



GOING GREEN

Are Chinese Cities Planting the Seeds for Sustainable Energy Systems?

Thibaud VOÏTA

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Executive Summary

The *Global Climate Action Summit* held in September 2018 in California has highlighted the importance of cities for promoting clean energy solutions and for combatting climate change. While energy policies in most countries depend primarily on national governments, cities have the possibility to develop and implement innovative solutions and ambitious policies. Chinese cities should be at the core of these developments, as they are confronted with many energy and climate challenges, often at an unprecedented scale: notably air quality, traffic congestion, energy security and massive consumption of building materials. For instance, outdoor air pollution in China has reportedly caused 1 million premature deaths in 2016, and in 2014 only 8 out of 74 Chinese cities would meet the national standards in terms of air quality.¹

The challenges are daunting and China's institutional framework may not generate incentives that would foster city-level innovations in the technology or policy fields. The Chinese political system is very centralized: the national leadership sets up objectives and plans that have to be implemented by local entities. However, there are plenty of national policies aiming at addressing energy challenges in cities: these include plans to fight pollution, energy and climate intensity objectives, technology plans to promote clean vehicles, or rating and labelling systems to promote building efficiency.

Some cities have taken advantage of the national policy frameworks and even set more ambitious targets and policies. Programmes and policies fostering sustainable cities in China are being developed at large scale, with several large cities surpassing centrally-planned policies and pioneering to become carbon neutral.

These developments will have major global implications: China's cities are already pioneering at large scale the autonomous and low carbon mobility, giving Chinese companies a technological and economic edge. They will progressively and increasingly reduce growth in the country's oil demand and imports. They will also fuel growth in natural gas demand and imports further as a large part of the country's cities are still not heated by centralized district heating systems, which, if built, will be mainly running

1. International Energy Agency (IEA), "World Energy Outlook Special Report: Energy and Air Pollution", 2016, pp. 169-189.

on gas. Overall, the period of super large building block construction is over, which will also reduce energy demand. Some of these initiatives are already considered as success stories and attract national and international attention: the electrification of Shenzhen's bus fleet, Wuhan's ambition to become a "hydrogen city", Suzhou's energy efficiency rating system or those who joined the Alliance of Pioneer Peaking Cities, and aim to reach their greenhouse gas emission peak ahead of China's official target, set around 2030. These can be powerful drivers of large scale deployment of low carbon technologies in China and beyond.

However, the track record of municipal energy policies in China also includes some bitter disappointments. This is especially the case for the so-called green cities or low-carbon development zones developed over the past decades. Many of them have been abandoned, or have failed to achieve their energy and environment goals – this is for instance the case in the Hebei province for Caofeidian or for the city of Baoding.

Fundamental challenges that remain to be addressed, and issues to be closely watched, include: the evolution of district energy systems (both on the cooling and heating sides), the evolution of energy consumption standards for vehicles and appliances, the development of alternative energy vehicles (in particular electric and hydrogen). In addition, the digital innovations in Chinese smart cities do not only aim at greening these cities, but also at strengthening social control over inhabitants, which may ultimately limit the exportability of the Chinese concept.

All these elements may explain why the most promising city-level experiment is currently piloted by the central government itself. 100 kilometers (km) southwest of Beijing, the Xiongan zone is a massive project covering a zone three-time the size of New York and should only be completed by 2035. Unveiled in April 2017, the project has already attracted China's best in class innovation and energy companies: Baidu, State Grid, or Sinopec. It aims at using artificial intelligence to develop smart energy systems and is branded by the central government as the "city of the future".

Résumé

Le *Global Climate Action Summit*, organisé en septembre 2018 en Californie, a mis en lumière l'importance des villes pour déployer les technologies bas-carbone et lutter contre le changement climatique. Alors que les politiques énergétiques dépendent principalement des gouvernements nationaux, les villes ont la possibilité d'élaborer et de mettre en œuvre des solutions innovantes et des politiques locales ambitieuses. Or, les villes chinoises sont confrontées à de nombreux défis énergétiques et climatiques: la qualité de l'air, la congestion du trafic, la sécurité énergétique, la consommation d'électricité et de chaleur dans les bâtiments et la consommation élevée de matériaux de construction. La pollution de l'air en Chine aurait par exemple provoqué 1 million de décès prématurés en 2016 et, en 2014, seules 8 villes chinoises sur 74 respectaient les normes nationales en matière de qualité de l'air.

Les défis sont considérables et le cadre institutionnel de la Chine pourrait être défavorable à l'innovation dans les domaines de la technologie ou des politiques des villes. Le système politique chinois est très centralisé: les autorités centrales fixent des objectifs et des plans qui doivent être mis en œuvre par les entités locales. Cependant, il existe de nombreuses politiques nationales visant à améliorer la situation énergétique des villes: il s'agit notamment de plans de lutte contre la pollution, d'objectifs d'intensité énergétique, de plans technologiques visant à promouvoir des véhicules propres ou de systèmes de classification et de labels visant à promouvoir l'efficacité énergétique des bâtiments.

Certaines villes ont tiré parti des cadres politiques nationaux et se sont même fixé des objectifs plus ambitieux. Alors que la Chine développe des programmes et des politiques à grande échelle encourageant les villes durables, plusieurs grandes villes entendent devancer les politiques nationales et visent la neutralité carbone dès 2030.

Ces évolutions auront des conséquences majeures: les villes chinoises pourraient être les pionnières de la mobilité autonome et bas-carbone, donnant aux entreprises chinoises un avantage technologique et économique ; ils réduiront progressivement la croissance de la demande et des importations de pétrole du pays ; ils alimenteront également la demande et les importations de gaz, puisqu'une grande partie des villes du pays ne sont toujours pas chauffées par des systèmes de chauffage

centralisés qui, s'ils sont construits, fonctionneront principalement au gaz. De manière générale, la période de construction de très gros ensembles est terminée, ce qui réduira également la demande en énergie. Certaines de ces initiatives sont déjà considérées comme des réussites et attirent l'attention nationale et internationale: l'électrification de la flotte de bus de Shenzhen, l'ambition de Wuhan de devenir une « ville de l'hydrogène », le système de classification de l'efficacité énergétique de Suzhou ou encore l'*Alliance of Pioneer Peaking Cities*, une alliance de villes qui ont pour but d'atteindre leur pic d'émission de gaz à effet de serre avant l'objectif officiel fixé par la Chine (vers 2030).

Les défis fondamentaux qui doivent encore être relevés et les problèmes incluent: l'évolution des systèmes énergétiques de quartier (tant du côté du refroidissement que du chauffage), l'évolution des normes de consommation d'énergie pour les véhicules et les appareils électroménagers, le développement des véhicules à énergies alternatives (notamment électriques et à hydrogène). En outre, les innovations numériques dans les villes intelligentes chinoises ne visent pas seulement à verdifier ces villes, mais également à renforcer le contrôle social des habitants, ce qui pourrait à terme limiter les possibilités d'exportation du concept chinois.

Table of contents

INTRODUCTION	11
CHINA'S GROWING URBANIZATION AND ITS CHALLENGES.....	13
Steadily growing urban population, yet with many unbalances.....	13
The air quality challenge.....	15
The building sector challenge.....	16
The heating challenge: an example of tensions between local and central government.....	18
The sustainable transport challenge.....	19
THE POLICY DIMENSION: STRONG CENTRAL PLANNING AND LOCAL AMBITIONS	25
The existing framework – a mix of national and local policies	25
<i>Innovative policies with a strong input from cities</i>	<i>27</i>
<i>Projects that have not worked well: low carbon zones, eco-cities.....</i>	<i>31</i>
Central Planning, Smart City and Artificial Intelligence: is Xiongan the future of energy innovation in China?	34
<i>Beijing's challenges.....</i>	<i>34</i>
<i>Xiongan: when the national government builds its own city.....</i>	<i>37</i>
CONCLUSION: THINK NATIONAL, ACT LOCAL?	41

Introduction

Cities recently imposed themselves as central actors in the energy and climate change arena. The *Global Climate Action Summit* held in September 2018 made the point: by their action, local governments can be instrumental in addressing climate change. Some cities in the United States (US) even challenge Donald Trump's decision to withdraw from the Paris Agreement on Climate.² China was one of the prominent participants in the Summit. However, its main representative was not a local governor or a mayor, but Xie Zhenhua, special representative for climate who reports directly to the central government.

The prominent role of the central government questions the weight cities can have today when it comes to China's energy policies. Given the centralized structure of the country, can they impulse changes through innovations and policies that would later expand to the rest of the country, and possibly beyond? As numbers of low carbon zones and green city projects have been developed over the past decades in China, will the country soon have a green-energy-focused Silicon Valley, that would impose itself as a global shaper of the climate change governance? If so, is this likely to generate some transformational change in the national political system, introducing some strong bottom-up elements?

This paper analyzes the current local energy initiatives in China and their national and global implications. It first assesses the main issues that cities are confronted with, and draws a map of policies and local initiatives to address them. It then assesses the development projects that failed to deliver expected results (low-carbon zones such as Caofeidian in Hebei), and focuses on the most promising plan (Xiongan, also in Hebei).

2. O. Milman, "Paris Deal: A Year after Trump Announced US Exit, a Coalition Fights to Fill the Gap", *The Guardian*, June 1st, 2018, available at: www.theguardian.com.

China's growing urbanization and its challenges

Steadily growing urban population, yet with many unbalances

China's urbanization has been different from the ones of other developing or emerging countries in many aspects: it has been slower than in many other economies and has avoided number of pitfalls. From 1978 to the mid-2010s, urban population in China jumped from less than 20% to more than half, and it should reach about 70% by 2030 as the World Bank is predicting a new wave of urbanization until 2030.³ This urbanization trend was driven by two main phenomena, each of them being responsible for around 40% of new city inhabitants: 1) cities grew and eventually encompassed surrounding rural areas, turning local inhabitants into citizens, and 2) people moved to big urban centers, attracted by high wages in the cities and the need for low-skilled workers. These factors are still strong incentives to move to cities for 38% of the share of labor force still working in the agriculture sector. In 2030, it is expected that China will have 173 cities with more than 1 million inhabitants (see Table 1).

Table 1: Number of inhabitants in Chinese cities in 1990, 2018 and 2030

Number of inhabitants	Year 1990	Year 2018	Year 2030
300,000 to 500,000	65 cities	140 cities	144 cities
500,000 to 1 million	37 cities	160 cities	175 cities
1 to 5 million	32 cities	105 cities	146 cities
5 to 10 million	2 cities	13 cities	19 cities
10 million or more	–	6 cities	8 cities

Source: United Nations Department of Economic and Social Affairs (UNDESA), World Urbanization Prospect 2018.

3. World Bank and the Development Research Center of the State Council, P. R. China, "Urban China: Toward Efficient, Inclusive, and Sustainable Urbanization", 2014, available at: <https://openknowledge.worldbank.org>.

Due to inadequate policies and regional inequalities, China's urbanization has been unbalanced. Though the numbers above may look impressive, China's urbanization level has lagged behind the country's economic development, and nowadays the national urbanization rate is 10% lower than countries with similar levels of GDP per capita.⁴ This is probably due mostly to the existence of the *hukou* (interior passport) that aims at controlling population flow within the country, by restricting access to public services for migrant workers unless they are granted urban residency permits. The country also managed to avoid some of the common problems linked to rapid urbanization, such as urban unemployment and poverty, and squalor. The biggest cities are concentrated on the coast, where economic growth and job opportunities have been the highest. According to Ming, the Guangdong province in the Southeast part of the country, saw its migrant population rising from 5.23% to 22.37% between 1982 and 2005. Zhejiang, Jiangsu and Shanghai also ranked at the top of the most attractive localities for migrants, followed by Beijing and Tianjin. In parallel, the desire to develop new centers of growth has sometimes led to the establishment of "ghost towns" with wasteful investments, and experimental eco-cities are no exception as will be analyzed later in this paper.

Another direct consequence of accelerated urbanization has been the impressive increase of concrete consumption in China. A stunning figure became famous as it was quoted by the business magnate and philanthropist, Bill Gates: in three years, between 2011 and 2013, China has consumed 6.6 gigatons of cement, almost a third more than the 4.5 gigatons the US consumed over the 20th century.⁵ One can expect the consumption of building materials to decrease, as number of infrastructures have been built over the past decades. However, in 2017, China had still produced 2,400,000 thousand metric tons of cement, approximately a third more than the 1,728,300 thousand metric tons produced by the rest of the world.⁶ This voracious appetite for cement has important consequences in terms of energy consumption and air quality: the cement industry is estimated to be the largest emitter of particulate

4. L. Ming, "Myths and Realities of China's Urbanization", *Paulson Policy Memorandum*, August 2015, available at: www.paulsoninstitute.org.

5. B. Gates, "A Stunning Statistic About China and Concrete", *Gatesnotes.com*, June 25, 2014, available at: www.gatesnotes.com.

6. US Geological Survey (USGS), "*Mineral Commodity Summaries 2018*", US Department of the Interior, 2018, available at: <https://minerals.usgs.gov>.

matters (PM): it accounts for 40% of industrial PM emissions and 27% of national PM emissions.⁷

As these cities developed very quickly, the urban sprawling quickly posed number of challenges to the governments and populations.

The air quality challenge

Air quality issues are one of the most daunting of these challenges. In addition to cement production, the problem comes mostly from the rapid expansion of the use of coal in industry and power generation, which in return dramatically increased sulfur dioxide (SO₂) and nitrogen oxides (NO_x) emissions. The increase of the number of vehicles on the road has also an important impact on air quality: according to the *Xinhua* news agency, over 30% of air pollution in Beijing comes from vehicle exhaust emissions. As of late 2016, emissions of pollutants reportedly reached 40,000 tons per year, including carbon monoxide, nitrogen oxide, hydrocarbon and PM.⁸ As of 2016, it was estimated that outdoor pollution would have caused 1 million deaths, with an additional 1.2 million caused by in-door air pollution; bad air quality was reducing life expectancy by 25 months. According to the then-Ministry of Environment Protection (MEP), only 8 of 74 cities would meet the required standards for clean air in 2014.⁹ The worst situations are to be found in three urban zones: 1) Beijing, Tianjin and the Hebei province, which is said to be the worst in the world, as well as 2) Yangtze River Delta (around Shanghai) and 3) the Pearl River Delta (with Shenzhen and Hong Kong). According to Lu *et al.*¹⁰, the average air quality in these cities is much higher than the World Health Organization (WHO) standards. Statistics show improvements in some areas: PM 2.5 pollutant¹¹ emissions have been reduced by 19% during the 2005-2015 period, while SO₂ emissions have decreased by a third. However, over the same period, NO_x increased by a third, mostly due to the increase of the number of cars.¹² Recent studies also show some

7. A. Hasanbeigi, N. Khanna, and L. Price, "Air Pollutant Emissions Projections for the Cement and Steel Industry in China and the Impact of Emissions Control Technologies", *Lawrence Berkeley National Laboratory*, March 2017, available at: <https://china.lbl.gov>.

8. "Beijing Removes 340,000 High-Emission Vehicles from Roads in 2016", *Xinhua News*, November 2nd, 2016, available at: www.xinhuanet.com.

9. International Energy Agency (IEA), "World Energy Outlook Special Report: Energy and Air Pollution", 2016, pp. 169-189.

10. F. Lu, W. Wei, and W. Zhang, "China Air 2015. Air Pollution Prevention and Control Progress in Chinese Cities", *Clean Air Asia*, 2016, available at: www.ccacoalition.org.

11. PM 2.5 are small particulate matter of a diameter of 2.5 microns or less, which generate cardiovascular and respiratory diseases as well as cancers.

12. International Energy Agency (IEA), "World Energy Outlook Special Report: Energy and Air Pollution", *op. cit.*

significant improvements, starting from 2015, probably as a result of aggressive policies enacted by the central government.¹³

Indeed, the Chinese government has made the improvement of air quality a key priority and taken measures to address these issues. The first plan against pollution covered the 2013-to-2017 period with a EUR 243 billion investment, and put the emphasis on the three geographical areas mentioned above. Results include emissions reduction of 15% in the Pearl River Delta region, and of 33% in the Beijing region. The second plan was issued in 2018 and will run for three years. It targets PM reduction of 35%, which is consistent with the objectives set by the 13th Five-Year Plan. It replaces the Pearl River Delta region with a new one, the so-called Fen Wei Plains, that includes the city of Xi'an as well as the Henan and Shanxi Provinces. More specifically, the plans target the use of coal in industry and power sectors, polluting vehicles, and also includes measures on air quality monitoring.¹⁴ This policy is also believed by experts to involve tougher evaluation of the local governments by the central government, and also more financial support through fiscal transfers.¹⁵

The building sector challenge

Building energy consumption and related pollutant emissions are directly linked to air quality issues.

Energy consumption in China's building sector has been continuously increasing, mostly due to the steady rise in incomes. As the urban population gets richer, it increases the size of its apartments: floor space of urban residential buildings and per capita floor space are both increasing. From 2008 to 2013, China's building energy consumption, excluding biomass energy, increased from 380 to somewhere between 735 and 789 million tons of oil equivalent (toe). These trends are unlikely to slow down in the near future, for two main reasons:

- A vast gap remains between China and many rich countries in terms of energy consumption per capita. For instance, US households use ten times more electricity than the Chinese ones;
- And China's urbanization is continuing, and urban households tend to

13. B. Silver, C. Reddington, S. Arnold, and D. Spracklen, "Substantial Changes in Air Pollution across China during 2015 to 2017", *Environmental Research Letters*, October 2018, available at: <http://iopscience.iop.org>.

14. State Council (Guowuyuan), "Guowuyuan guanyu yinfa daying lantian baowei zhan sannian xingdong jihua de tongzhi [State Council's Notice on the three-year action plan to win the war for the blue sky]", July 2018.

15. F. Hao, "China Releases 2020 Action Plan for Air Pollution", *China Dialogue*, June 7th, 2018, available at: www.chinadialogue.net.

consume more energy than rural ones (about 1.4 more, on average).

China's building energy intensity is growing rapidly due to local habits and operating practices of dwellers (because of cultural habits and acceptance of larger expanded indoor temperature range),¹⁶ but residential energy intensity is likely to remain lower than in most OECD countries (which is not true for commercial building energy intensity). This growth of building-related energy consumption generates number of urban issues, such as air pollution, the need to provide for indoor comfort (e.g. maintaining an indoor cool temperature during winter or summer without increasing the energy consumption), and others.

Building efficiency is addressed by a number of policies. Building codes started to appear in China in the 1980s and have become more and more stringent over the years. Now, their coverage includes design, construction, operation stages. They also take local climate zones into consideration and cover mandatory measures in all types of buildings in terms of their envelopes, heating, ventilation systems, air conditioning, and power systems. Potentially, these codes can reduce the energy consumption of a building by 13 to 22% and related CO₂ emissions by 14 to 20%.¹⁷ According to the inspections conducted, the compliance level is significantly increasing over the years. In 2008, the Ministry of Housing and Rural-Urban Development (MOHURD) issued two ratings and labelling programs: the Green Building Evaluation and Labelling (GBEL) and the Building Energy Efficiency Evaluation and Labelling (BEEL). The current 13th Five Year Plan (FYP) also aims at green certification for 50% of all new buildings in urban areas. Building efficiency is also mentioned in China's Nationally Determined Contribution, submitted in preparation of the COP 21 Paris Conference on Climate.¹⁸ However, these programs tend to suffer from the lack of local expertise and of oversight.

In addition to these national policies, rich cities have also enacted local regulations that are more stringent than the national ones. Beijing and Tianjin have their own building codes and Ohshita *et al.*¹⁹ report that close to 20 cities have set their own building efficiency targets that are

16. N. Zhou, N. Khanna, and W. Feng, "Policy Roadmap to 50% Energy Reduction in Chinese Buildings by 2050", ACEEE Proceedings, 2016, available at: <https://aceee.org>.

17. S. Yu, M. Evans, and Q. Shi, *Analysis of the Chinese Market for Building Efficiency*, Pacific Northwest National Laboratory, 2014, available at: www.pnnl.gov.

18. National Development and Reform Commission of China (NDRC), "Qianghua yingdui qihoubianhua xindong – Zhongguo guojia zizhu gongxian" [Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions (unofficial translation)], UNFCCC, 2015, available at: www4.unfccc.int.

19. S. Ohshita, J. Zhang, L. Yang *et al.*, "China Green Low-Carbon City Index. Report on the Performance of 100+ Cities (2010-2015)", Berkeley: Lawrence Berkeley National Laboratory, May 2017, available at: <https://china.lbl.gov>.

more ambition than the 13 FYP's ones.²⁰ During Autumn 2018 and in the context of the international C40 initiative, the four Chinese cities of Beijing, Fuzhou (Fujian Province), Qingdao (Shandong Province), and Shanghai also pledged to completely remove GHG emissions from their buildings. Some central government institutions are part of this effort, for instance the Center of Science and Technology and Industrialization Development of the Ministry of Housing and Urban-Rural Development (MOHRD). Some specific policies have been highlighted to reach this goal:

- ▀ Promotion of the construction of ultra-low energy efficiency buildings in Beijing,
- ▀ Scaling renewable energy utilization in buildings in Fuzhou, including solar thermal hot water, surface water and ground source heat pumps, air source heat pump, and solar photovoltaic in residential, commercial, and public buildings,
- ▀ Financial incentives for energy retrofits in residential buildings in Qingdao, and
- ▀ Acceleration of energy efficiency upgrade of existing commercial and public buildings in Shanghai.²¹

The heating challenge: an example of tensions between local and central government

China is also facing a very concrete building efficiency policy issue, which is directly caused by the lack of comfort of number of citizens, an issue that led to tensions between the national and city governments. This problem relates to a North-South division, that defines which part of China is entitled to district heating, and which one is not. The central government set up this division in the 1950s, with a line running along the Qin mountains and the Huai river (the Qin – Huai line). Regions located in the North of this line usually enjoy heating from November 15th to March 15th. However, regions located in the South of this line can also suffer from cold winters. For instance, during winter 2011, average temperatures were below 10 degrees, and often below 5 degrees in at least 7 big cities that do

20. Data from these paragraphs taken from: W. Feng, N. Zhou, S. de la Rue du Can, M. Bendewald, and E. Franconi, "Building Energy Codes in China: Recommendations for Development and Enforcement", Paulson Institute, CEO Council for Sustainable Urbanization, and China Center for International Economic Exchanges, October 2015; Q. Xiao, Z. Ma, S. Li, and Y. Liu, "The Impact of Winter Heating on Air Pollution in China", 2015, available at: <http://journals.plos.org>.

21. "Four Chinese Cities Commit to Slash Emissions from Buildings", C40 Cities Press release, September 2018, available at: www.c40.org.

not benefit from district heating: Shanghai, Nanjing, Hefei, Wuhan, Changsha, Chengdu and Guiyang.²² This situation is problematic: as citizens in these regions are now much wealthier than in the 1950s, they now aspire to more comfort and warmer dwellings. Against this backdrop, they tend to opt for inefficient and costly distributed heating solutions, such as electric heaters.

In 2005, the city of Wuhan tried to initiate the development of its own district heating system, but the project was then rejected and suspended at the central government level by MOHURD. Many financial and political issues are at stake here, but studies have shown that the development of heating systems in these cities would make sense from a number of point of views: first and most importantly, it would improve the comfort of city-dwellers, allowing them to benefit from heating infrastructure. This would also reduce the energy consumption (heating represents 45% of building's energy consumption) and energy bills: the current heating cost in South China is 1.32 times higher than in regions with district heating in North China, and would actually increase if taking comfort into account.²³ Additional gains relate to less energy-related GHG emissions (possibly reducing building-heating related emissions by at least 1.32 times in the South), and less air pollution. As the IEA shows, there is a strong political support to increase production of heat from gas-fired boilers and co-generation, against coal-fired heat production.²⁴ This is likely to result in a significant rise of natural gas contribution to heat supply.

The sustainable transport challenge

Despite the rapid development of public transportation in Chinese wealthiest cities, individual cars are spreading – which creates important issues in terms of energy security, traffic congestion, clogged cities, air quality, noises and others. China's National Bureau Statistics (NBS) estimates that between 2006 and 2015, private vehicle ownership experienced an average annual growth of 19.7%, reaching over 140 million vehicles. In Beijing only, car-use increased six-fold from 1986 to 2017. This growth should continue if not accelerate in the foreseeable future.²⁵

22. It should be noted that south of this line, lies a zone considered as “Hot Summer and Cold Winter” by the China Academy of Building Research. This zone includes big cities such as Shanghai, Hangzhou, Nanjing, and Wuhan.

23. J. Guo, Y. Huang, and C. Wei, “North-South Debate on District Heating: Evidence from a Household Survey”, *Energy Policy*, 2015, available at: www.sciencedirect.com.

24. IEA, “District Energy Systems in China: Options for Optimization and Diversification”, 2017, available at: <https://webstore.iea.org>.

25. J. Guo *et al.* and NBS, 2014, available on www.stats.gov.cn.

Inevitably, the multiplication of cars generates an increased energy consumption: consumption of the Chinese road transport segment for instance represents about 85% of the national oil consumption, and, under the current trends, the demand is poised to continue growing at an average rate of 6% per year which could lead to a quadrupling of oil consumption by 2030, representing more than two-thirds of the overall national oil demand increase.²⁶ This creates important energy security issues as it fuels the growth of imports. Air pollution has also become a major issue in big Chinese cities, as highlighted above. Cars represent 10 to 12% of national CO₂ emissions, and are responsible to up to 30% of particle matters in some cities.²⁷

The government has issued a number of policies to address these issues, and China is investing important efforts in order to develop sustainable transportation. This was reflected in the 12th FYP (2011 – 2015), which included the “promotion of a comprehensive, smart, green and safe transport” and the formulation of transportation plans for two regional development programs: the Beijing-Tianjin-Hebei Integration Initiative, the Yangtze River Economic Belt Initiative, as well as for the Belt and Road Initiative (BRI). As a follow up, the 13th FYP mentioned for the first time the concept of “low carbon development in the transport sector” and stresses the need for an efficient intelligent, green, integrated and inter-connected infrastructure network, though the targets mostly touch upon non-urban areas, by focusing for instance on high-speed trains, highways, and air or sea transportation. It is complemented by China’s Nationally Determined Contribution which includes the objective of increasing to 30% by 2020 the share of public transport in motorized travels and in large-and-medium-sized cities.²⁸

The government is also pushing for the development of vehicles with fewer emissions – this is for instance stressed in the *Made in China 2025*, a technology roadmap that includes one chapter (out of 10) on Energy Saving and New Energy Vehicles. *Made in China 2025* aims at a domestic share of

26. Cathorpe Associates *et al.*, “Emerald Cities: Planning for Smart and Green China, Energy Innovation and Energy Foundation China”, 2018, available at: www.efchina.org.

27. S. Ibold, “Overview of China’s Five-Year Plans in the Transport Sector – Issue 1: Transportation in the 13th Five-Year Plan for Economic and Social Development of the People’s Republic of China 2016-2020”, GIZ China Sino-German Cooperation on Low Carbon Transport, December 2017, available at: www.sustainabletransport.org.

28. National Development and Reform Commission of China (NDRC), “Qianghua yingdui qihoubianhua xindong – Zhongguo guojia zizhu gongxian. Enhanced Actions on Climate Change: China’s Intended Nationally Determined Contributions (unofficial translation)”, UNFCCC, 2015, available at: www4.unfccc.int.

New Energy Vehicles of around 70% by 2020, and 80% for 2025.²⁹ In terms of electric vehicles (EV), the objective is to have 5 million EVs on the roads by 2020. There are three main types of policies that have increased China's market and allowed it to become the biggest in the world:

1) Customers are strongly encouraged to acquire EVs, e.g. through subsidies that represent on average 23% of the price of the car from both national and local governments;³⁰

2) Innovative local policies encourage the use of EVs: cities like Beijing or Shanghai are exempting EVs from existing policy restrictions to the acquisition of new cars, such as the lottery system (potential buyers can only acquire a vehicle through a lottery system, the average time to “win” this right is said to be about two years). Cities are also electrifying their fleets: in late 2017, the city of Shenzhen, home of BYD, a pioneer in terms of EVs, replaced its bus fleet with 15,000 electric buses. At that time, there were already around 380,000 electric and plug-in hybrid buses in the country;³¹

3) Important investments are made to expand infrastructures: 107,000 public charging outlets have been installed in 2015, and altogether there were 230,000 of them in 2018. In addition, the Chinese market is also protected from foreign car-makers, which represent only 4% of the plug-in electric vehicle (PEV) sales.³² These policies have allowed China to become a world leader in that field, as half of the world's PEVs produced in 2017 came out of Chinese factories, and the Chinese market represented in 2017 about half of the 1.2 million plug-in vehicles sold worldwide; Chinese carmakers manufactured 47% of the PEVs sold on that same year.³³ The objective is to reach 7 million EVs sold by 2025.³⁴ China is also leading the battery market, as it ensures 25% of the global supply.³⁵

29. J. Wübbeke, M. Meissner, M. J. Zenglei, J. Ives, and B. Conrad, “Made in China 2025: The Making of a High-Tech Superpower and Consequences for Industrial Countries”, *MERICCS Paper on China*, No. 2, Mercator Institute for China Studies, December 2016, available at: www.merics.org. Ministry of Industry and Information Technology (MIIT), “‘Zhongguo Zhizao 2025’ jieduzhi: Tuidong jieneng yu xinnengyuan qiche fazhan” [Interpretating ‘Made in China 2025’: the Promotion of Energy Saving and New Energy Vehicle Development], May 2016, available at: www.gov.cn.

30. J. Pontes, “2017 China Electric Car Sales Blow World Out of the Water – BAIC EC-Series Is A Superstar”, *Cleantechnica*, January 29th, 2018, available at: <https://cleantechnica.com>.

31. Asian Development Bank (ADB), “Sustainable Transport Solutions: Low-Carbon Buses in the People's Republic of China”, November 2018, available at: www.adb.org.

32. J. Pontes, *op. cit.*

33. *Ibid.*

34. C. Jun, “Climate Change Cooperation Is a Silver Lining”, *US China Daily*, September 20th, 2018, available at: www.chinadaily.com.

35. P. Hertzke, N. Müller, and S. Schenk, “China's Electric-Vehicle Market Plugs In”, *McKinsey Quarterly*, July 2017, available at: www.mckinsey.com.

The development of hydrogen-fuel cell battery (HFLB) vehicles is also a national priority, China aiming at becoming the world leader in that technology. HFLB is part of the *Made in China 2025* plan. In 2017, China produced 1,000 HFLB vehicles, breaking a world record. The objectives are to reach 3,000 by 2020 and no less 1 million by 2030. In order to accommodate these new vehicles, China is also ramping up its infrastructures, with 12 fueling stations across the country as of late 2018, and 19 additional ones under construction. Policies target in priority hydrogen-powered buses, which benefit from both central and local government-levels subsidies. Currently, such buses can be found in the cities of: Foshan (Guangdong Province, more than 7 million inhabitants), Yancheng (Jiangsu Province, more than 8 million inhabitants), Zhangjiakou (Hebei Province, more than 4 million inhabitants) and in Beijing and Shanghai. Other city-level initiatives include a United Nations Development Program (UNDP) project running from 2016 to 2020 that aims at demonstrating the application of hydrogen production and application technology in the city of Rugao, right by the North of Shanghai.

The city of Wuhan (Hubei Province) also has plans to become a leader in that technology. It is developing a hydrogen industrial park with factories from 100 fuel cell automakers and related companies. This should help the city becoming a world leader in hydrogen production storage, transport and infrastructures. The city is building 20 hydrogen fueling stations that should have the capacity to support approximately 3,000 hydrogen fuel-cell-powered vehicles. By 2025, the city aims at having between 30 to 100 stations. By then the annual production value of hydrogen fuel cells is estimated to exceed EUR 13.7 billion.³⁶ The city is competing with other projects, as Rugao's (see above), as it also ambitions to become "a hydrogen city". Finally, in the city Qingdao, the railway company China Southern Rail Corp. (CSRC) has developed a hydrogen-powered tram.³⁷ Some car producers are already targeting foreign markets, such as BYD which will produce buses for the Honolulu airport, in Hawaii.³⁸

36. "Report: Wuhan to Build Itself into a 'Hydrogen City'", *Green Car Congress*, January 22nd, 2018, available at: www.greencarcongress.com.

37. Society of Automotive Engineers of China (SAEC), *Hydrogen Fuel Cell Vehicle Technology Roadmap*, (translation), 2017, available at: www.ieafuelcell.com, "Hydrogen City' to Be Built in Central China", *Xinhuanet*, January 21st, 2018, available at: www.xinhuanet.com; Wang Keju, "Hydrogen on Track to Drive China's Development", *China Daily*, June 5, 2018, available at: www.chinadaily.com, and Y. Shenggao, "Hydrogen Cars Set to Take Off", *China Daily*, August 2nd, 2018, available at: www.chinadaily.com.

38. "Firms Partner to Bring New Zero Emission Transportation to Honolulu Airport (HNL)", *BYD Press release*, May 2nd, 2018, available at: <http://en.byd.com>.

Finally, *Made in China 2025* also includes measures on the energy performance of combustion engine vehicles. This echoes the Energy Saving and New Energy Vehicle Industrial Development Strategy Plan running from 2012 to 2020. China is pursuing an aggressive policy in terms of fuel efficiency standards, some of them being implemented first in pilot cities. The Standard China VI for light-duty vehicles (LDV) has been developed in 2016 by the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) and the Standard Administration of China (SAC). It sets up standards that are more stringent than the ones in force in Europe and in some aspects to EURO VI) in terms of diesel and gasoline.³⁹ These measures are to be implemented in two phases: 2020 for LDV of no more than six passengers including the driver, and then 2023 for the others LDVs. Requirements include for each car produced after 2020 to consume 5 liters of fuel per 100 km (against 6.9 liters now).⁴⁰ In line with the 2013 Air Pollution Control Action Plan, the region around Beijing will implement China VI earlier than the rest of the country. This region includes “2+26 cities”, i.e. Beijing and Tianjin, plus 26 other cities from the four surrounding provinces (8 cities from Hebei, 4 from Shanxi, 7 from Henan, and 7 also from Shandong). The standards there have been adopted in late 2017, and should be fully implemented by January 1st, 2019.⁴¹

39. H. Cui and R. Minjares, “China VI: A Milestone for the World’s Transition to Soot-Free Vehicles”, The International Council on Clean Transportation, 2018, July, available at: www.theicct.org.

40. C. Clover, “China Fuel Economy Rules set to Drive EV Production”, *Financial Time*, January 24, 2018, available at: www.ft.com.

41. ICCT, “Early Adoption of China VI Vehicle Fuel Standards in Jing-Jin-Jin and Surrounding Areas”, *Policy Update*, April 2018, available at: www.theicct.org.

The policy dimension: strong central planning and local ambitions

The Chinese national and local governments are fully aware of the challenges that cities are currently facing. The very poor and concerning air quality in some regions of the country, and citizens' discontent have urged policy makers to act. However, finding the most appropriate and efficient policy remains a challenge.

The existing framework – a mix of national and local policies

China's institutional framework is a mix of a centralized and decentralized governance, with on the one hand a powerful national government in charge of setting up priorities and managing finances, and on the other hand, local governments that would enjoy some flexibility (or sometimes, take some liberties *vis-à-vis* central government directives) in policy implementation. This translates into four main types of energy policies for cities summarized in Table 2. At the national level, the most notable policies in the energy sector listed by the International Energy Agency (IEA)⁴² are the following:

- The Energy Production and Consumption Revolution Strategy 2016-2030,
- Made in China 2025,
- The Five -Year Plans (currently running is the 13th, from 2016 to 2020) and their sub-plans, focusing on specific sectors,
- The National Plan for Tackling Climate Change (2014-2020), issued in 2014,
- The Energy Technology Revolution Innovation Plan (2016-2030).

42. IEA, "Part C. China Energy Outlook", *World Energy Outlook 2017*, November 2017.

Table 2: Type and list of policies influencing city-level energy measures

Type of target	Type of policies	Origin of the policy	Examples	Geographic coverage
National	Plans, programs, often with specific goals	Central government	- Five-year plans - Made in China 2025	Covers all the country, but with targets sometimes declined into specific targets adapted to each provinces and cities, as for instance for the national energy intensity target which starting from the 12 th FYP has been declined into specific local targets
Sectoral	Sectoral plans	Central government	Further Deepening the Reform of the Electric Power System	National
Limited to specific regions	National plans, but with specific focus	Central government	Plans against pollution	Beijing & Tianjin; Shanghai region (1 st & 2 nd plans); Pearl River Delta (1 st plan only), Xian region (2 nd plan only)
Limited to specific regions	Experimentations, before adoption at national level	Central government	Emission trading schemes (ETS)	Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong, Shenzhen
Local	Local policies	Local government, with strong central government support/impulse	Alliance of Pioneer Peaking Cities (APPC)	Depends on the measures, often rich cities
Local	Local policies	Local government	Suzhou energy star program	Mostly rich cities

Innovative policies with a strong input from cities

At the local level, some cities are complementing the national framework with innovative policies: the purpose of these can either be to help them reach the goals and targets set up at the national level, or to appear as “best-in-class” with local policies that, if successful, may later be adopted at the national level.

Promoting energy efficient cooling and heating through centralized district energy systems

China is an important player in the field of district energy systems. The IEA defines district energy systems as “a proven solution for delivering heating (including hot water) and cooling services”, and insists on the fact that they are “an inherently diverse system that connects multiple thermal energy users through a network of insulated pipes to efficient or renewable energy sources, such as co-generation (often referred to as combined heat and power, or CHP), industrial excess heat (IEH), municipal waste, biofuels, geothermal heat, and solar and wind energy. Because they can use diverse energy sources, including locally available resources, district energy systems are flexible, allowing for economies of scale as well as reliable heating and cooling services, without depending on a single supply source”.⁴³ According to the same IEA report, China has built the world’s largest district energy system, with a total of 192,721 km of hot water networks and of 11,692 km of steam networks in 2015. The district heating generation system in 2015 would consume more than 185 million tons of coal equivalent, and covering around 8.5 billion m² (three times the surface covered in 2005).

The country abounds with district energy projects, some aiming at modernizing existing ones as in Anshan. This city is located in the Northeastern province of Liaoning, and has the objective of reducing its coal consumption by 1.2 million tons. Until the mid-2010s, it had a fragmented district heating system, dominated by private and state-owned companies. They would operate separate networks, fueled by inefficient coal boilers that are not optimized for the load on the network. The program it engaged in the 2010s with the support of the Danish company Danfoss is to pool separate networks and to capture 1 gigawatt of waste heat from a steel plant from the Angang company. The transmission line is to be co-owned by a municipal company and a private one, and it should

43. IEA, “District Energy Systems in China: Options for optimization and Diversification”, 2017, available at: <https://webstore.iea.org>.

allow further connections to local heat networks and Combined Heat and Power (CHP) plants.⁴⁴ In addition, boilers will be modernized with more efficient equipment. Danfoss invested RMB 170 million in a local heating facility that opened in June 2018.⁴⁵

Promoting Energy Efficiency Labelling: The Suzhou Energy Star Program

City-level initiatives are also used to promote energy efficiency, as for the Suzhou Energy Star Program. Suzhou is a city located near Shanghai, in the Jiangsu province. In 2015, it had a population of more than 10 million, and a GDP of RMB 14500 billions, ranking it as a wealthy Chinese city. Suzhou is trying to move away from its industrial structure, with approximately half of its GDP based on services, with a 18% energy intensity reduction target for 2020 and a goal of peaking its emission by 2020.

The local Energy Conservation Center, a government branch representing the central body in charge of energy efficiency policies, established the Energy Efficiency Star (*Nengxiao zhi Xing*) program in order to reach its energy intensity targets during the 11th Five-Year Plan (FYP). The program continued then and is now used to reach further targets. It consists in a labelling scheme, inspired by the US Energy Star Rating Program: after conducting energy audits, the government provides companies with a number of stars, based on their energy performance. The program started with local companies in the late 2000s and then expanded to global companies with production bases in the region, such as H&M, Gap, Intel, Walmart and IKEA. The stars are awarded depending on the energy efficiency measures implemented by the company. Three stars award an energy performance at the top the Jiangsu province, while five stars (the maximum) means an energy performance at the top of international standards, with global best practices. The stars are available during three years and are awarded after evaluating different elements: energy performance, energy management systems, technological advancements.⁴⁶

By November 2017, the program had awarded five stars to 1 company, four stars to 4 companies and 3 stars to 27 ones.⁴⁷ Altogether, the

44. UNEP, "District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy", 2015, available at: <https://wedocs.unep.org>.

45. "New Plant of Danish Heating Group Starts Operation in Northeast China", *Xinhuanet*, June 10, 2018, available at: www.xinhuanet.com.

46. "Suzhou Energy Efficiency Star Program", Supply China Initiatives Database, Institute for Industrial Productivity, available at: www.iipnetwork.org.

47. "2017 Niandu Suzhou shi "nengxioa zhi xing" sanxing ji yishang chuangjian qiye mingdan gongshi" [List of companies with three stars and more in the Suzhou Energy Efficiency Star Program], Suzhou

33 companies invested RMB 194 million in energy saving measures, and saved about 47,500 tons of standard coal.⁴⁸ The program is supported at the central government level, by the Ministry of Industry and Information Technology (MIIT). Local leaders were initially hoping that their initiative would gradually be adopted in other parts of the country, before becoming a national program.⁴⁹ This has so far not been the case.

City-level climate policies: **The Alliance of Pioneer Peaking Cities**

Chinese cities go further than adopting clean energy policies, and can also plan long-term climate actions, as a local translation of the country's national goals. This is the case with the Alliance of Pioneer Peaking Cities (APPC). It gathers about 25 Chinese cities that all committed to reach a GHG emission peak before the national goal, i.e. 2030. It is the first time in China that cities are setting up their own low-carbon target, each of them having different ambitions: Ningbo is the leading city, with target set for 2018, while a group of 7 cities have adopted a target similar to the national one (Table 3). Measures to be adopted in order to meet the ambitions are summarized by the Rocky Mountain Institute (RMI)⁵⁰ and include measures targeting an economic transition, the use of more efficient materials, alongside demand and supply measures: 1) industrial shift, 2) demand reduction through materials, 3) energy efficiency, and 4) decarbonization. RMI identifies five groups of cities (Table 3).

The program has attracted important attention at the national and even international levels, and one can question the role of the cities (as opposed to the national government) to impulse the program: the Alliance is in line with the 16th Five-Year Plan, which mentions the need for cities to set up objectives of peaking emissions ahead of the national target. In addition, the NDRC listed 42 cities and provinces that should be part of the national effort. The political dimension of the APPC is also highlighted by the fact that the Alliance was officially announced at a US-China Climate Leaders Summit, in California, in September 2015.⁵¹ Further announcements were made during a follow-up high-level political event, the 2016 China – US Climate Smart/Low Carbon Cities in Beijing, in June

Economic & Information Technology Commission (*Suzhoushi Jingji he Xinxihua Weiyuanhui*), November 8th, 2017.

48. Interview with one of the program coordinators, February 2nd, 2018.

49. Interview with the local government, June 2010.

50. Rocky Mountain Institute (RMI), "City Peaking Decarbonization Handbook", 2017, available at: <https://rmi.org>.

51. "Fact Sheet: US – China Climate Leaders Summit", The White House, Office of the Press Secretary, September 15, 2015.

2016.⁵² The initiative also benefits from international cooperation, with prominent clean-energy US NGOs providing support – including the Rocky Mountain Institute, the World Resources Institute, the US-funded China Energy Foundation, as well as the recently established Innovative Green Development Program (iGDP).

Table 3: Characteristics of the first cities to be part of the APPC

Cluster	City	Tertiary share	Scheduled peaking year
1. Low GDP/carbon emissions per capita	Guangyuan	30 to 40%	2030
	Zunyi	30 to 40%	2030
	Guilin	30 to 40%	2030
	Ganzhou	40 to 50%	2023
2. Moderate GDP per capita, increasing carbon emissions	Wenzhou	50 to 60%	2019
	Nanping	30 to 40%	2020
	Yan'an	20 to 30%	2029
	Guiyang	50 to 60%	2025
	Chizhou	40 to 50%	2030
	Jilin	40 to 50%	2025
	Jincheng	40 to 50%	2023
3. Moderate GDP, high carbon emissions	Jinchang	20 to 30%	2025
	Urumqi	60 to 70%	2030
4. Relatively high GDP and mid-range carbon emissions	Wuhan	50 to 60%	2022
	Ningbo	40 to 50%	2018
	Zhenjiang	40 to 50%	2020
	Qingdao	50 to 60%	2020
	Beijing	Over 70%	2020
5. High GDP per	Guangzhou	60 to 70%	2020

52. “23 Chinese Cities Commit to Peak Carbon Emissions by 2030”, *WRI Blog*, June 08, 2016, available at: www.wri.org.

capita, falling carbon emissions	Shenzhen	50 to 60%	2022
Other	Suzhou	40 to 50%	2020

Source: RMI (2017).

Local Emissions Trading Schemes

The local Emission Trading Scheme (ETS) is another important local policy with a direct impact on city/local-energy systems. The ETS has been designed as a pillar to address China's climate goals of lowering its CO₂ emissions per unit of GDP by 40 to 45% by 2020 from 2005 level, and to peak the CO₂ emission by 2030 or earlier. The scheme has so far only been initiated as a trial in 7 cities and provinces, starting from 2013: Beijing, Shanghai, Tianjin, Shenzhen, Chongqing, as well as the provinces of Guangdong and Hubei. These local trials were supposed to be transformed into a national scheme that would cover most GHG-emitting sectors. However, announcements made by the government in late 2017 have casted some doubts about the coming national carbon scheme, which should only be operational by 2022 and only cover the power sector.⁵³

Projects that have not worked well: low carbon zones, eco-cities

The development of green cities or low-carbon zones has not always been successful though. Special zones benefit from preferential economic policies, and some of them (Shenzhen, for instance) have strongly contributed to China's impressive economic growth during the past 40 years. Local governments have strong incentives to establish their own special zones, with a special focus on low-carbon or green economy zones since the late 2000s:

The first Chinese eco-city (*shengtai shi*) dates back to 1985, with the city of Yichun (in Jiangxi province) and its experimental project on agro-ecology. This initiative marked the beginning of research activities on the concept, led by the State Statistics Bureau, the Chinese Academy of Sciences and the body in administration of environment protection. In 2003, these research initiatives resulted in a list of indicators defining eco-provinces, eco-cities and eco-counties. They included elements from various perspectives: economics, environment, and social. That same year, Yangzhou (Jiangsu province) was awarded the status of "national eco city". The indicators were revised in 2008, and started including important

53. T. Voïta, "China's National Carbon Market: A Game Changer in the Making", *Édito Énergie*, Ifri, March 2018, available at: www.ifri.org.

energy elements, such as energy intensity. In the meantime, various policies were enacted in order to accelerate the development of these low-carbon initiatives (table 4). They were followed by a number of announcements of new green zones. For instance, in 2006, Dongtan (Chongming island, north of Shanghai) was announced as being the first “zero-carbon’ eco-city in China and was followed by the Sino-Singapore Tianjin Eco City, the Caofeidian International Eco-city (near Tangshan, in Hebei province).⁵⁴

Table 4: National programs promoting sustainable development in cities

Name	Central administration in charge	Launching year
National Forest City	National Forestation Committee and State Forestry Administration	2005
National Eco-city	National administration in charge of environment	2002
National Environmental Technology Industrial Park	National administration in charge of environment	2000
National Eco-Industrial Demonstration Park	National administration in charge of environment, Ministry of Commerce, Ministry of Science and Technology	2000
Eco-demonstration Region	National administration in charge of environment	1995
National Garden City	MOHURD	1992

Source: T. Zou, "Eco-city Indicator Systems Evolving: The Case of China", presentation at the Eco-cities in the making: Sustainability and the dynamics of place & scale, International Conference, Songdo/Incheon Yonsei University, 20th August 2014.

Many of these projects, despite the enthusiasm they first generated, turned out to be failures and were abandoned, or were substantially changed. Caofeidian is a good example of what can go wrong. It is a 2,000 km² area located in the North of Bohai Bay, close to a harbor. This area was chosen to become a platform for petrochemicals, steel, electricity, and port activities. In 2005, the steel company Shougang decided to

54. T. Zou, “Eco-city Practices in China: Learning from Failure and the Transformation of Implementation Mechanism”, presentation at Cleaner Production for Livable Cities, SWITCH-Asia Networking Conference, 2014.

develop part of its production there. The area also benefited from the 2007 – 2008 stimulus plan, that aimed at countering the effects of the economic crisis. All this helped the government promote the new concept of “Symbio City”, developed by a Swedish company, and that would involve a complex set of indicators to measure the green achievements of the zone: these included urbanistic considerations as well a land-use, energy, building waste and transport. However, in the 2010s, the funding stopped and many investors withdrew from the project. Other problems came up for the area: the Swedish company left the project as it was not duly paid. The neighboring harbor, that was supposed to be part of the development zone, started its own new town development. Local bureaucrats who had supported the project were moved to other positions. Finally, Caofeidian also suffered from the competition of similar projects conducted in the neighboring city of Tianjin. In 2016, it was estimated that the zone’s bad loans could amount to billions of yuans. The Hebei province does not have resources to support the project anymore, and focuses its attention on other cities, including the local capital, Shijiazhuang.⁵⁵

The city of Baoding, also located in Hebei, is another example of a failed low-carbon project. The 11 million population city became in 2010 a pilot for low-carbon zones, which included the plan to use renewable energy for street lighting and residential heating. It set a goal of GHG emissions reduction of 52% by 2020, significantly higher than the 40-45% national one. Baoding would benefit from Yingli, a major solar company’s industrial park, that also includes wind company factories. That was not enough to turn the city into a green zone, and the local bureaucrats lacked guidance from the central government and probably did not have a clear vision on how to reach their ambitious objectives. They were unable to develop an appropriate policy framework, and failed to modernize its heavy industries like steel and cement production, infamous for their inefficient and polluting equipment such as coal-fired steam boiler systems. The new facilities developed to manufacture solar panels also contributed to the increase of energy consumption and additional pollution. The air quality did not improve. In 2013, the level of harmful particles was 40% above

55. Field visits in 2008-2009. See also W. Wu, “What Really Happens When Chinese Investment Goes Bad, and It There Any Way out of the Hole?”, *South China Morning Post*, June, 22, 2016, available at: www.scmp.com and “USD 16 to 20 billion already spent on Singapore Tianjin eco-“ghost” city”, *The Independent*, September 11, 2016, and M. De Jong, “The History and Geography of the Eco City Indicator and System in China: How Did the Eco-City Assessment Framework Evolve in China and How Is It Used in a Variety of Eco-City Projects around the Nation?”, Proceedings from a Workshop at the Tsinghua Urban Tongheng Urban Planning & Design Institute, April 19, 2015.

Beijing's, and in 2015 Baoding had become China's city with the worst air quality.⁵⁶

Few reasons can be invoked to explain these failures, most of them come from poor design and management from the national government. The different sectors and administrations would not cooperate, making it difficult for local governments to obtain the support they need. For instance, different ministries or administrations (NDRC, State Environment Protection Administration/Ministry of Environment and Ministry of Housing and Urban-Rural Development – MOHURD) had developed their own sets of indicators, which generated confusion among local governments. Some would also argue that these indicators suffer from the fact that they are too “fact-sheet oriented”, with the sole purpose to assess whether the local governments are working well, from a top-down perspective. Some projects, for instance in Tianjin, may also have turned out to be successful from an investor perspective, but failed to achieve their environmental goals.⁵⁷

Central Planning, Smart City and Artificial Intelligence: is Xiongan the future of energy innovation in China?

These failures probably created incentives for the central government to create its own local green-city project, the Xiongan development zone, that aims at addressing the many challenges faced by Beijing.

Beijing's challenges

Important resources have been invested by the Beijing government to address the city's energy challenges. In order to overcome its air quality issues, Beijing has put together a number of measures aiming at changing the structure of its economy and improving the existing equipment. Guo et al. have documented the impact of various policies from 1990 and 2012 on Beijing's energy consumption structure (see figure 1 with the evolution of Beijing energy consumption).⁵⁸ They list measures taken to reduce dependency on coal, including the replacement of big stoves, small boilers, small coal-burning stoves by electric stoves in the late 1990s. In addition,

56. J. Duggan, “Welcome to Baoding, China's Most Polluted City”, *The Guardian*, May 22, 2015, available at: www.theguardian.com; D. Stanway, “Pollution Plagues China's Baoding Despite Bid to Clean Up Act”, *Reuters*, May 14, 2014, available at: www.reuters.com.

57. M. De Jong, “The History and Geography of the Eco City Indicator and System in China”, *op. cit.*

58. R. Guo, P. Song, and M. Neelis, “Energy Dimensions of China's Urbanization – Business Opportunities and Challenges”, Ecofys and Rijksdienst voor Ondernemend Nederland (RVO), 2014.

industrial and thermal power plants were moved out of the cities and relocated in the Hebei province. These include 200 coking, chemical and steel firms that had to move in the run-up to the 2008 Olympic Games. Another significant move was taken by Shougang, a major steel company, that decided in 2011 to move one of its biggest plants 225 km away from the capital.⁵⁹ Beijing's five-year plans (FYP), starting from the 11th, also contributes to the transition to greener energy systems: the usage of coal is strictly limited, and coal-fired power plants and boilers are being renovated. Finally, policies encourage coal replacement by natural gas, and the development of renewable energy sources. In 2017, Beijing closed its last coal plant and the neighboring province of Hebei have ordered the most important steel-making towns to cut half of their production during winter.⁶⁰

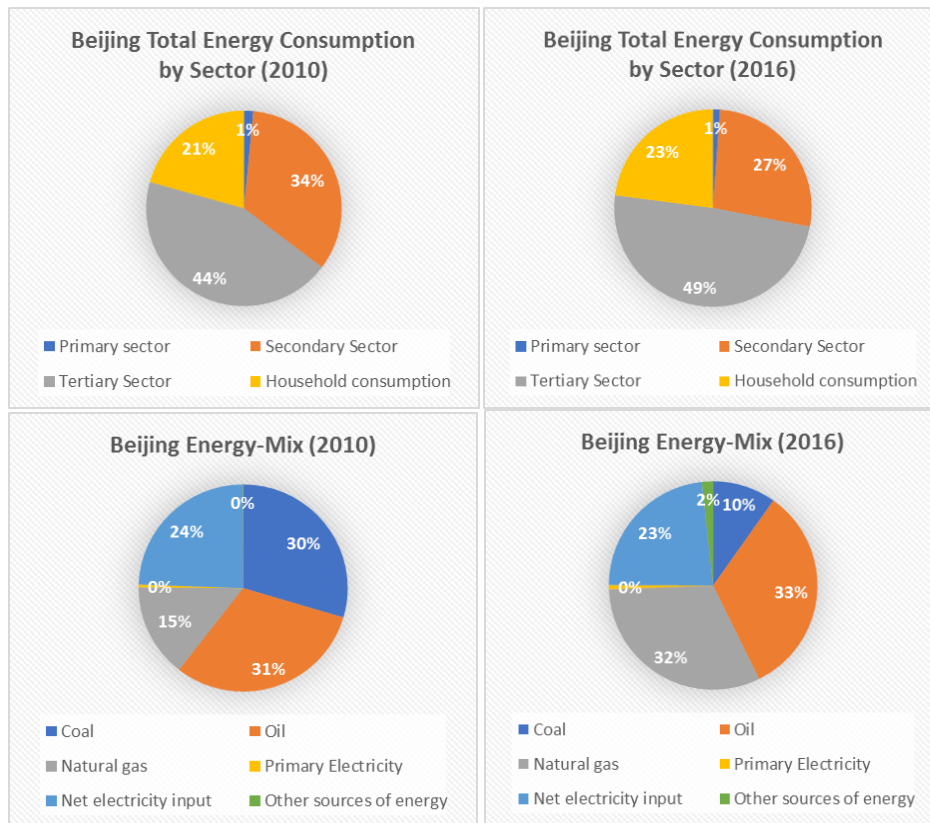
An assessment of Beijing's energy consumption evolution from 2010 to 2016 highlights the progress made during the first half of the 2010s. During that time, the city's energy consumption increased from 63.59 to 69,62 Mtce (see figure 1). Two clear trends appear, that both reflect the policy push: 1) the tertiary sector is gaining importance and was by 2016 consuming almost half of the energy, 2) the share of natural gas in the energy mix has more than doubled (from 15 to 32%), replacing coal whose share was divided by 3 (from 30 to 10%).⁶¹

59. L. Qin, "Xiong'an New District: An Old Idea if Finally Accepted", *China Dialogue*, July 25, 2017, available at: www.chinadialogue.net.

60. T. Damin, "Climate Change May Temper Grand Plans for Xiongan", *ChinaDialogue*, April 7th, 2017, available at: www.chinadialogue.net.

61. However, the Beijing statistics do not provide any further information on what "primary electricity" or "net electricity input" are referring to. Given the national energy mix that relies mostly on coal, chances are coal plays an important role in the power generation of these items.

Figure 1: Beijing energy situation: a comparison between 2010 and 2016



Source: based on data from Beijing Government, China Statistics Press, 2018.

Despite the progress made over the past years, Beijing remains plagued with important energy-related issues. Air quality has improved, but remains poor.⁶² Many of Beijing's policies just consisted in removing polluting industries to neighboring areas, especially in Hebei, without addressing the problems. The 2016 World Health Organization (WHO) ranking of the most polluted cities in the world (based on 2014 data) included five Hebei cities. The pollution from these cities does not spare Beijing, which for instance led authorities in late 2016 to issue a five-day warning, to order schools to close, residents not to go out and heavy industries to slow or sometimes halt production.⁶³ The situation seems to be gradually improving in these cities, though.⁶⁴

62. Z. Pinghui, "Beijing's Choking Smog Is Back and the Government Is Blaming Perfume and Hair Gel", *China Southern Morning Post*, October 15, 2018, available at: www.scmp.com.

63. T. Phillips, "Beijing Smog: Pollution Red Alert Declared in China Capital and 21 Other Cities", *The Guardian*, December 17, 2016, available at: www.theguardian.com.

64. L. Qin, "China's Far West Poised to Overtake Hebei in a 'Most Polluted' List", *China Dialogue*, June 15, 2016, available at: www.chinadialogue.net. *The Guardian* also published impressive pictures of local

Xiongan: when the national government builds its own city

The central government is leading a project that aims to create a low-carbon and green city close to Beijing. One of the objectives is to improve the situation of the capital city. This project includes some important green energy innovation with a strong investment from the State Grid Corp. of China and, if successful, this project could become a model for green cities. The creation of this new city was announced on April 1st 2017, with the purpose to divert population from Beijing, and to spare it of functions unrelated to its national capital status.⁶⁵ This new special economic zone will be built on three counties, of Xiong, Rong and Anxin, all located in Hebei and about 100 km southwest from Beijing, and also close to Tianjin. The city will only be completed in 2035 but aims at already having a population of 2 million by 2022.

Xiongan has been conceived as a green city. With billions of Yuans invested in its infrastructure, it aims to become a hub for high-tech industries, innovative and sustainable finance. This should have impact on the design of the city itself, with large green spaces and smaller streets and building blocks than in other Chinese cities.⁶⁶ The city should rely on natural gas (often considered as a clean energy in China), biomass, geothermal and solar energy. It will also act as a demonstration hub for clean heating in the North region of China, the objective being to phase out some coal-based systems and as such to avoid the use of 74 million metric tons of coal in 2019 already, and 150 million tons by 2021.⁶⁷ On the building efficiency front, special materials have been used for constructions, with a focus on insulation. It is said that indoor temperature can be kept above 16 degrees Celsius during winter without heating. As for clean transportation, fossil fuel cars are banned from the center area.⁶⁸ Xiongan will also develop important underground public transport infrastructure, to be complemented with self-driving private vehicles.

China's corporate champions are helping the government to reach Xiongan's ambitions and develop smart city technologies, and more

steel industry and its consequences on the environment: E. Hilaire, "Hebei Steel Cities and China's Pollution Crisis – In Picture", *The Guardian*, January 13th, 2015, available at: www.theguardian.com.

65. A. Baijie, "Xiongan Should Get More Room to Act on Innovation", *China Daily*, July 7th, 2018, available at: www.chinadaily.com.cn.

66. L. Jing, "Is China's 'City of the Future' a Replicable Model?", *China Dialogue*, June 29th, 2018, available at: www.chinadialogue.net.

67. Z. Xin, "Xiongan to Run on 100% Clean Power", *China Daily*, August 28, 2018, available at: www.chinadaily.com.cn.

68. "Xiongan Building Complex Sets Example for Infrastructure in China's Future Cities", *Xinhuanet*, May 18, 2018, available at: www.xinhuanet.com.

specifically artificial intelligence. Here are some examples of the companies investing in the new zone:

- Baidu: the internet search company is working with the Hebei government to develop the smart city, with a research center focusing on artificial intelligence for cars, as well as smart public infrastructure. China Telecom is also part of the companies involved.
- Chang'An Automobile will also probably be involved, as they have recently reached the “level 2” of self-driving technology, which allows cars to accelerate and brake by themselves.⁶⁹
- Sinopec: though the zone focuses mostly on non-fossil fuel resources, the oil company Sinopec also announced during Summer 2018 that it created a new investment arm, Sinopec Capital with a 10-billion-yuan (EUR 1.2 billion) capital to fund projects on green energy and artificial intelligence.⁷⁰
- The State Grid Corp. of China (SGCC) has also positioned itself in Xiongan, which should be used as an experimental ground for its “re-electrification” (*zaidianqihua*) program. The concept has been defined by the Chairman of the company: it consists in the replacement of coal as a source for electricity by “more diverse sources of energy, such as wind, solar and other new energies”. It also includes an end-use dimension, with the phasing out of equipment and devices using fossil fuels through, for instance, the use of electric vehicles or other means of transportation or new equipment at the factory level. SGCC is said to have conducted more than 100,000 projects of approximately 360 billion kWh accumulated where power as an energy source replaced oil or coal. For instance, SGCC led the electrification of Beijing heating system, allowing each household to save two tons of coal per year. The SGCC ambitions to use the re-electrification technologies abroad, for instance in the context of the BRI.⁷¹

The Xiongan plan is very ambitious and raises questions about the targets and replicability of the experience. Whether Xiongan will be successful or not is beyond the scope of this paper. What seems important is that the development of Xiongan enjoys a direct support from the highest level of the Chinese government, benefits from important

69. S. Tabeta, “China Intends for Self-Driving Cars to Propel Smart Megacity”, *Nikkei Asia Review*, May 20, 2018, available at: <https://asia.nikkei.com>.

70. “Sinopec Launches USD 1.5 Billion Investment Company in China’s New Economic Zone of Xiongan”, *Reuters*, July 19, 2018, available at: <https://uk.reuters.com>.

71. “Shu Yinbiao xiangjie guojia dianwang ‘zaidianqihua’ zhanlve jian zhi qingjie nengyuan ‘sanqi’ wanji” [Shun Yinbiao explains State Grid Corp. of China’s strategy of ‘re-electrification’ and points out the “three abandoned” ills of clean energy], *Security Times*, March 16, 2018.

investment and has driven interest from major companies. Experts have highlighted important challenges that the plan will face, notably water and air pollution. Xiongan is located in the middle of one of the worst areas in the world in terms of air quality, as mentioned previously. It is also neighboring the city of Baoding, which despite its status of low-carbon zone has a very poor record in terms of air quality (see above). Water pollution in the region and encroachment of unsorted waste are also a challenge, due to the absence of sewage or solid waste disposal systems in the surrounding area. Finally, some question whether the proximity of a development zone like Xiongan may not attract number of industries that would not bother with environmental standards and would end up adding to the current pollution.⁷²

This highlights two further issues: whether Xiongan can be replicated in other Chinese cities, and whether it can be exported, for instance through the Belt and Road Initiative (BRI). As for the replicability of Xiongan in other cities, some have already expressed skepticism, advancing the specificity of the city and past failures to develop green cities or low-carbon zones.⁷³ Indeed, success of other plans would depend on the capacity of other cities to mobilize both financial and technological resources that would be similar to Xiongan's. But the experience is very likely to inspire current sustainable city plans in China, and also to create incentives for green planning. And technologies developed in Xiongan, if successful, will surely be used in other cities. In addition, as Xiongan is branded "city of the future", it would be no surprise if its experience was promoted abroad, through the BRI or even the New Development Bank and the Asian Infrastructure Investment Bank. Given the social control dimension in most Chinese smart city projects, any export strategy would foster the gap between countries that put clear privacy limits to the use of big data and those who use them for active surveillance and control.

72. L. Qin, "Water Scarcity Might Be Xiong'an's Undoing", *China Dialogue*, April 27, 2017, available at: www.chinadialogue.net; Z. Che, L. Rongde, and Y. Xiaohui, "Xiongan's Cleanup Efforts Don't Hold Water", *Caixin*, July 2nd, 2018, available at: www.caixinglobal.com.

73. L. Jing, "Is China's 'City of the Future' a Replicable Model?", *op. cit.*

Conclusion: think national, act local?

The situation and challenges faced by Chinese cities today are a result of the economic growth China has experienced over the past four decades. Inhabitants in cities are suffering from the extensive use of resources and unsustainable development. This creates strong incentives for policy makers to act and promote more sustainable cities, with greener energy systems. And indeed number of initiatives have appeared recently, promoting local green energy policies, and sometimes innovative systems. Among them, Shenzhen appears to be a global pioneer with its electric bus fleet. Suzhou is another interesting example of energy-efficiency promotion at the local level.

However, it would probably be wrong to say that the key to China's energy future lies in cities. This is demonstrated by the many disappointing results of green/low-carbon development zones. While cities are sometimes the laboratories of new policies, the central government remains the main driver when it comes to the impulsion of new energy policies, even at the local level. It is therefore no surprise that the flagship of China's green cities is Xiongan, a project entirely driven by the central government. Top-down structures still prevail over bottom-up approaches. A question is whether this will be enough for China to meet its climate and environment goals, to address local issues, and also to create green cities that are attractive enough to become a model that can be sold abroad, potentially as part of the BRI.

