transparency, the selection of third-party verification agencies has since shifted from the government to the companies themselves. The funding for the verification process has also changed from public to private, further separating market and government interests. This is an important step toward full marketization of carbon emission trading.

Shenzhen ETS also insists on timely, complete, and continuous disclosure of carbon trading information. It is the only one in the seven pilot ETSs to retain and present all historical transaction data from the launch of the carbon market. Alongside transparency, Shenzhen makes a great effort to avoid price fluctuations. It does not make any changes to market price and distribution rules, which helps sustain a predictable and stable market.

Financing the Carbon Market

The vitality of the carbon market has been noticeably related to the degree of participation from the financial industry. In Shenzhen, multi-party forces—including the Shenzhen Financial Office, the Municipal People's Bank and the State Administration of Foreign Exchange, the Authority of Qianhai and other major financial institutions—have come together to try to integrate the carbon trading market and the financial market.

Shenzhen, a city known for its innovative nature, also applies creative ideas in carbon trading. In 2014, Shenzhen began exploring innovation in carbon finance and has been at the helm of many domestic firsts in the carbon finance market. It was the first to open the carbon market to foreign investors, the first to successfully issue domestic carbon bonds, and the first to support the launch of a carbon fund in China. It also created a carbon credit pledge, quota-related structured deposits, and other products and research. These innovative attempts have provided a basis for the introduction of carbon finance policies, and in January 2018, the People's Bank of China issued the "Notice on Further Improving the Cross-Border Business Policy of RMB to Promote Trade and Investment Facilitation" based on the experiences of foreign investors participating in the carbon market in Shenzhen.

The National Development and Reform Commission officially launched the national carbon market on December 19, 2017, six years after Shenzhen was chosen to be one of the seven pilot ETS. In the past six years, Shenzhen has not only built its own open and innovative carbon market but has also actively expanded regional collaboration. Now, it has changed its focus from the introduction of the national carbon market to establishing a "carbon market capacity building center" in Shenzhen. By bringing in strict carbon market legislation, monitoring, reporting, and verification (MRV) methods, quota allocation, and more, Shenzhen's carbon trading market is now a model to many other domestic attempts.

CHENGDU: SHOWCASING LOW CARBON TRANSPORTATION IN WESTERN CHINA

INTRODUCING SMART TRANSPORTATION MANAGEMENT AND PROMOTING LOW CARBON ALTERNATIVES

Despite ranking second among Chinese cities in private vehicle ownership, Chengdu has made significant progress in developing public transportation infrastructure and mitigating traffic congestion. The city has become a leader in green and low carbon transportation among its peer cities in China's western regions. In recent years, through international cooperation and innovative traffic demand management strategies, Chengdu has strengthened its technical expertise and its public transportation system. It has also promoted bike sharing, electric vehicles, and other solutions to pollution and traffic issues.

blogg.flygstolen.se/blog/2017/02/15/hit-ska-du-resa-april

Chengdu is one of the third round Chinese low carbon pilot cities. In March 2017, the city released the "Low Carbon Pilot City Action Plan," officially announcing its goal of peaking carbon emissions by 2025. This case focuses on the city's continuous effort and progress in the transportation sector.

Chengdu's motor vehicle fleet is the second largest in China. Since 2012, the number of passenger vehicles has increased by a compound annual rate of 17%—averaging out to roughly 430,000 new vehicles each year. At the end of 2012, Chengdu was home to more than 2 million vehicles. By December 2017, that figure had increased to more than 4.52 million—far more than in cities such as Chongqing, Shanghai, or Shenzhen. Chengdu has also rapidly grown into a hub for China's automobile production. As recently as 2003, no vehicles were produced in the city. However, by 2010, Chengdu was producing 94,000 vehicles a year; by 2015, just twelve years after its automobile industry first took off, Chengdu was producing over one million. By the end of 2016, annual production reached 1,154,000 units. Chengdu's expanding automobile manufacturing industry, growing vehicle fleet, and increasing car ownership present harsh challenges to the city's early emission-peaking goals.

More vehicles on the road have also led to more severe traffic; in 2015, a popular navigation company ranked Chengdu in the top ten cities with worst traffic in China, prompting netizens to dub Chengdu "the city of congestion" in a play on the city's Chinese name. However, even amidst increasing vehicle ownership, the city's traffic situation has since improved. Since 2016, and contrary to its high levels of vehicle ownership, Chengdu has not recently been in the rankings of even the top 20 worst traffic cities in China. What policies have allowed the city to mitigate traffic and cut emissions?

Traffic Demand Management

Chengdu was the first of China's western cities to implement traffic demand management (TDM). TDM is a relatively new concept in China. It refers to strategies and policies that are adopted to reduce travel demand or reallocate this traffic demand in space or in time to avoid congestion. This strategy is meant to affect the behavior of travelers, especially targeting private car users. Even though Chengdu did not cap automobile ownership in the city, it developed other effective measures to address traffic.

One of Chengdu's strategies to combat traffic and encourage commuters to use public transportation is its prioritization of bus traffic. (See Figure 7) In as early as 2008, Chengdu began setting up bus lanes. Today, the city has about 85 bus lanes total, which amounts to more than 748 kilometers.[4] Chengdu has by far the most bus lanes of China's western cities and nearly as much as Beijing, which had 851 kilometers at the end of 2017.[5]

Figure 7 | Designated bus lane in Chengdu

Image Source: http://www.sohu.com/a/125718308_470707

In September 2016, the Chengdu municipal government also issued the "Opinions on Promoting Development of Systematic Public Transportation." The document affirmed that priority should be given to public transport and advocated for dedicated bus lanes on roads with six or more lanes, accelerated construction of a bus lane network, and improved management of dedicated bus lanes to enhance the reliability and timeliness of public bus transport.

Chengdu was also an early mover in promoting bus rapid transit (BRT). In 2013, the city became the first in China to combine BRT with elevated expressways. The city is in the process of establishing more BRT corridors (see Figure 8). Today, the system provides 300,000 rides per day. In addition, Chengdu is setting up express bus lanes. These lanes, which operate only during rush hour, limit stops along their normal routes to improve transit times for workers with long commutes.

At the same time, Chengdu has sought to discourage private vehicle use. Since October 2012, Chengdu has limited private vehicle use based on plate numbers on second- and third-ring roads during the workweek. In January of 2018, these limits were expanded to expressways around the city.

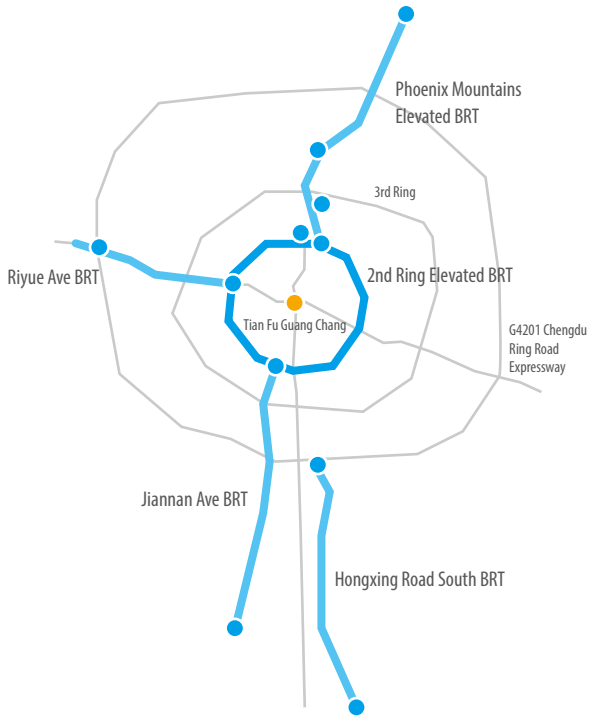


Figure 8 | Chengdu BRT corridor planning map

Netease News, http://news.163.com/15/1117/05/B8JNV9L100014AED.html

Chengdu also stands out for its effective distribution of bus stops. The "2017 Big Data Analysis of Public Transportation in Cities," a report published by Gaode Maps and Transportation Research Institute, noted that 86% of Chengdu has at least one bus stop within 500 meters, a coverage rate exceeded only by the likes of Shenzhen and Shanghai.[6] Chengdu also boasted a low bus line redundancy rate and a geographically balanced distribution of bus lines. Compared to other provincial capitals such as Shenyang, Nanjing, Wuhan, and Harbin, Chengdu's public transportation infrastructure ranks first. As one of the 13th Five Year Plan's 50 bus-centric transportation pilot cities, Chengdu is determined to continue developing its public transport system. By 2020, the city aims to shift 65% of transit to public systems, far above the 45% mandated target and up from 48% in the city's center today.[7]

International Cooperation in Traffic Research and Governance

In 2012, Chengdu won a 3 million USD grant from the Global Environmental Facility's (GEF) Large-City Congestion and Carbon Reduction Project. This was matched by a commitment of 23 million USD of dedicated funding from the Chengdu municipal government. Together, these funds were put to work improving public transportation projects and finding new, innovative solutions through transportation demand management. New initiatives include pilot traffic control systems at intersections and interchanges, improvements in traffic channeling* as well as bus stops, and expanded public transportation research. The program has also supported systems capable of real-time collection and sharing of traffic information, new parking and differential pricing systems, and research into further reducing traffic-related vehicle emissions.

Beginning in 2012, with the support of the World Resources Institute (WRI), Chengdu launched a five-year "Sustainable and Livable City" project to research pathways to sustainable development and urbanization. Under the guidance of the Climate Change Division of the National Development and Reform Commission (China's top governmental think tank) and collaboration with experts from the National Center for Climate Change Strategy Research and International Cooperation, the National Development and Reform Commission Energy Research Institute, Renmin University of China, and other scientific research institutions, the project completed more than 20 reports and tools. The "Smart Strategies for Private Vehicle Ownership and Usage in Chengdu" research provided important technical support for the low carbon development of Chengdu's transportation sector. In particular, the research aims to help ease urban traffic congestion and alleviate a rapidly growing private car market by proposing policy solutions for parking management and traffic restrictions.

Promoting and Standardizing Bike Sharing

The development of the bicycle sharing economy has greatly facilitated the ease of urban travel, especially in solving the "last mile" problem. However, the rapid delivery and implementation of shared bicycles has also created many new problems, such as vandalism and random parking. Since bike sharing first appeared in Chengdu, the city has sought to both promote the industry and regulate its harmful byproducts. Chengdu was the first city in China to issue official guidance encouraging bike sharing. In March 2017, the city released the "Trial Opinions on Encouraging the Development of Shared Bicycles in Chengdu." This was followed by the "Work Plan for Further Strengthening the Management of Shared

* Traffic channeling refers to designs that separate and divert vehicles and pedestrians according to the flow of the intersection in order to improve traffic efficiency in these locations. This type of design also ensures the safety of pedestrians and non-motor vehicles, and reduces the hidden dangers of traffic accidents.

Car ownership continues to rise, but with continued innovation in traffic demand management, Chengdu is making strides in green development and low carbon transportation.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Bicycle Management" in April 2017. Together, these policies regulated bike sharing operations, managed bike parking, and addressed other issues that emerged with the rapid proliferation of shared bikes. The city subsequently introduced the "Chengdu Shared Bicycle Operation Management Service Specifications (Trial)" and "Chengdu Shared Bicycle Service Quality Credit Assessment Methods (Trial)" to regulate the service quality and accountability of shared bikes in the city.

According to data from bike sharing companies, Chengdu ranks among the country's leading adopters of shared biking. Ofo, a leading bike share company, reported that Chengdu residents were the most prolific users of its bikes in two quarters of 2017. The city has also won accolades from shared bike companies for providing one of the best policy environments in China. In May 2018, Mobike, another prominent bike share firm, ranked Chengdu first in its index of bike share cities in China.[8] The WRI estimated that Mobike use in the city had displaced 68,474 tons of cumulative CO_2 emissions through January 2018, a total trailing only Beijing and Guangzhou.[9]

Promoting New Energy Vehicles (NEVs)

Although new energy vehicles will not alleviate traffic congestion, they can play a major role in improving the city's air quality. Among other western cities, Chengdu is leading the promotion of new energy vehicles. At the end of 2017, the city was home to 35,000 NEVs, including buses, government vehicles, and industrial vehicles in addition to passenger cars. In 2017 alone, Chengdu added 16,000 electric vehicles, overshooting a target for 10,000. The city hopes to field more than 80,000 electric vehicles by 2020.

To bring about cleaner skies, Chengdu has actively promoted NEV ownership. In July 2017, the city issued the "City's Pledge to Support New Energy Vehicles," which, according to Chengdu, will subsidize an additional 50% on top of existing central financial subsidies for NEVs registered at the local department of motor vehicles. Chengdu waives restrictions based on plate number for electric vehicles, and NEVs in Chengdu also benefit from preferential parking fees at public lots. Furthermore, the city has issued an ultimatum banning diesel freight trucks (with some exceptions) within the next three years; distribution-related electric vehicles will not have this restriction. In addition, according to the "Chengdu Low Carbon City Construction 2017 Annual Plan," the city intends to take its entire bus fleet electric through new purchases and refurbishments. It also states ambitions to electrify the city's taxis, online car-hailing, and shared vehicles.

BEIJING: SCALING-UP LOW CARBON BUILDINGS

LEARNING FROM BEST PRACTICES AND FORMING A COMPREHENSIVE MUNICIPAL POLICY FOR ULTRA-LOW CARBON BUILDINGS

In a short time, Beijing has charted a clear path forward for ultra-low carbon buildings in the city. By learning from the experiences of other cities, Beijing is able to incorporate this expertise into crafting a supportive policy environment. These policies include scaling up subsidy support and removing regulatory barriers and uncertainties surrounding the adoption of ultra-low carbon buildings. With continued initiative, ultra-low carbon buildings can become an important tool for achieving the city's climate goals.

In 2015, Beijing announced its intention to peak carbon emissions by 2020—some 10 years ahead of the national target. Ultra-low carbon buildings are key to Beijing's ambitions. In October 2016, the city released the "Beijing Ultra-Low Carbon Building Development Action Plan for 2016-2018" (hereinafter referred to as the Action Plan). This plan called for the development of more than 300,000 square meters of ultra-low carbon buildings by the end of 2018. To speed up the development of these projects, the plan also dedicated funds to stimulate private investment. Guidelines for these funds, the "Beijing Interim Measures for Construction of Ultra-Low Carbon Building Demonstration Projects and Award Funds," were announced in June 2017 with the endorsement of the Beijing Municipal Housing and Urban-Rural Development Commission, the Finance Bureau, and the Commission for State Land Use Planning.

Unlike most other cities, why did Beijing target buildings instead of industries to achieve its early peaking goals? What is driving Beijing's interest in ultra-low carbon buildings? How did the city navigate challenges such as a lack of consumer awareness, fuzzy standards, and an absence of experienced developers? The answers to these questions will provide valuable lessons for other cities that must also add ultra-low carbon buildings to their climate policy portfolio.

Moving Beyond Beijing's Industrial Roots Toward a Low Carbon Future

Despite efforts to accelerate China's transition to a post-industrial service economy, many cities are still home to heavy industry, which accounts for the bulk of China's carbon emissions. However, in some cities where the service economy dominates, buildings are now the leading source of emissions. Beijing, having shed much of its heavy industry, is one such city. As China continues to move toward a service and consumption-led growth model, curbing the building sector's emissions will become increasingly important to the country's climate policy.

Emissions from Beijing's building sector have risen consistently over the last decade. In 2014, civil buildings consumed 31.14 million tons of standard coal equivalent of energy, accounting for 45% of the city's overall energy consumption—more than either the industrial or transportation sectors.[10] As Beijing's economy continues to pivot away from its industrial roots, the relative share of building sector emissions in the city's overall emissions profile will only increase. At the same time, experts have consistently identified the building sector as the most cost-efficient area in which to cut emissions.[11]

To seize this opportunity, the government released the "Beijing 13th Five Year Plan for Improving Energy Efficiency, Reducing Energy Consumption, and Combating Climate Change." This plan calls for Beijing to cap its energy consumption at 76.51 million tons of standard coal equivalent by 2020. It also aims to limit building sector energy consumption to 41 million tons of standard coal equivalent, which accounts for 54% of the overall goal. The rapid development and construction of ultra-low carbon buildings are thus crucial to achieving these goals.

Learning from Best Practices

Beijing has already made strides in improving energy efficiency. Today, the city promotes standards on windows and insulation to reduce heating and cooling needs; roughly three-

WHAT ARE ULTRA-LOW CARBON BUILDINGS?

The phrase "ultra-low carbon buildings" has existed for a long time but always lacked a clearly agreed-upon definition. This concept emerged when people started thinking about the future of architecture. Ultra-low carbon buildings represent a next step beyond existing energy efficiency upgrades; they are "smart" enough to manage different patterns of energy consumption and built from the ground up to curb climate and environmental footprints. However, even now, countries struggle to agree on definitions and standards for ultra-low carbon buildings. Some examples of these structures include "energy-plus" homes that generate significant portions of power from on-site renewables and "zero net energy buildings," which produce as much power from on-site renewables as they consume. Other examples also incorporate next-generation energy efficiency technologies to minimize power consumption. In theory, all buildings mentioned above are ultra-low carbon buildings even though there still is not a mutually agreed upon definition.

quarters of residential buildings are now in compliance with these measures. However, these improvements, while important, represent the low hanging fruit in reducing energy consumption. As marginal returns on investment from these upgrades fall, Beijing will need to look for new measures to promote energy efficiency. Adopting ultra-low carbon buildings present opportunities, as well as new challenges.

To meet this challenge, the Beijing Municipal Housing Urban-Rural Development Committee has sought to learn from the experiences of other cities. Projects in Hebei, Shandong, Liaoning, Heilongjiang, and other provinces offer promising examples for study. Examples include the energy-saving building demonstration of Tsinghua University completed right before the 2008 Beijing Olympic Games, the passive house demonstration project of Qinhuangdao in Hebei Province completed in 2013, and the near-zero-energy consumption building demonstration of the China Academy of Building Research completed in 2017. Of these demonstrations, the passive house project has had the most widespread adoption in recent years. Many cities in Hebei, Shandong, Liaoning, Heilongjiang and other provinces have built residential buildings, office buildings, schools and other demonstration projects with passive house principles.

Since 2014, Beijing's government has organized study trips, hosted expert panels and presentations, conducted technical training, funded research teams, and coordinated the development of regulatory logistics to promote low carbon buildings in the city.[12] These measures, bolstered by local authorities' support of private demonstration projects (See Figure 9), have created a more robust regulatory, technical, and business environment for low carbon buildings to flourish.

Figure 9 | Ultra-low energy demonstration building

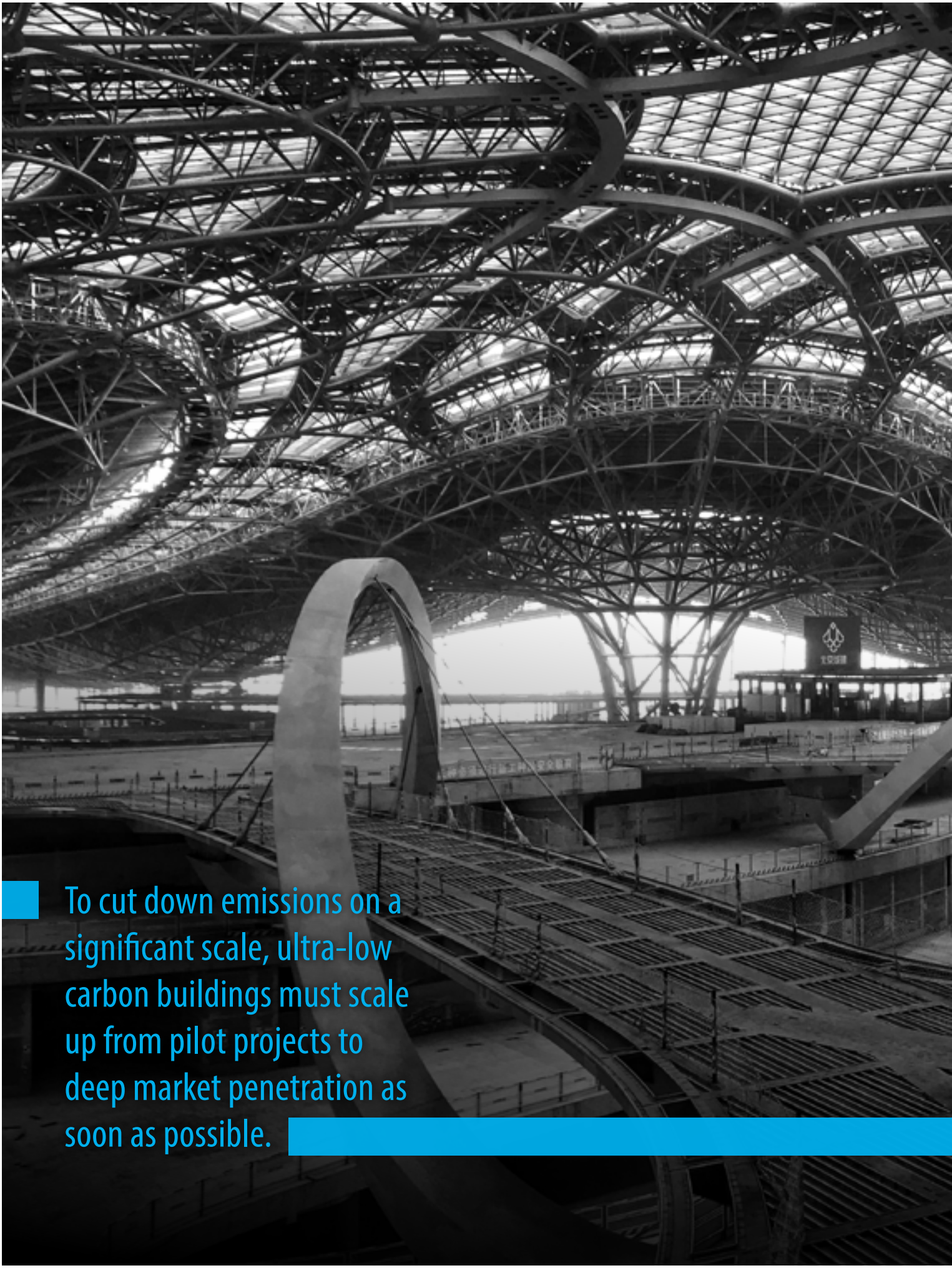
Image Source: China News Service, Peng Nian

Using Policy Innovation to Lever the Power of the Markets

Designing ultra-low carbon buildings is a much greater challenge than carrying out common energy efficiency upgrades. The need for better performance from insulation materials, doors, windows, heating and cooling equipment, as well as for more precise construction measures, means that the incremental costs of ultra-low carbon buildings are much higher than those of traditional counterparts. Pilot projects in China's colder regions, including places like Beijing, Hebei, and Shandong see additional costs that typically reach 1000RMB per square meter, while those in even harsher cold climate zones like the Heilongjiang Province can see costs of up to 1500-2000RMB per square meter. Although home and business owners can recoup those costs over the long run with lower electricity and heating bills, the higher upfront cost of ultra-low carbon buildings can still discourage the investment of potential developers or buyers.

In designing policy to support ultra-low carbon buildings, regulators have adopted an incremental approach, gradually ratcheting up standards to allow market demand and technical capacity to develop as well as ratcheting down subsidies when private developers become able to compete on market terms. In the initial stages of market development, before more widespread expertise and economies of scale drive costs down, government support can allow demonstration projects to get off the ground while drawing in additional private capital.

Beijing's Action Plan calls for subsidies that will scale down as the market for ultra-low carbon buildings develops. In the first year of implementation, municipal funds will provide 1000RMB per square meter; this subsidy will fall to 800RMB per square meter in the second year and 600RMB per square meter in the third year before phasing out entirely. The Action Plan also enforces a cap of RMB30 million for each project, which scales down to RMB25 million, RMB20 million, and zero along the same schedule. To ensure the implementation of the policy, the Action Plan targets major government investment projects, such as the ultra-low carbon development of the administrative office area of the Beijing City Sub-Center and government-invested affordable housing.



To cut down emissions on a significant scale, ultra-low carbon buildings must scale up from pilot projects to deep market penetration as soon as possible.

Setting the Stage for Ultra-Low Carbon Buildings

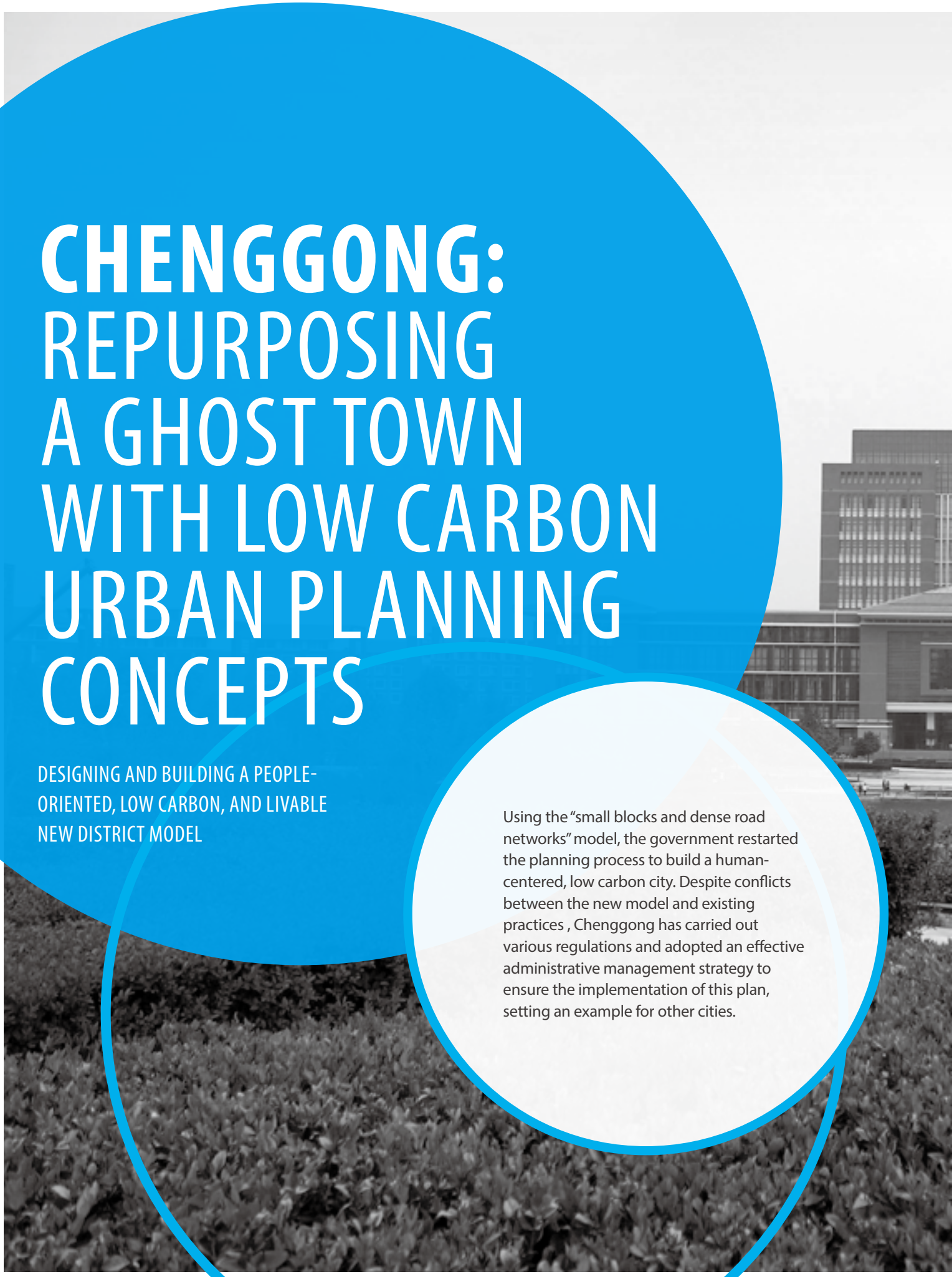
Several outdated policies and standards currently limit the development of ultra-low carbon buildings. For example, ultra-low carbon buildings require additional insulation and thicker walls; in extremely cold environments, insulation alone typically takes up more than 30 centimeters in addition to the external wall—more than double what is required to meet typical energy efficiency standards. Since existing standards include both walls and insulation in the square footage, extra insulation is thus penalized and makes it challenging to sell ultra-low carbon buildings.

To address this problem, Beijing stipulated that additional space for insulation in ultra-low carbon buildings beyond what is required to meet baseline energy efficiency standards should not be counted against the square footage. More broadly, Beijing has crafted unified city-wide standards, definitions, and technical guidance on ultra-low carbon buildings, alleviating uncertainties among potential developers. Beijing′s policy guidance also identifies key technical indicators and streamlines the application and review procedures necessary to go ahead with ultra-low carbon buildings. The city aims to finalize the current round of technical standards, regulations, and guidance for public, residential, and rural homes by the end of 2018.

To cut down emissions on a significant scale, ultra-low carbon buildings must scale up from pilot projects to deep market penetration as soon as possible. As ultra-low carbon buildings proliferate, the industry will encounter barriers beyond the immediate obstacles to getting pilot projects off the ground. Building such structures at scale will require key resource inputs and technologies that China currently lacks. To the extent that they are available, many of these materials must be imported at costs that strain the underlying economics of ultra-low carbon buildings. Beijing′s Action Plan provides direction on how to address deficiencies in existing supply chains, products, and technologies. These measures, beyond their direct effects, also provide an important signal to markets that both regulatory support and future demand for ultra-low carbon buildings is imminent.

CHENGGONG: REPURPOSING A GHOST TOWN WITH LOW CARBON URBAN PLANNING CONCEPTS

DESIGNING AND BUILDING A PEOPLE-ORIENTED, LOW CARBON, AND LIVABLE NEW DISTRICT MODEL



Using the "small blocks and dense road networks" model, the government restarted the planning process to build a human-centered, low carbon city. Despite conflicts between the new model and existing practices , Chenggong has carried out various regulations and adopted an effective administrative management strategy to ensure the implementation of this plan, setting an example for other cities.

zhangmoom618 /CC BY

Chenggong New District of Kunming is located in the southeast region of the city on the east bank of Dianchi Lake. In 2003, the Yunnan Provincial Party Committee and Provincial Government along with the Kunming Municipal Party Committee and Municipal Government designated Chenggong as the administrative and employment center of Kunming. Since the formulation of the Chenggong master plan (2003-2020) in 2004, a successive series of special plans have been introduced. Under these plans, Chenggong developed into a car-oriented district characterized by super blocks with street lengths of 400-500 meters. In addition, many buildings sit more than ten meters away from the street. As a result, these urban planning techniques have created deserted streets and less than a 30% occupancy rate in large-scale residential buildings. The Chenggong New District thus became known as one of the most notorious "ghost towns," comparable to the New Khamashi district in Ordos, Inner Mongolia, and Zhengdong New District in Zhengzhou, Henan.

In 2008, the Kunming municipal government began a new round of planning, but this time focused on human-oriented design. In 2010, with the support of Energy Foundation China (EFC), Chenggong invited Peter Calthorpe—an internationally-recognized urban planner known for codifying transit-oriented development (TOD*) —to lead the planning and redesign of Chenggong's core area as a livable low carbon district. In recent years, Chenggong New District has slowly shed its "ghost town" label and shown promising signs of vitality. According to the statistics of the Chenggong Industrial and Commerical Bureau, the total number of enterprises and merchants in the district increased by more than 25,000 in the first quarter of 2018. What difficulties did Chenggong face in pivoting away from being a "ghost town" toward becoming a low carbon district?

Replacing Existing Structures with Small Blocks and a Dense Road Networks

With its wide road network and scant space for pedestrians and cyclists, Chenggong's early urban planning contradicts the district's administrative, commercial, financial, and residential needs and functions. The "small blocks and dense road networks" model— which was first proposed by the "New Urbanism" movement of the American urban planning community in the 1990s to combat urban sprawl and vehicle-oriented city development— seemed to be a suitable solution; thus, Chenggong New District became the first district in China to practice this street planning concept.

Using these methods as well as the TOD model, the design team led by Calthorpe redesigned the core area of Chenggong within 12.16 kilometers. They split the original plot and increased the amount of branch roads. Block sizes were reduced to about 1.5 hectares, and the distance between branch roads was shortened from 400 meters to 100-200 meters, which doubled the road network density. According to the "2018 China Major Urban Road Network Density Test Report," the road density of the core area of Chenggong New District has reached a level that is comparable to New York and Chicago and now stands at the forefront of Chinese cities.[13] Chenggong's doubled road network density only increased the total road area by 7%,[14] while more rationally allocating land resources and creating a more pleasant, livable urban space.

In order to achieve low carbon goals, the new plan increased mixed land use to reduce the use of cars. For example, by mixing residential land use with commercial and other service facilities, the residents don't have to drive to access shops or other facilities. The use of vehicles is further discouraged by

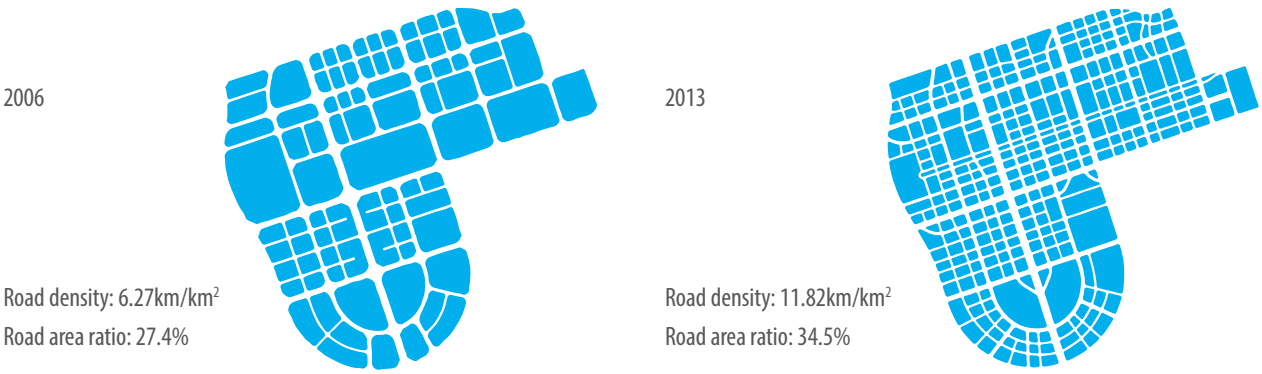


Figure 10 The Chenggong new core area schematic plan, with the old (left) compared to the new core area plan (right).

Image Source: https://www.thepaper.cn/newsDetail_forward_1449376

* Transit-oriented development (TOD) is a type of urban development technique that maximizes the amount of residential, business and leisure space within walking distance of public transport.

limiting parking spaces and motor vehicle entrances. Moreover, to optimize the distribution of different modes of transportation, it designated more lanes for pedestrians, cyclists, and buses with the hopes of mitigating problems such as tailpipe gas pollution, noise pollution, and congestion. Figure 10 shows schematic drawings of the old and new plans.

Conflicts Between New Concept and Established Models

Although the concept of "small blocks and dense road networks" has been successfully adopted in European and North American countries for many years, planners faced setbacks in changing the status quo in China.

First of all, by implementing smaller blocks and denser road networks, the land parcels for sale also become smaller, which can negatively affect the government's fiscal revenue and lose the interest of investors who prefer large plots. Faced with this dilemma, the planning committee continuously communicated and negotiated with interested parties, finally reaching an agreement to sell parcels of land in packs of three or more. This type of sale avoids the pressure of small plots on government finances and still draws the interest of developers. Local authorities are trying to direct urban construction practices through more detailed, technical construction rules because in this type of sale, developers have the ability to build lifted corridors to physically integrate small plots into big ones, which may cause safety issues as well as negatively harm the urban landscape and ground transportation.

Secondly, implementing smaller blocks and denser road networks brings about problems of ownership and responsibility regarding the construction and maintenance of the underground pipe network. As the number of small plots increases, the government's investment in infrastructure construction also increases. In order to alleviate some financial pressure, the government entrusts the right to use underground space to enterprises that then have to build pipelines and other underground infrastructures in accordance with government regulations. However, construction technology amongst various companies is inevitably different in level and quality, which creates mismatches when the pipe networks must connect. While enterprises are in charge of the construction underground, the government is responsible for the construction and maintenance of the roads above. Chenggong is gradually working to clarify the inconsistencies in the division of ownership and responsibilities for below- and above-ground infrastructures.

Regulations and Management to Ensure Implementation

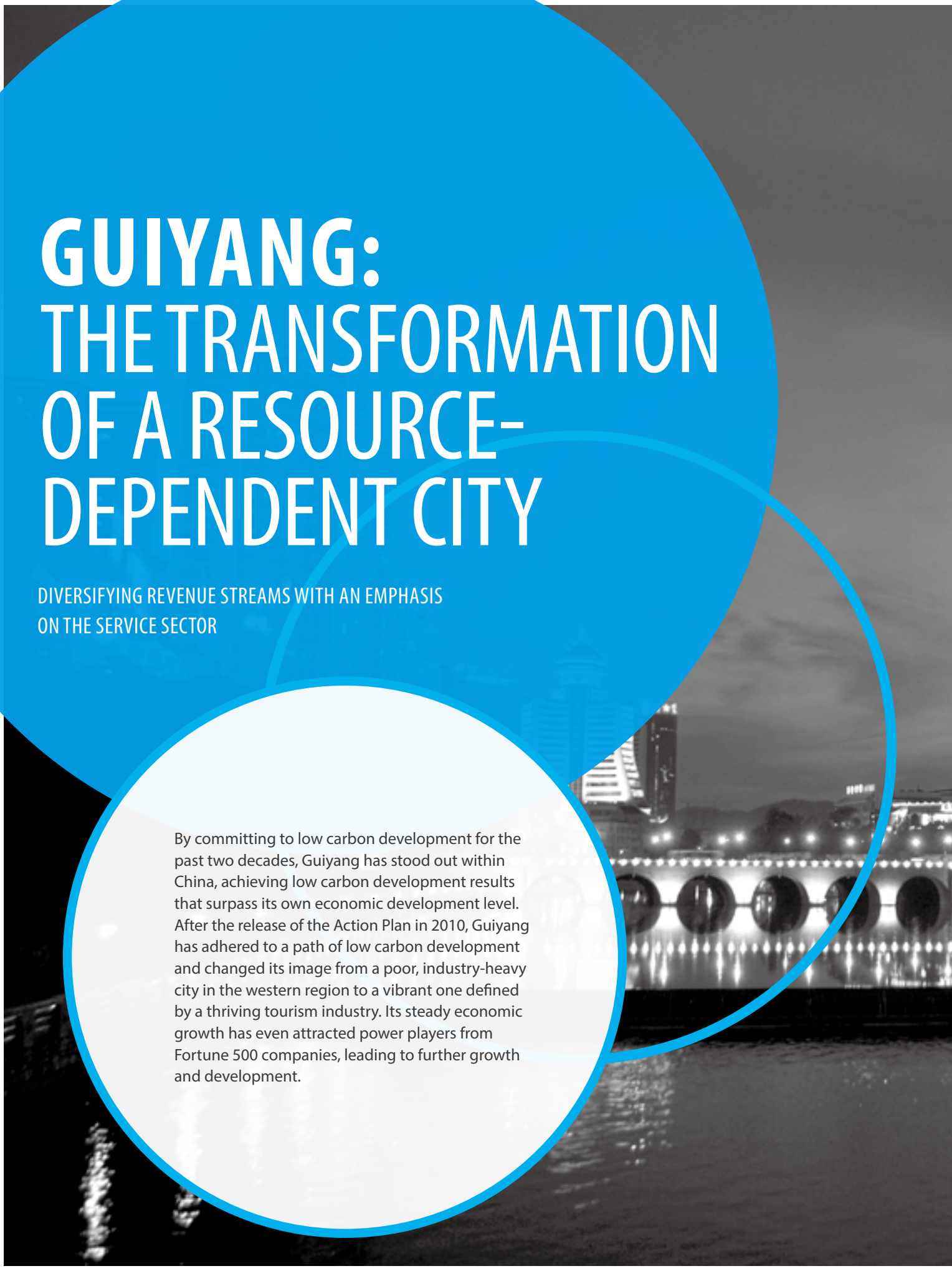
In 2010, the 8th Directors' Meeting of the Kunming Municipal Planning Commission adopted the "Conceptual Plan for the Core Area of Chenggong," which was completed by the Calthorpe Associates. However, to ensure proper implementation, conceptual planning of green low carbon strategies needs to be supplemented with effective government regulation and management. In February 2012, the Municipal Regulation Committee reviewed the Detailed Control Plan for Chenggong Core Area (hereinafter referred to as the Control Plan). In the Control Plan, 13 regulations were dedicated to ensure low carbon development; one of which was the construction of a low carbon road network. Kunming used the Chenggong core area as a special area of technical management to further guarantee implementation. It gave the Control Plan authority over sometimes conflicting older regulations from the original "Kunming Urban Planning Technical Management Regulations"; examples include differences in building distance from road, road width, and parking supply.

In the following February, zoning diagrams were compiled and incorporated into the Control Plan. For example, all new buildings must be "green buildings." At least one green building in every district must feature low energy consumption, high efficiency, and zero waste. The complementary, legally-binding regulatory texts and diagrams help Chenggong ensure implementation of low carbon development in the core area.

To properly implement low carbon development in Chenggong, effective supervision and management is also needed. The Chenggong New District Management Committee oversaw administrative management of the district and authorized the Chenggong New District Land Service Center to undertake part of the urban and rural planning management during the transition period. In addition to the regular administrative structure, Chenggong New District also established a special "Chenggong Low Carbon City Pilot Office" to coordinate work among different departments. Now, every year there is a construction site meeting in Chenggong New District to promote the overall development and construction of the new district. Chenggong also invites the Chinese Academy of Building Research, the Energy Foundation, and the Yunnan Provincial Department of Housing and Construction to serve as technical support agencies to encourage cooperation between different industry sectors in the pursuit of a green, low carbon urban district.

GUIYANG: THE TRANSFORMATION OF A RESOURCE-DEPENDENT CITY

DIVERSIFYING REVENUE STREAMS WITH AN EMPHASIS ON THE SERVICE SECTOR



By committing to low carbon development for the past two decades, Guiyang has stood out within China, achieving low carbon development results that surpass its own economic development level. After the release of the Action Plan in 2010, Guiyang has adhered to a path of low carbon development and changed its image from a poor, industry-heavy city in the western region to a vibrant one defined by a thriving tourism industry. Its steady economic growth has even attracted power players from Fortune 500 companies, leading to further growth and development.

Guiyang's economic transformation has taken more than ten years. While some may criticize this progress as slow, Guiyang has developed from one of China's poorest cities in the western region—reliant on heavy industries—to the Chinese city with the highest GDP growth rate in 2017—now well-known for summer resorts and big data centers. As an originally economically underdeveloped city, what lessons can Guiyang share with other cities in similar positions?

Low Carbon Development ahead of Its Time

Through forward thinking and strong political will, policymakers in Guiyang have steered the city toward an early green transition well ahead of other Chinese cities. Guiyang began to experiment with the concept of a circular economy as early as 2002 when the municipal Party Committee and government—with approval by the State Environmental Protection Administration—decided to restructure Guiyang as China's first eco-city with a circular economy. With effective government promotion, it took only two years of education and training to write China's first local special legislations, the "Regulations on the Establishment of Circular Economy Eco-Cities in Guiyang," which ensures the long-term development of the circular economy. During this period, Guiyang also completed the "Guiyang Circular Economy Eco-City Construction Master Plan" and "The First Batch of Pilot Projects of Guiyang Circular Economy Eco-City."

On top of the legislative progress, Guiyang's green transition relied heavily on institutional change. Guiyang established the nation's first environmental protection court to unify jurisdiction and address environmental pollution problems across different administrative regions and affiliations. In November 2011, Guiyang formed an administrative body called the Ecological Construction Committee—the first of its kind in China—comprised of the Environmental Protection Bureau, the Municipal Bureau of Forestry and Afforestation (formerly the Municipal Garden Management Bureau), part of the Economic and Information Commission, the Industry and Information Technology Commission, the Construction Bureau, the Urban Management Bureau, and the Agricultural Commission. As a component of the municipal government, this new committee is in charge of the overall planning, coordination, and supervision of ecological construction in the city. In the same year, the Ecological Protection Bureau under the Municipal Procuratorate and the Ecological Protection Branch office of the Municipal Public Security Bureau were set up. Guiyang took the lead in establishing a legislative, judicial and administrative system for ecological development in China.

Not only did Guiyang start its economic transformation ahead of other cities, but its level of low carbon development policymaking was unexpected because it was premature to its own economic development level, according to the Kuznets curve. The Kuznets curve[15] suggests that economic growth initially leads to environmental deterioration; however, when the increase in per capita income and economic development reaches a certain critical point, or "inflection point," environmental pollution will gradually slow down and reverse from high to low. China reached its environmental "inflection point" in 2014. Even though Guiyang lagged behind the national average at this time in its economic development, the city still began exploring carbon development options earlier than even more developed regions.

External Experts Help Achieve Green Transformation

The economic development of Guiyang has traditionally depended on its mineral resources. 52 types of minerals have been identified in the region, including 430 million tons of bauxite reserves—which accounts for one-fifth of the country's total—and 464 million tons of phosphate—making Guiyang one of China's three major phosphate bases.[16] However, due to poor infrastructure and distance from the rest of the national market, Guiyang could not mirror the economic transition of cities in the eastern region of China. Guiyang still had low levels of industrialization, high levels of pollution, and a low GDP. As the pollution made it more and more difficult to continue to develop, Guiyang turned to experts from Renmin University to find a way to transform its economy.

One solution was to move up the value chain, but this long-term process would require large investments in infrastructure and human resources. In order to quickly transition to a path of low carbon development, Guiyang would need to shift its reliance on heavy industries and adjust its industrial structure. When determining how to veer Guiyang's economy, experts were inspired by Yunnan, which has similar geographical and climate conditions. Yunnan is known for its beautiful natural landscape and mild climate year-round, which gave rise to a booming tourism industry in Kunming (the capital city of Yunnan province). With similar features in climate and forest coverage, Guiyang saw an opportunity to also become a tourist hotspot and benefit from such development. The Renmin University experts proposed an idea that followed a path of low carbon transformation through the construction of vacation home real estates. This was quickly supported by Guiyang's government. Despite the risk of low revenue, Guiyang's municipal government invested in tourism

industry infrastructure and took advantage of its favorable geographical location to attract buyers from Chongqing and the Pearl River Delta while vigorously promoting the city.

With help from the experts, in July 2010, Giuyang released the first low carbon action plan in the country—the Guiyang Low Carbon Development Action Plan (Outline) (2010-2020) (hereinafter referred to as the Action Plan). The first of the ten major action items was to "increase investment in infrastructure to enhance service capabilities and achieve great development in tourism, conferences, vacation home real estate, and modern logistics." Since the tourism industry has a relatively low energy consumption intensity, creates local jobs, and increases government revenue, the strategy to shift Guiyang's reliance on heavy industry toward tourism proved to be effective. In 2014, Guiyang was the second-highest ranking city in the southwest region for land transfers to tourism development, second only to Chongqing and higher than large cities such as Chengdu and Kunming. [17]

The experts also created a method of carbon inventory based on the energy balance sheet at a time when an official carbon inventory preparation method simply did not exist. Unlike low carbon development action plans released by various provinces and municipalities in recent years, the carbon inventory for Guiyang was compiled once every year instead of once every five years. This method was simple, fast, and could be updated every year to reflect the completion of established goals as well as provide effective, real-time support for policy. This set of measures fully considered the financial and technical capacities of Guiyang at the time and provided the basis and guarantee for the implementation of the Action Plan.

Tourism, Tech, and Green Finance Keep Guiyang on Track with Low Carbon Development

Along with the implementation of the Action Plan and other low carbon development initiatives, Guiyang has achieved environmental, technological, and economic advancements. Since Guiyang first became a low carbon pilot city in 2010, the annual GDP growth rate has reached levels of 15.1% by 2015. In 2014, the carbon emissions intensity at 15.7 tons per thousand RMB dropped 16% from what it was in 2010. In recent years, tourism, tech, and green finance have helped Guiyang pursue its low carbon development.[18]

With the rise of its tourism industry, Guiyang's image is no longer associated with poverty but rather with

Figure 11 | Green Guiyang

Image Source: China News Service, Peng Nian

summer resorts and convention centers. In particular. 2018 was the 10th anniversary of the Guiyang International Forum on Ecological Development, which marked the first thousand-person conference in the field of ecology after the 19th National Congress of the Communist Party of China. It was also the only internationally-recognized, ecological civilization-themed platform approved by the state. This conference served as an opportunity to both inspire new ideas on low carbon development as well as present Guiyang's low carbon transformation to the whole country and greater world.

Since 2014, when the city was approved to become China's first, national-level, big data industry development zone, 61 Fortune 500 companies have moved into Guiyang, including Qualcomm and Apple, as well as the three major data communications operations of Telecom, Mobil, and China Unicom. These companies were attracted to Guiyang because of low land and electricity prices, temperate climate, and low power consumption in the summer. Guiyang serves as a data center, which has helped it set up the first big data exchange in China.[19]

Guiyang has also ventured into green finance. On October 16th, 2017, China's first green financial court, the Green Finance Court of the Guanshan Lake District People's Court of Guiyang, was established. The court presides over the green economy and promotes the development of green finance by providing official trials and accelerated processes for 40 major bank headquarters, insurance companies, and more than 300 financial institutions in the green economy in Guizhou province.

SHANGHAI: PROMOTING LOW CARBON TRANSPORTATION ALTERNATIVES WITH STREET DESIGN GUIDELINES

A TRANSFORMATION FROM THE "ROAD" TO THE "STREET"

China's first Street Design Guidelines proposed a design goal that transformed the "road," dominated by traffic-centered thinking, to the "street," which integrates human-centered design thinking into public spaces. By involving key stakeholders and public opinion in the preparation process, the Guidelines was not only able to draw upon experience and inspiration from international practices but also from localized knowledge. The Guidelines emphasizes four major shifts in road rights, design method, design strategy, and evaluations and provides a series of design requirements and quantitative indicators to create human-oriented streets.

Between 2009 and 2014, the car ownership in Shanghai doubled; since then, road congestion has become increasingly problematic. Even if the city increased road space, it would still only continue to perpetuate a vehicle-centered street. Thus, among many challenges facing the Shanghai Transportation and Planning Department are how to alleviate congestion under the existing urban traffic patterns, achieve walkable and cyclable streets, and promote people-oriented neighborhoods.

To address these challenges, Shanghai, like many other Chinese cities, began with street design. This strategy falls in line with the Shanghai 2040 Master Plan, which declares clear aims to transform the city into a more pedestrian-friendly place.

In 2016, Shanghai issued the first Street Design Guidelines (hereinafter referred to as the "Guidelines") in China. What particular features make Shanghai's "Guidelines" innovative? What particular features make Shanghai's street design guide innovative?

The Importance of History and Multi-Party Participation

The "Guidelines" design team is comprised of experts from the Shanghai Municipal Administration of Planning and Land Resources, the Shanghai Transportation Commission, the Shanghai Urban Planning and Design Research Institute, as well as various other Chinese and foreign design teams including the Energy Foundation, China Sustainable Transportation Research Center, and Gehl Architects. The "Guidelines" design team first conducted extensive field research on hundreds of streets in Shanghai. From this research, they selected about 30 existing people-oriented streets as case studies to understand which types of streets work in this city specifically. They also studied typical communities constructed during different time periods in Shanghai that demonstrate specific street design features of those periods in order to determine the feasibility and operability of these particular historical practices in Shanghai.

Through an understanding of the past and current situations of Shanghai's streets, the "Guidelines" states that designs on all historical and cultural blocks should maintain the block's appearance in addition to the overall conservation of the street network and block pattern. By protecting historic buildings, spatial patterns, greening, and other elements of historical and cultural blocks and districts, the "Guidelines" hopes to continue to preserve Shanghai's unique urban environment.

Understanding physical layout and historic features is only the start to thoroughly understanding streets; it is even more important to understand who uses various streets and how they use them. Safe, livable, and vibrant streets are arguably the most important public spaces in the city; thus, they are created from and maintained by the participation of a variety of stakeholders. Therefore, the "Guidelines" was not solely targeted toward planners and designers but also toward street-related managers, business-owners, and other members of the community. These community stakeholders were invited to participate in an open discussion about the basic designs of the street, reflecting a spirit of openness and inclusivity. These steps were important to reach a community consensus on the street concepts that would guide overall development.

To reach out to as many stakeholders as possible, the design team planned a series of special events during various stages of drafting the "Guidelines." Examples included "Streets Dialogue" salons, expert consultation and opinion collection, and a coordinated survey involving multiple online and offline parties. A series of news reports led by the design team and conducted by China Construction News, Wenhui Daily, Oriental Morning Post, and The Paper, have further roused public attention for this project. The design team made sure that the "Guidelines" is easily accessible by different groups of people and publicity by using pictures and simple texts to explain technical concepts. Inclusion of multiple parties reflects major goals of the "Guidelines," as it ultimately aims to promote the coordination and cooperation of all street users and stakeholders, achieve understanding and consensus on streets, and achieve a human-oriented street transformation.

Transitioning from "Road" to "Street"

To transition from a "road" that emphasizes traffic functions to a "street" that focuses on urbanite

The world's first guidelines on green street design were released in London in 2004; their goal was to make London into a pedestrian-friendly city by reducing dependence on private cars and making available multiple transportation options with low-environmental impact. New York, Abu Dhabi, New Delhi, and other major cities have all similarly issued their own street design guidelines. In October 2016, Shanghai was the first Chinese city to make its own. Its actions were later imitated by second-tier cities such as Nanjing and Kunming.

Figure 12 Redesign of Yuyuan Road creates seating for pedestrians.

Image Source: Baidu Streetview

Figure 13 Historic district on Duolun Road.

Image Source: Baidu Streetview

activities, the "Guidelines" proposes four avenues of change. The first is to shift systematic design from solely paying attention to the right of way of motor vehicles to the right of pedestrians. This would be accomplished by integrating slow traffic, static traffic*, motorized traffic, and other street activities into considerations when designing streets. The second change about design methods suggests that there needs to be a change from simply considering the current "road boundary line control" to also thinking about "street space control." That is, the area of the street being considered for reconstruction should increase, expanding from the traditional "road boundary line*" to the whole area between the walls of the structures lining the street. (Figure 12)

The third shift concerns design strategy, as the "Guidelines" promotes changes from technical, engineering design to comprehensive spatial and environmental design. Current engineering design codes and standards are determined mostly from the perspective of transportation and municipal facilities, leading to an excessive emphasis on the technicalities of road engineering and minimal acknowledgment of the overall social and spatial environment. The "Guidelines" breaks through this pre-existing engineering-based mindset and integrates municipal facilities, landscape, buildings along the street, and historical features, forcing the designers and engineers to acknowledge the overall environment of the streets. (Figure 13)

The "Guidelines" fourth proposed change is in evaluation, transitioning from "emphasizing traffic efficiency" to "promoting the confluent development of street and blocks." Whereas the key indicator of road evaluation was traffic efficiency, the "Guidelines" proposes that evaluating the street pays more attention to the function of public places. The street has thus become regarded as a public space that combines traffic, culture, and neighborhood activities.

Quantifying Human-Centered Streets

The "Guidelines" quantifies the ideal street with various technical indicators, making it easy for designers to understand and objectivize. For example, when designing the width of the sidewalk/pedestrian zone, the "Guidelines" considers a comprehensive list of factors including function of the block, building facade, and location. It categorizes sidewalks into different types according to their placement near landmarks such as temporary walls, inactive walls, commercial activities, entrances and exits to public transport services, and pedestrian crossings. These placements then help determine the width of the pedestrian zone, which often ranges from 1.5 to 6 meters.

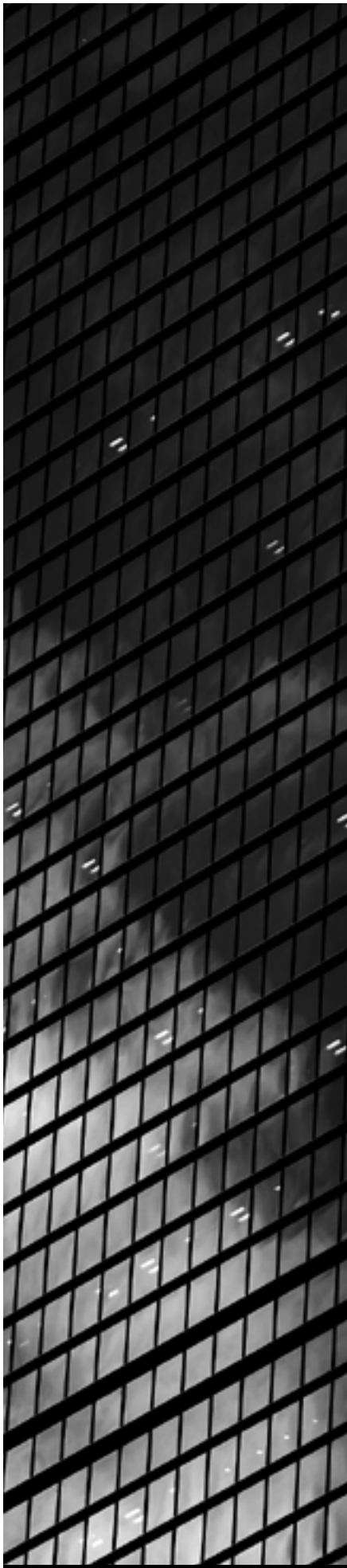
The "Guidelines" also presents a series of standards for visual street design. For example, to create more aesthetic appeal for pedestrians, the "Guidelines" requires the usage of transparent interfaces for more than 60% of the total interface area on the first floors of commercial streets and advocates for increased artistic design of display windows. To avoid long swathes of monotonous, high-reflective glass facades and large stone walls, these types of interfaces are limited to 50 meters in length. The "Guidelines" also encourages the adoption of low reflection glass and exquisitely decorated stone walls to enrich the visual experience when walking.

* Static traffic refers to the temporary idling of public transportation vehicles when passengers get on and off, freight vehicles when loading and unloading, and parking for passenger cars, bicycles, etc. Although the purpose of parking varies and the length of time is different, static traffic is always considered part of the traffic dynamic. Various parking lots can also be classified as static traffic.

* The road boundary line generally refers to the boundary line defining the road areas.

References

1. 武汉市发展和改革委员会. 武汉市国民经济和社会发展第十三个五年规划纲要[EB/OL](2016-04-18)(2018-03-25).http://www.whdrc.gov.cn/html/xwzx/tzgg/20160418/18174.html
2. 武汉市人民政府. 武汉市人民政府关于印发武汉市能源发展"十三五"规划的通知：武汉[2017]15号[EB/OL](2017-07-4)(2018-03-26).http://www.wuhan.gov.cn/hbgovinfo_47/szfggxxml/zcfg/szfwj/201707/t20170704_130276.html
3. 深北极星电力网新闻中心.深圳排放权交易所总裁葛兴安：深圳碳交易试点成效及启示. [EB/OL](2018-01-8)(2018-04-20). http://news.bjx.com.cn/html/20180118/874911.shtml
4. 全景网.王昌干:让百姓出行有尊严是公交供给侧改革的出发点和落脚点[EB/OL] (2016-03-7)(2018-04-20).http://www.p5w.net/news/xwpl/201703/t20170307_1729395.htm
5. 千龙网，北京市2020年公交专用道将达一千公里[EB/OL](2017-11-22)(2018-03-25). http://www.sohu.com/a/205955217_161623
6. 知识库. 高德地图：2017年度中国主要城市公共交通大数据分析报告[EB/OL]. http://www.useit.com.cn/thread-19010-1-1.html
7. 2018年1月22日起 我市汽车尾号限行扩大至绕城以内. 成都市公安局交通管理局网[EB/OL](2017-12-20)(2018-04-20). http://www.cdjg.gov.cn/Html/News/20171220/content_11_1100027366.html
8. 成都全搜索. 共享单车发布多个城市"骑行指数"：成都排名榜首[EB/OL](2017-05-27)(2018-03-30). http://news.chengdu.cn/2017/0527/1880709.shtml
9. 世界资源研究所. Mobike, 2017年共享单车与城市发展报告：骑行改变城市[EB/OL](2018-01-12)(2018-03-20). https://data.mobike.com/data/how_cycling_changes_cities_zh.pdf
10. 北京市住房和城乡建设委员会，北京市发展和改革委员会，关于发布《北京市"十三五"时期民用建筑节能发展规划》的通知：京建发[2016]386号[EB/OL](2016-10-31)[2018-03-25]
11. Buildings and Climate Change: Summary for Decision-Makers DTI/1240/PA (UNEP, 2009)
12. 路国忠,薛军等.提升建筑品质 助力美好生活—北京市超低能耗建筑发展纪实.[J]. 绿色建筑·背景在行动, 2017(4):19-23
13. 住房和城乡建设部城市交通工程技术中心.中国城市规划设计研究院.北京四维图新科技股份有限公司. 中国主要城市道路网密度检测报告[R/OL]. （2018-4）http://www.planning.org.cn/news/uploads/2018/05/1525240509.pdf
14. 林微微，向泽涛等.昆明呈贡新城低碳规划建设实践[A].绿色低碳发展智库伙伴.中国城市低碳发展规划峰值和案例研究[C].北京：科学出版社，2016.
15. "环境库兹涅茨曲线"拐点到了吗？.国家信息中心[EB/OL](2016-05-27)(2018-4-20).http://www.sic.gov.cn/News/455/6394.htm
16. 中国百科网. 贵州省贵阳市矿产资源概况及分布[EB/OL](2018-05-15).http://www.chinabaike.com/z/keji/ck/528626.html
17. 中国房地产业协会商业地产专业委员会.EJU易居(中国)控股有限公司.中国旅游地产发展报告(2014-2015) [R] （2015-3）)
18. 国家应对气候变化战略研究和国际合作中心等.中国低碳省市试点进展报告. [R/OL] 中国计划出版社, 2017 :159
19. http://finance.eastmoney.com/news/1365,20180227837236273.html



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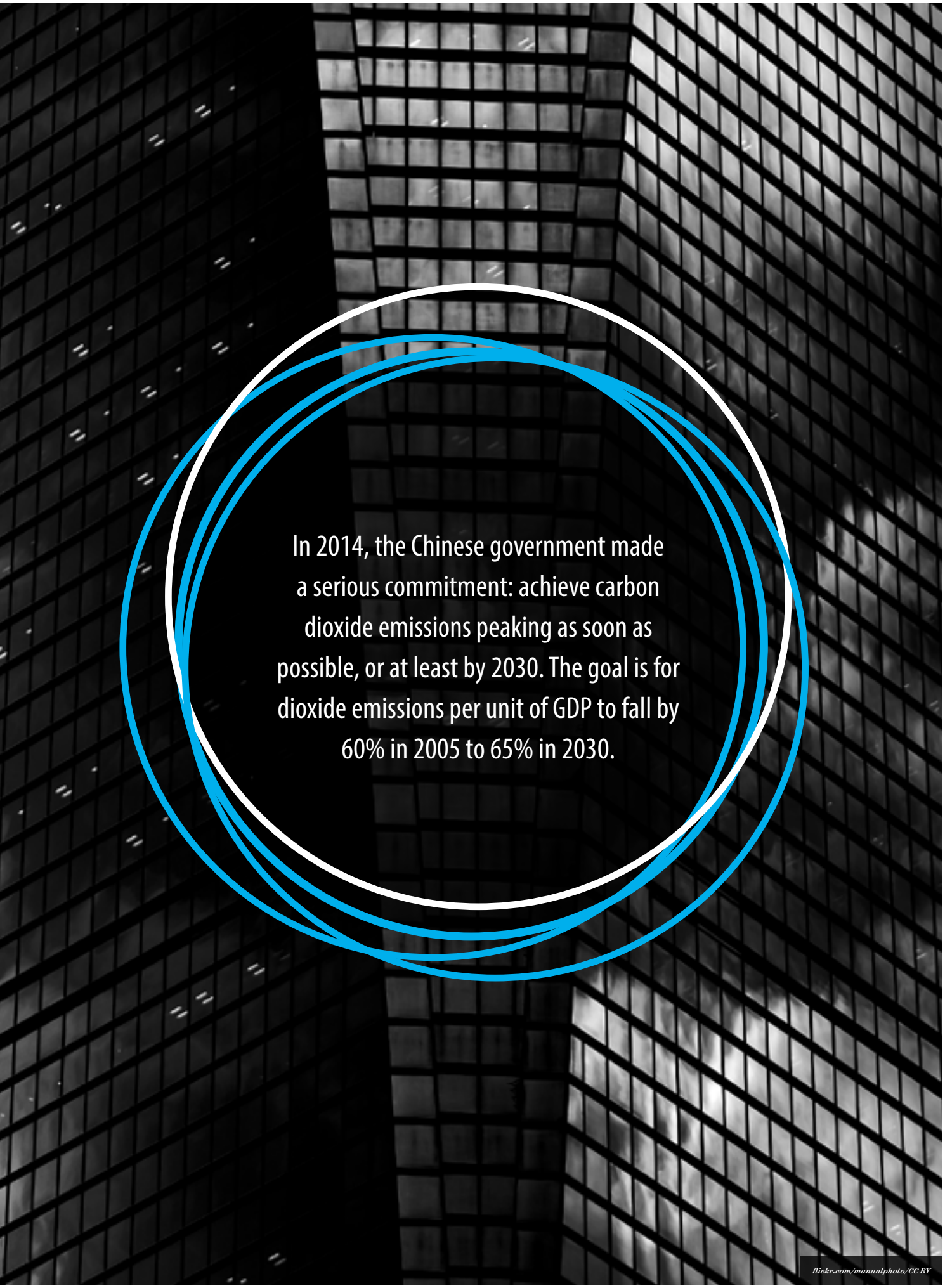

In 2014, the Chinese government made a serious commitment: achieve carbon dioxide emissions peaking as soon as possible, or at least by 2030. The goal is for dioxide emissions per unit of GDP to fall by 60% in 2005 to 65% in 2030.