

Toward Low Carbon Cities: The Chinese Experience

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Abstract When surveying the extent to which cities around the world are greening, there is a striking fact about the Chinese experience. It presents both the worst and best facets of the process. The worst is encapsulated by the environmental toll taken on the country, and particularly its cities, in its three decades of high-speed growth—unbreathable air, polluted and undrinkable water, loss of soil, build-up of heavy metal contamination, and many other such problems. On the other hand, and certainly linked to this catalogue of problems, China is also leading the way in terms of solutions. It promotes eco-cities that take sustainability as their development model, and set performance goals in terms of conservation and circulation of resources, utilization of renewable energies, and financing by novel instruments such as green bonds. The issue is: which trend is leading in China?

Keywords China • Low carbon cities • Resource efficiency

Key Terms

1. Greening cities—meaning ‘sustainable city’ or ‘eco-city’, where the city is designed with full consideration of environmental impact and with minimization of energy, water and food inputs and heat, pollution and carbon outputs
2. China—the people’s Republic of China (PRC), an emerging giant with a total population of more than 1.37 billion in 2015 and urban population accounting for more than half of this
3. Circular Economy—generic term used in China to depict an economy where material flows are designed to circulate at high quality without entering the biosphere

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4. Renewable energies—energies derived from resources that are naturally replenished such as sunlight, wind, tides, waves and geothermal sources
5. Sino-Singapore Tianjin Eco-City (SSTEC)—collaborative project between the governments of China and Singapore where the aim is to develop a socially harmonious, environmentally friendly and resource-conserving city for the twenty-first century in China

1 Introduction

When surveying the extent to which cities around the world are greening, there is a striking fact about the Chinese experience. It presents both the worst and best facets of the process. The worst is encapsulated by the environmental toll taken on the country, and particularly its cities, in its three decades of high-speed growth—unbreathable air, polluted and undrinkable water, loss of soil, build-up of heavy metal contamination, and many other such problems. On the other hand, and certainly linked to this catalogue of problems, China is also leading the way in terms of solutions. It promotes eco-cities that take sustainability as their development model, and set performance goals in terms of conservation and circulation of resources, utilization of renewable energies, and financing by novel instruments such as green bonds. The issue is: which trend is leading in China?

In this chapter, we provide an overview of the conflicting trends in China's urbanization, and offer a judgment as to what has been the experience so far, and what might be the results in the near term, up to 2015 (by the end of the period of the 12th Five Year Plan) and to 2020 (the span of the successor 13th Five Year Plan, which was recently released in March 2016). We discuss some of the China eco-city cases such as Qingdao and the Tianjin eco-development zone, and the broader policy environment that is driving the greening of China's cities.

2 China's Urbanization Challenge

China is urbanizing and industrializing at the same time—at a pace unprecedented in history. In the space of just a few decades China has changed, and is changing, from a largely rural to a largely urban population. The figures speak for themselves. China was a largely rural country at the time of the revolution. Then it reached an urbanization level of 20 % by 1980; then 30 % by 1996; then 40 % by 2002 and 50 % by 2011—so by 2012 there were more people living in cities in China than in the countryside (Fig. 1). The urbanization trend is expected to continue. According to the 12th Five Year Plan, China's urbanization level should have reached 54 % by 2015. The latest data released by the National Bureau of Statistics indicate that this

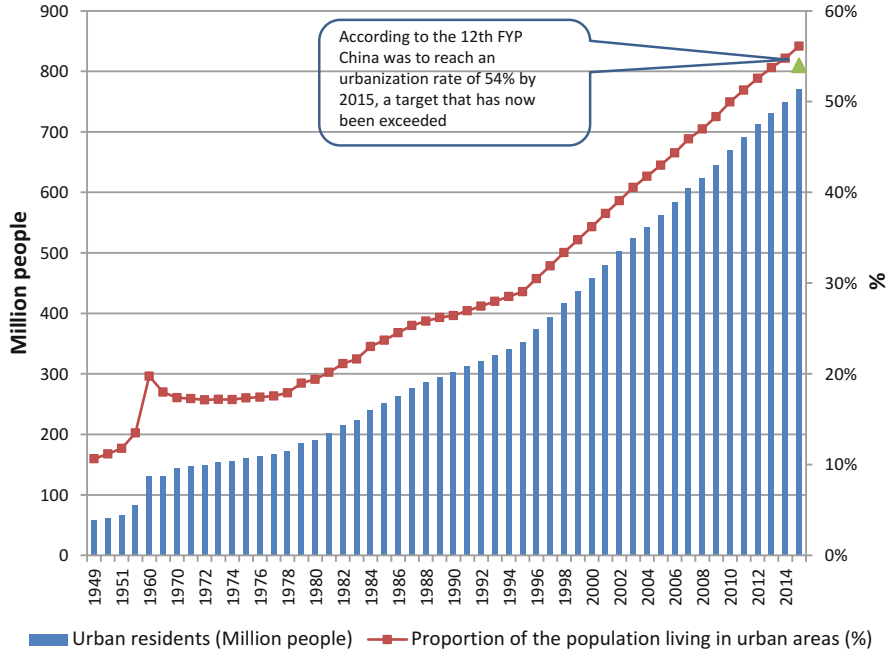


Fig. 1 Urban residents and their proportion in the total population in China: 1949–2015. *Source:* authors based on data from the NBS (2015) [1]. *Note:* The spike around 1957/58 is not an artefact of statistics, but the result of the decline of the rural population resulting from the three-year ‘Great Chinese Famine’ of 1958–1960, which was jointly caused by drought and by the policies of the Communist Party of China aimed at making a ‘Great Leap Forward’

target has already been exceeded, with China reaching 56 % urbanization level by the end of 2015.¹

To gain a feel for this frantic pace of urbanization, which drives the greening of China’s urban economy, consider the following. Over the decade 2005 to 2015 China raised its number of urbanized residents from 560 to 770 million today. This means an increase of 210 million over the decade—or on average, 21 million newly urbanized people every year. This amounts to building seven new cities of three million inhabitants each, every year—a phenomenal rate of change. No wonder China is viewed as the urbanizing powerhouse of the planet, with a construction and housing industry to match.

Rapid urbanization in the twenty-first century raises critical challenges for China to combat pollution and climate change while utilizing the low carbon cities programme to leapfrog to advanced green construction technologies and practices.²

¹See NBS http://www.stats.gov.cn/english/PressRelease/201602/t20160229_1324019.html

²This section is based on Mathews and Tan 2015 [2], pp. 136–137.



Fig. 2 Sustainable KPIs for SSTECS. *Source:* Based on IEK [10]

Compared to its rural living conditions, the modern urban life style tends to lead to higher energy consumption and carbon emissions per capita. Current levels of per capita energy consumption in Chinese cities reflect higher income levels and better quality of life as the city greens its operations. Moreover the new cities represent an opportunity to introduce new green construction and energy-saving technologies [3]. Against this background, it is not surprising that increasing efforts have been made in China to reduce pollution and energy consumption in cities through what is known as the low carbon cities programme.³

It was not until 2008 that the concept and term ‘low carbon city’ was introduced in China by the World Wildlife Fund (WWF), a non-government organization [4]. In that year the WWF in collaboration with two municipal governments in China introduced a ‘Low Carbon City Initiative’ which was specifically designed for the context of cities. Among the two participating cities in the initiative, Shanghai was expected to focus on promotion of new eco-buildings and improvement of energy efficiency of existing buildings, and engagement of the public to raise their awareness in energy saving. Another participating city, Baoding, was to facilitate local renewable energy industries as a means toward establishment of low carbon cities.⁴ In addition, China’s first carbon trading exchange market was also established in Tianjin in 2008.

³See ‘China must take care of its city-dwellers’, by Tom Miller, *Financial Times*, April 14, 2013, <http://www.ft.com/intl/cms/s/0/ab9a6376-a358-11e2-ac00-00144feabdc0.html#axzz2mRQqJ011>

⁴On these initiatives see Nan Zhou et al. [5] and Li Yu [6].

In 2010, the notion of low carbon cities was picked up at the national level and integrated with the concurrent Circular economy initiatives. In 2010, the National Development and Reform Commission (NDRC), the country's premier policy maker, chose five provinces (Guangdong, Liaoning, Hubei, Shaanxi and Yunnan) and eight cities (Tianjin, Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang and Baoding) as pioneering cities and provinces for pilots of low carbon initiatives, complemented by Circular economy initiatives.⁵ In 2012, the second batch of participating provinces and cities for low carbon pilot projects was announced, including two municipalities (Beijing and Shanghai) and 26 other cities, with emphasis on energy- and water-saving initiatives.⁶

Among those pilot 'low carbon' cities, a number of measures have been introduced, as summarized in Table 1.

We highlight some examples from two cities—Qingdao and Tianjin.

3 Qingdao

Qingdao is a coastal city in Shandong province, well known for its Tsingtao beer and for its hosting the 2008 Olympics sailing competition on its harbour. But Qingdao, with an urban population of 4.6 million in 2015, is also a focus of sustained efforts to create an eco-city based on a Circular Economy. It is a naval base, a seaport and an industrial centre. The city boasts a high level of Japanese and Korean investment. Qingdao High-Tech Industrial Development Zone was approved by the State Council in 1992 and now forms the basis of the city's Circular Economy initiatives.⁷

One of the principal environmental problems faced by Qingdao was the stockpiling of chromic slag, a product of the Qingdao Redstar Chemical Group formed in the manufacture of chromic salts and resulting in a 'mountain' of chromic waste severely contaminating ground water. A solution was found in 2005 with the Qingdao Iron & Steel Group developing a method for using chromic slag as replacement for dolomite (naturally occurring calcium-magnesium carbonate) in the sintering process in iron production. This is a typical 'Circular Economy' solution where a waste is turned into a valuable input into a different industrial process—modelled on natural cycles where 'waste equals food' [9].

This and many more examples of Circular Economy initiatives reveal that national policy, in the form of the Circular Economy Law of 2007, is driving

⁵See the 'Notice from the NDRC about carrying out the work of low-carbon provinces, autonomous regions, and cities pilot projects', http://www.sdpc.gov.cn/zcfb/zcfbtz/2010tz/t20100810_365264.htm (in Chinese)

⁶See http://www.ndrc.gov.cn/gzdt/t20121205_517506.htm (in Chinese)

⁷See 'Greening up Qingdao', *China Daily*, 12 January 2009, http://www.chinadaily.com.cn/bw/2009-01/12/content_7386366.htm

Table 1 Low carbon measures taken by Chinese cities: some selected measures

Region	Cities	Illustrative measures
Bohai Rim region	Beijing	The city is to promote greening systems in production, consumption and environment protection, by implementing nine programmes in areas including energy, building, transport, air, solid waste, water and ecology
	Dezhou	Based on its industrial advantages as the ‘China Solar City’, the city is to accelerate application of solar energy in various areas
	Baoding	The city is focused on development of industrial parks and industrial clusters focusing on wind power, PV solar, energy saving, energy storage, electric power transmission and transformation, and electric automation equipment manufacturing etc.
Yangtze River Delta region	Shanghai	By applying the low carbon concept that has been implemented in the Shanghai 2010 Expo, the city plans to complete three low carbon demonstration areas in Songming, Lingang and Hongqian Business District, and a Dongtan Eco-city project during the period of 12th Five Year (2011–2015)
	Nanjing	The city is to increase the proportion of renewable energy in total energy consumption by encouraging ‘green consumption’
	Hangzhou	The city has established a comprehensive development goal toward low carbon economy, low carbon buildings, low carbon transport, low carbon life style, low carbon environment and low carbon society
Pearl River Delta region	Shenzhen	The city is to focus on energy saving in key areas, to use public funding for promoting investment in low carbon development, and to develop three strategic industries including biology, new energy and Internet-related industries
	Zhuhai	The city is to identify key areas in carbon emission reduction and establish solid reduction targets
	Nanchang	The city is to build a number of low carbon demonstration industrial parks. The city is also to provide its residents free bicycles to encourage low carbon transport
Southeast China region	Chongqing	The city is to develop low carbon economy in adjunct with its industrial structure change, urban planning and technological innovation, and to increase the share of energy-saving and environmental protection industries in the economy
	Chengdu	The city is to build a low-carbon economic development experimental zone, zero-carbon agricultural demonstration zone, and zero-carbon tourism demonstration zone. The city is also to establish and improve its public ecological compensation mechanism, and compensation and incentive mechanisms based on energy consumption per unit GDP
	Guiyang	The city has established the first court in the country specialized in legal cases in relation to environmental protection; and has issued the first local regulation on ecologic progress. The city has also converted all its buses from petrol engines to LPG engines

Source: Based on Chen et al. [7] and Tian [8]

these local-level initiatives. Under the 12th FYP (2011–2015) and the current 13th FYP (2016–2020), there are chapters on CE initiatives and further development; the State Council (equivalent to the Cabinet) issued a series of proposals to implement the Circular Economy goals, followed up by a series of more detailed regulations issued by the ND&RC. This is a typical sequence found in China—a general goal or aspiration (as in the 12th FYP and the current 13th FYP) is followed up with a decision by the State Council to embark on serious implementation, with guidelines and regulations then being issued by the ND&RC. This sequence ensures that China’s greening of its cities is being pursued in a systematic and serious way with legislative backing for administrative and financial promotion. A particularly good example of this process is found near the port city of Tianjin.

4 Tianjin

The Sino-Singapore Tianjin Eco-City (SSTEC) is a new eco-city with sustainable features built in from the start, involving a collaboration between the Chinese and Singapore governments. The SSTEC is situated within the Tianjin-Binhai New Area, a fast-growing industrial region located in the Bohai Bay area and now identified as a third industrial engine in China behind the Pearl River delta (featuring the cities Guangdong and Shenzhen) and the Yangtze River Delta (featuring Shanghai and Suzhou). Its rate of industrial growth is more than twice the national average. Within this cluster of industries the SSTEC is designed as a fresh start for a city drawing on the experience in recycling and resource efficiency already developed by Singapore. The eco-city, designed to have a population of 350,000, is located 40 km from Tianjin city centre, which is in turn located just 110 km from Beijing and connected by a very fast high-speed rail service, the first and still most significant in China.

Following earlier collaboration between Singapore and China over the Suzhou technology park, a new agreement was reached between the governments in 2007 for the creation of an eco-city near Tianjin. The ground-breaking ceremony was held in September 2008. This has been followed by new memoranda of agreement and the adoption of standards consistent with Singapore’s own standards for water, waste and energy renewal. The Singapore government has formed an Inter-Ministerial Committee to coordinate its input, as a sign of the importance attached by Singapore to the eco-city’s success. The Master Plan for the city has been prepared by the Singapore Urban Redevelopment Authority (URA). As a planned eco-city, SSTEC has a number of metrics that ensure its development proceeds along sustainable lines. Amongst these are: close-to-zero carbon emissions; all buildings to qualify as ‘green’ in terms of renewable energy and water recycling; overall solid waste recycling to reach 60 %; and 100 % water recycling. Particular features are the installation of an underground vacuum-driven waste disposal system for the city (a world first) and experiments with driverless automatically guided vehicles

(supplied by Google). Charging stations for electric vehicles are to be installed at every major intersection.⁸

One of us (MCH) visited the SSTECH in June 2011 and September 2012 having the chance to walk around the city. It had been built on an unpromising reserve of industrial wasteland, on the principle that if an eco-city could be built *here*, then it could be built anywhere. The city is now half-built and still has a drab feel to it—but with noticeable drive and ambition. Walking down the central avenue it is easy to see how the different facets of green development (lighting, water recycling, waste disposal) have all been integrated, while the buildings are ultra-clean and all are equipped with solar panels. It is a city with grand ambitions. A key aspect of the city's development involves the smart grid, providing both an experimental city-wide implementation zone as well as an opportunity for large corporates to test their latest technologies and designs. The Chinese white goods manufacturer Haier, for example, is developing new standards for the operation of the green home or smart house Energy Management System (EMS) as part of the architecture of the smart grid—promising it leadership of this emerging huge market both in China and internationally [11]. This is what China calls its 'indigenous' innovation system, promising to drive the country's efforts to shift from imitation to innovation.

The SSTECH has attracted much international attention, including a World Bank study in its early phases [12]. Particular attention is being paid to the capacity of the eco-city to attract lower-cost financing (because of its green credentials) and its capacity to capture latecomer (and first mover) advantages in having entire systems that are based on renewable energies, water and waste recycling [13]. Ultimately the goal of China's green city strategy is to demonstrate that eco-cities carry a cost and competitive advantage over their older, smoke-filled industrial predecessors.

5 China's Greening City Strategy

China clearly recognizes that its urbanization and industrialization are twin revolutions, both setting unprecedented challenges as well as opportunities to build an alternative, green industrial and urban model. To combat and complement the conventional industrialization model, involving fossil fuels and extensive resource throughput, China is seen to be making huge efforts to build a green alternative—starting with energy and water renewal and encompassing not just power plants and factories but whole cities and regions in the measures being taken. International

⁸See Coco Liu, 'China's city of the future rises on a wasteland', *New York Times*, September 28, 2011, <http://www.nytimes.com/cwire/2011/09/28/28climatewire-chinas-city-of-the-future-rises-on-a-wastela-76934.html?pagewanted=all>

agencies and organizations as well as international consultancies are keeping close tabs on China's efforts to green its cities.⁹

The McKinsey 2009 report [11] on China's urbanization identifies four possible models for China's greening of cities, namely (1) a small number of super-cities (such as Beijing and Shanghai); (2) a hub-and-spoke model, involving two or three hubs and several smaller cities clustering around them; (3) distributed growth involving a large number of medium-sized cities; and (4) unplanned urbanization involving lots of smaller towns competing with each other. Taking this as a convenient framework, we see that the SSTECS fits within a hub-and-spoke model with Tianjin as one of the hubs and smaller entities clustering around it, with SSTECS providing the template for a fresh start. The model encourages resource-sharing in the way of all clusters and networks, but applied at a larger scale. The idea is that core centres of green development will be initiated and then expand and make connections with each other—rather like the stones in the ancient Chinese board game GO, where strength is found through connection rather than through stand-alone policies.

The outcome of China's efforts to green its cities, and thereby green its twenty-first century economy, is one of the great 'uncontrolled' experiments of the twenty-first century—uncontrolled in a social scientific sense, of conducting a process without a 'control group' for comparison. The outcome is anything but determined. But there are grounds for cautious optimism in the fact that China's development is increasingly urbanized, with the energy and efficiency gains that can be captured by smart catch-up strategies.

6 Chapter Summary

- China is embarked on a major industrialization and urbanization programme, equivalent to building seven new cities of three million inhabitants each, every year.
- The environmental costs of following a 'Business as usual' model would be prohibitive, and so China is experimenting with an alternative 'low-carbon cities' model.
- The 'low-carbon cities' programme is driven by local initiatives but coordinated as a central planning goal by the National Development and Reform Commission.
- China is capturing latecomer advantages by leapfrogging to advanced low-carbon city designs, following a greening model of development that maximizes the diffusion of new approaches to urban design.

⁹See OECD 2013 report 'Urbanisation and green growth in China' which gives a comprehensive update [14], and World Bank reports including *Eco² cities: Ecological cities as economic cities* (WB 2010) [15], and *Building sustainability in an urbanizing world* (WB 2013) [16]. McKinsey has been a leading international consultancy examining the greening of China's cities, as in [11, 17, 18].

- There are grounds for cautious optimism in that industrial development that is increasingly urbanized promises energy and resource efficiencies that can be captured by smart catch-up strategies.

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