

Refereed article

Governance of the Low-Carbon Transition in China: The Building and Transport Sectors

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Summary

Rapid urbanization is one of the key features of China's modern development. Chinese cities, growing in number and scale, consume evermore energy and their carbon footprint makes the country the world's largest carbon emitter. In response, China is now pursuing low-carbon development. The low-carbon transition ideal suggests a fundamental change in the way that energy is produced and consumed. Governance plays a crucial role in the low-carbon transition process. Low-carbon governance in China has a hierarchical structure to it. The national government establishes strategies and the legal framework for it, whereas local government is responsible for its actual implementation. The steps that local government takes are analyzed from two perspectives in this paper: mode of governance and type of initiative. Case studies of low-carbon governance in the building and transport sectors show that a mixed mode of governance is characteristic of both, yet specific combinations of modes lead to different results. Risky and quick decisions made by the local government lead to fast results. However, these projects are prone to being unsustainable over the course of time. The current lack of participation by non-state actors in low-carbon governance in China is a key obstacle to a successful transition, and the effective reduction of carbon emissions.

Keywords: China, low-carbon transition, urban governance, governance innovation, sustainable urban development, geothermal heat pump, public bike sharing

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Introduction

China has been undergoing a rapid urbanization process ever since the 1980s due to its “open door” policy. The urbanization trend is measured by the total number of people living in urban areas. The Chinese urban population outnumbered the rural one in 2012, with the trend projected to continue in the years ahead (UNDP 2013). Growing urbanization leads automatically to the growth of cities in terms of size and scale. China had only 193 cities in 1978, but this had risen to 657 by 2010 (Khanna et al. 2014). In 1978 there were no Chinese cities with a population of more than ten million people; in 2010, however, there were already six cities with more than that number of inhabitants (Roberts 2014).

Cities are the growth engines for the local economy. China’s total gross domestic product (GDP) in 2013 was about RMB 56.6 trillion, compared with only RMB 3.6 trillion in 1978. The average income per capita had increased to almost RMB 42,000 by 2013 compared with just RMB 380 in 1978 (China Statistic 2014). The interrelation between cities, energy, and GDP is straightforward: the energy used in cities by transport, industry, commercial activities, the building sector, and infrastructure generates about 75 percent of the country’s GDP (UN Habitat 2012). Therefore the Chinese government views urbanization positively; the State Council’s “National New-Type Urbanization Plan (2014–2020)” encourages further urbanization by setting a clear urbanization target of 60 percent by 2020 (Roberts 2014). This is part of the national strategy to nurture more urban consumers, so as to stimulate local economic growth (Ecola et al. 2015).

However, cities are also energy demand hubs and greenhouse gas producers. Cities and urban areas use 75 percent of the world’s energy and produce 80 percent of its greenhouse gas emissions (Williams 2007). The significantly large scale on which China’s cities are emerging indicates not only economic growth opportunities but also serious challenges too, such as sustainable energy supplies and sustainable urban development. China’s energy consumption surpassed that of the United States in 2010 already, and the former has also become one of the top countries worldwide for CO₂ emissions (Zhang and Nian 2013; Spencer and Shai 2010). The United Nations Environment Programme (UNEP) released a report (2013) that shows that China’s per capita energy consumption was 31 percent of the world average level in the 1970s but had increased to over 95 percent thereof by 2009 (West et al. 2013). The major source of energy in Chinese cities is coal, which accounts for about 67 percent of the total primary energy supply (West et al. 2013). It is argued that coal as a primary energy source has caused severe air pollution in Chinese cities during the urbanization process, especially due to the heavy reliance on coal in the industrial sector. The Chinese urbanization process has depended heavily in recent decades on the consumption of natural resources such as land, water, and greenery. For example vast areas of agriculture land have been converted into urban construction land, and the current amount of available farmland in China is just 120 million hectares —

which is the lower limit for guaranteeing food security (The World Bank Group 2016).

Following its national growth strategy, China is facing not only the challenge of developing a sustainable energy supply but also that of finding a sustainable urbanization path that is energy efficient and low carbon. Indeed, the Chinese government has already realized that the development path pursued in the past was unsustainable and has pledged to promote low-carbon development in future. For example the “12th Five-Year Plan (2011–2015)” set out clear goals for greenhouse gas emission reduction in a number of different sectors (State Council 2011).

Cities are encouraged to take action to explore the low-carbon development path in different sectors based on their capacities and resources. It is therefore important to investigate the governance structure underpinning China’s low-carbon transition to achieve a deeper understanding of the underlying difficulties embedded within Chinese governance and thus affecting the promotion of low-carbon development. The study focuses on the question of how the choice of governance tools influences the outcomes of low-carbon innovation.

The paper is structured as follows. The next section provides an overview of China’s low-carbon development. The third section then introduces the governance of the low-carbon transition in China. The fourth section establishes the analytical framework, and includes two case studies of low-carbon governance in the building and transport sectors. This is followed by the conclusion.

Governance of the low-carbon transition in China

Overview

The term “low-carbon transition” we understand to mean the coevolution of institutions, technologies, ecosystems, business strategies, and user practices in order to achieve a reduction in carbon emissions (Foxon 2011). A low-carbon transition requires fundamental changes in the way that energy is produced and used (Grubler 2012). Bulkeley et al. (2011) argue that studies on low-carbon transitions in cities are dealing with three sets of challenges: the fragmented nature of the transition process, who the actors are who are involved in the transition as well as their role therein, and divulging the complex network of institutions, politics, and processes that together form the low-carbon transition. Two of these challenges relate to issues of actors, institutions, and politics, in other words to “governance.” In this paper, governance is defined as “the way collective action steers and controls society to achieve collective goals” (Mai et al. 2015: 3).

Considering hierarchical governance arrangements and the state’s overall control of the energy sector in China, governance plays an important role in the low-carbon transition (Fouquet 2010; Meadowcroft 2009). City-level low-carbon policies prove to be most effective, which is why it is particularly important to study urban low-

carbon transition governance (Dhakal 2009; Francesch-Huidobro 2016; Mai et al. 2015). We offer an analytical framework for the study of the governance of low-carbon transitions in China, and specifically in order to understand how the choice of mode of governance influences the outcomes of low-carbon innovation in the Chinese context. We start by defining the national low-carbon development setting; this is followed by the analysis of current low-carbon governance arrangements in China.

National framework

Development stages

The low-carbon concept entered Chinese government policy programs relatively late. Historically speaking China's low-carbon strategy is based on its environmental agenda, which has gone through four stages (Wang 2014). Prior to 1992, the Chinese government gave priority to economic development — paying less attention to environmental issues. During the second stage, from 1992, when China joined in the international debates on climate change, the government discussed energy efficiency and the development of renewable energy — but avoided setting precise targets however.

The “11th Five-Year Plan (2006–2010)” marked the beginning of the third stage, which lasted until 2008. For the first time ever, targets for energy efficiency were officially announced. This was followed by an increasing number of energy-related policies and pilot projects across the country, including China's “National Climate Change Plan” announced in 2007. In the same moment, the concept of “low-carbon development” first entered government documents. The main areas of governmental attention included scientific development, market regulation, adaptation to climate change, optimization of industry structure, top-down energy management, resource security, forestry, and stimulating and monitoring local government.

The fourth — and currently still ongoing — period started in 2009, when China announced at the Copenhagen Climate Change Conference its target to cut carbon dioxide emissions by 40–45 percent per unit GDP compared with 2005 levels. Fostered by the “National 12th Five-Year Plan (2011–2015),” low-carbon policies became target oriented — with emphasis on renewable energy development, energy efficiency, carbon emission reduction, reforestation, and the like. Thus, China's approach to low-carbon development has gradually shifted over time from a passive to proactive one.

Pilot low-carbon projects, launched during the third stage, produced fruitful results in terms of experience and revealing the challenges facing China on its way to a low-carbon future (Wang 2014). Governance innovation appears to be among these key challenges, as low-carbon development requires a new form of governance wherein different combinations of government strategies are linked together and

well-coordinated. Also crucial is allowing new actors into the governance networks, so as to achieve more effective results.

Strategies and policies

The low-carbon governance mechanism in China might be described as a top-down, three-step process, including process of strategy elaboration, legal framework design, and local implementation (Wang 2011). The national government is responsible for providing strategy. In practice, that strategy is stated in policies and white papers, five-year plans, and medium- and long-term development plans. China's "Agenda 21: White Paper on China's Population, Environment, and Development in the 21st Century" (1992) and "Program of Action for Sustainable Development in China in the Early 21st Century" (2003) are the core documents on China's sustainable development. They are complemented by China's aforementioned Five-Year Plans, which specified targets for energy conservation and carbon emission reduction. Sector-oriented strategic documents include China's "Medium- and Long-Term Energy Conservation Plan" (2004), the "National Medium- and Long-Term Plan for the Development of Science and Technology 2006–2020" (2006), and the "Medium- and Long-Term Development of Renewable Energy" (2007).

Following the national development goals, various government ministries have initiated a series of low-carbon development plans. Among these are the National Development and Reform Commission (NDRC), the Ministry of Environmental Protection (MEP), and the Ministry of Housing and Urban–Rural Development (MoHURD). These have initiated, respectively, the "Low-Carbon City," "Eco-City," and "Low-Carbon Eco-City" programs (Yu 2014).

Laws and regulations

Whereas the abovementioned documents provide strategies for low-carbon development, the legal framework — in the form of laws and regulations — facilitates actual change. There are a number of key laws in place related to energy efficiency: the Law of the PRC on Energy Conservation (2008), which aims to increase the efficiency of energy use; The Law of the PRC on Promotion of Cleaner Production (2009), which promotes sustainable development while also reducing and preventing industrial pollution; The Circular Economy Promotion Law of the PRC (2009), which defines the relationship between economic development and environmental protection; and, finally, the Renewable Energy Law of the PRC (2010), which declares the exploration of alternative energy sources to be a key focus area of China's future development.

Taxation, as a crucial part of the whole process, is regulated by the "Detailed Rules for the Implementation of the Interim Regulations of the PRC Concerning Resource Tax" (2008) and "The Provisional Regulations of the PRC Concerning Resource Tax" (2008). As for funding, the government has established various financial

mechanisms to support low-carbon development. For example, a special government fund awarded the top ten energy-saving projects a total of RMB 235 billion in 2007 (Wang 2011).

Sector-specific regulations

Building sector

China's building energy consumption accounts for nearly one-third of the country's total energy consumption. This share of total energy consumption is relatively low compared to developed countries, which means that there is great growth potential and the upward trend is most likely to continue (Lin and Liu 2015). What is more, since the year 2000 China's building stock has been increasing by 2 million square meters annually (Li and Colombier 2009). All this makes the building sector in China a core area of importance for energy conservation and emission reduction.

The Chinese government recognizes the importance of building energy efficiency and promotes a number of measures to reduce the carbon footprint in the sector, including energy codes for new buildings, energy labelling and evaluation of buildings, heat metering and energy efficiency retrofits, use of renewable energy sources, and energy efficiency audits of public buildings.

Sector-specific regulations include the Quality Management Ordinance for Construction (2000), Management of Energy Conservation Regulation for Civil Buildings (2000), and Energy Conservation Ordinance for Civil Buildings (2008). These documents provide general guidelines, which local governments supplement with local standards to fit regional conditions.

Transport sector

The transport sector accounts for about 22 percent of global CO₂ emissions from fuel combustion, while in China that figure is current at about 7 percent (Loo et al. 2012). Motorization growth in China's big cities has led to a number of problems, such as slowing down vehicle speeds in urban areas, inefficient energy consumption, and economic loss due to traffic congestion (Ma et al. 2007). In accordance with the 12th Five-Year Plan, the Ministry of Transport (MoT) has initiated a number of policies to promote low-carbon development in China. These include: the "Construction of a Low-Carbon Transportation Guidance System" and the "Construction of a Low-Carbon Transportation System Pilot Program"; the "12th Five-Year Development Plan for Transportation" and "12th Five-Year Plan for Energy Conservation and Emission Reduction of Highway and Waterway Transport" (Gao and Lu 2012). The Chinese national government has thus demonstrated a strong commitment to its low-carbon goals at the level of planning and policies. However, there are several fundamental challenges at the local level that still hinder low-carbon development in China.

Urban governance

While national policies, laws, and regulations serve as guidelines for low-carbon development, the actual change to it is occurring at the local level. Policy implementation and the fulfilment of low-carbon targets largely depend on local government performance: its commitment, resources, and choice of governance tools. Existing energy efficiency standards in transport (e.g. “Multiple Performance Requirements and Detecting Methods for Commercial Vehicles (GB18565-2001)”), and in the building sector (e.g. “Design Standards for the Energy Efficiency of Residential Buildings in Severe Cold and Cold Zones (JGJ26-2010)”) provide very specific principles to follow in order to achieve low-carbon targets. Nonetheless, the studies show that these standards are often neglected due to a lack of enforcement of them (Li 2009).

According to a survey conducted by the Chinese Society of Urban Studies, many Chinese cities had adopted a low-carbon development strategy already by 2012 — including 97 percent of prefectural cities, subprovincial cities, and metropolises under the direct jurisdiction of the State Council. More than half of them have already taken action on ecological urban development, while another 28 percent have invited planning consultants to work on eco-city plans and 19 percent are focusing on policy formulations for eco-city development (Yu 2014). Despite the fact that many Chinese cities have initiated their own low-carbon development plans, however, there is still a lack of national-level guidelines in the various sectors for local governments to follow. Cities are instead encouraged to find their own ways of reaching the low-carbon target goals that have been set by the national government.

The governance structure in China tends to be top down rather than bottom up. The municipality is the key player in many aspects of urban development, including policy formulation, the establishment of financial mechanisms, and pilot project implementation. In the context of low-carbon development, the municipality’s role includes initiating carbon reduction targets and strategies, assigning planning tasks to the various departments involved, launching pilot projects, and creating project evaluation criteria. The conventional top-down planning governance structure is, perhaps, not always efficient in terms of meeting the-low carbon transition goals in the different sectors.

Below, we offer a framework to analyze low-carbon governance mechanisms and provide two case studies of low-carbon development in the building and transport sectors. The choice of sectors for the case studies can be explained by two factors. On the one hand, they are among the main CO₂ emitters. On the other, while heavily regulated by the government, they can still benefit from new forms of governance — and specifically by involving nongovernmental actors therein.

Case studies

Analytical framework

The selected analytical framework approaches the low-carbon transition from two perspectives: mode of governance and type of initiative. Mode of governance refers to resources and tools available to, and utilized, by the local government in order to achieve the collective goal of emission reduction. Importantly, it reveals whether and if so how non-state actors are involved in the process — and, further, whether institutional innovation takes place.

Distinction between types of initiative adds the dimensions of time and attitude to the analysis. In the process of a low-carbon transition, time is a critical aspect. Taking into consideration rapid urbanization and the growing impact of climate change, a low-carbon transition needs to be dynamic and continuous. The process is also heavily dependent on actors' attitudes to it. A low-carbon transition suggests the inevitable taking of the road less traveled, which certainly requires stakeholders' political will, commitment, and readiness to take risks. This framework helps to analyze and compare low-carbon transition initiatives within and between sectors, in order to understand how the combinations of governing modes and types of initiative influence outcomes.

Modes of urban low-carbon governance

Mode of governance refers to the governing capacities of local government. There is a distinction to be made between the following modes: governing through enabling, governing by provision, and governing by regulation (Kern and Alber 2008).

Governing through enabling refers to the mode of governance whereby local authorities act as a facilitator of change. It aims to motivate non-state local actors to take action, and to connect private actors and civil society in pursuit of a low-carbon future. This mode of governance manifests itself in educational campaigns, public-private partnerships, the promotion of e-mobility, campaigns for waste recycling, and the like. For example, in 2014 the Beijing authorities launched a video campaign promoting green transport concepts. The cartoons were broadcasted on all metro lines and buses, reaching about ten million people every day. This mode of governance is certainly effective in putting low-carbon development on the political agenda and raising public awareness.

Governing by provision suggests that local government, being a provider in this case, delivers services and resources for low-carbon development. It is achieved by means of infrastructure and financial policies, such as grants for energy-efficient projects, the provision of public transport, or charging stations for electric vehicles. For example, the government of Dezhou, known as China Solar City, has committed to allocating RMB 80 million annually to renewable energy demonstration projects (Li et al. 2011). Compared to European cities, which have to follow European Union

regulations on the liberalization of energy markets, Chinese ones can benefit greatly from this mode of governance. Local governments in China are, as a rule, shareholders in the local utility providers of energy, transport, water, and waste services. Thus the municipality has an opportunity to pursue the low-carbon transition through the transformation of urban infrastructure, followed by making changes also in consumption patterns — potentially achieving a remarkable reduction in carbon emissions.

Governing by regulation implies traditional forms of authority imposed through control and sanctions. It includes strategic energy, transport, and land-use planning. Specifically, it might lead to strict regulations on new buildings' energy efficiency, road-use charges, or a carbon tax. For instance, in order to reach the national standard for air conditioning systems, Jiangsu Province obliged all government departments to purchase only those products that meet the stipulated standard (Zhou et al. 2010). Although governing by regulation is one of the most effective modes of low-carbon governance, municipalities are often reluctant to pursue it — as it might hinder economic growth or meet with strong opposition from local actors.

Types of low-carbon initiative

In order to understand the governance of urban low-carbon development, Mans et al. (2012) suggest assessing such activities by a series of characteristics — including scope of change, type of innovation, level of risk taking, and speed of change. *Scope of change* defines whether the change is radical or incremental, in other words whether it is a disruptive innovation or a logical consequence of previous developments. For example, the city of Baoding has been developing the Green Power Valley,¹ a renewable energy cluster, since 2008. This kind of innovation is radical in nature because it is disconnected from the previous industrial infrastructure and policies in the city (Mans et al. 2012).

Type of innovation describes the governance approach to innovative activity: is it learning by doing, or rather a well-thought-out and carefully planned process? Thus, we differentiate between pro-experimental and pro-safeguard types of innovation. For example, Hangzhou, prior to the adoption of the low-carbon city development plan in 2010, delivered a well-elaborated framework for the implementation of the plan (Khanna et al. 2014). This might be considered a pro-safeguard innovation.

Level of risk taking refers to the government's readiness to accept potential failure in the process of innovation. There is gradation from a high-risk to a risk-averse attitude. For example, the city of Wuxi,² despite its strong dependence on energy-

1 Baoding was among the first cities to join the Low-Carbon City Initiative. It has established six industrial clusters including wind power, photovoltaic power, power storage, power-saving, power automation, and equipment manufacturing.

2 Wuxi is the pilot city for The Low-Carbon Future Cities Project, which suggests a three-dimensional integrated approach to city development: low-carbon development, adaptation to climate change, and gains in resource efficiency.

intensive industries, has committed to a 50 percent reduction in carbon emissions by 2020 as compared to a 2005 baseline. Thus, the local government is willing to take risks in order to reach low-carbon goals.

Speed of change refers to the pace of decision making by the actors involved: dynamic or relatively stable. For example, in 2011 the city of Changchun joined the Ten Thousand Enterprises Program.³ Under pressure from the central government, the local government had to provide data on energy-saving targets as soon as possible. As a result, the local government has set individual energy-saving goals for 66 enterprises with minimal to no consultation with the latter — they, nonetheless, had to comply with these (Lo 2014).

Below, two case studies of low-carbon development in China are analyzed. This is done in order to describe governance mechanisms and best practices, as well as to define existing obstacles to the successful implementation of low-carbon strategies. The studies are based on data gathered by the authors during their fieldwork in China in 2015-2016.

Geothermal heat pump — a low-carbon heating option for the building sector

A remarkable 65 percent of energy in China's building sector is expended on heating, ventilation, and air conditioning (HVAC). Therefore, reducing the energy consumed by HVAC may significantly contribute to meeting overall energy efficiency goals. Geothermal heat pumps (GHPs)⁴ fit this purpose.⁵

Development of the GHP sector in China has accelerated since 2005, when the central government first promulgated renewable energy policies and development

3 The Ten Thousand Enterprises Program is a low-carbon policy that was initiated by the NDRC and Ministry of Industry and Information Technology in 2011. It is an extension of the successful Thousand Enterprises Energy Conservation Program launched in 2006. It requires a large number of industrial enterprises — and also a certain number of those in the transport, commercial, and education sectors — to comply with individually set energy conservation targets that are supported by governmental subsidies and followed by punishment in the case of noncompliance (Lo 2014).

4 A GHP (also known as a ground source heat pump) is an energy-efficient and environmentally friendly technology for space heating and cooling. It relies on ground sources for heat extraction, including soil, groundwater, and surface water (Yang et al. 2010). It can serve new constructions or retrofits of existing buildings. The system operates on electricity. It either directly heats the space or warms up the water for the central heating system. GHPs are up to six times more efficient than traditional heating technologies (Self et al. 2013). The system's carbon footprint is determined by the source of electricity production. High initial investment costs, lack of policymaking, and little consumer knowledge or trust in GHP — alongside the limitations of GHP installation infrastructure — create barriers to the rollout of the technology, however (Hughes 2008).

5 It is estimated that replacing coal-based central heating with GHPs in China would be able to cut carbon dioxide emissions by 83.7 percent, and accordingly decrease CO₂ emissions per unit GDP by 4.2 percent by 2020 compared with the 2005 baseline. This would contribute about 10.5 percent to China's 2020 emission reduction target (Wang et al. 2011).

plans. In 2004, the total application area of GHPs in China was about 7.67 million m². It had reached 330 million m² by 2014 (Zheng et al. 2015).

The governance of GHP application in China is hierarchical. The foundation for policies promoting GHPs is laid by a series of national regulations (see Table 1). They encourage large-scale GHP implementation under conditions of good environmental management and the replacement of coal- and oil-fired heating and cooling systems with GHPs, the introduction of standards and technical requirements, and the initiation of financial support.

Table 1: China's GHP-related national regulations

Year	Title
2004	Medium- and Long-Term Plan for Conserving Energy Resources
2007	Energy Conservation Law
2008	Regulation on Energy Conservation in Civil Buildings
2006	Renewable Energy Law
2007	Renewable Energy Long-Term Development Plan
2003	Key points of new and renewable energy industry development plan
2013	Guidelines on Promoting Geothermal Energy Development and Utilization
2006	Opinions on promoting application of renewable energy principle in buildings
2006	Tentative management method of special funds for renewable energy development
2003	Water-Source Heat Pumps (GB/T19409-2003)
2006	Technical Code for Ground Source Heat Pump System (GB50366-2005)

Inspired by the national regulations, in 2007 the city of Shenyang invested some RMB 10 billion in 188 GHP projects, surpassing by far the former leader in GHP application: Beijing. Exposed to long and cold winters, with growing house stocks mainly heated by coal, both cities were interested in sustainable heating solutions such as GHPs.

However, despite observed similarities between the two cities, there is variation in the dynamics of their respective GHP implementation. Beijing has been doing this since the early 2000s, and that at a steady pace with annual growth of about 2 million m² of GHP application area — reaching 17 million m² in 2012. Shenyang started from almost zero, meanwhile, rising to 15 million m² in 2007 and having reached almost 60 million m² by 2010. The two cities' different GHP governance systems appear to explain this variation.

GHP governance in Beijing

The key document regulating GHP application in Beijing, entitled “Guidance on the Development of Heat Pump Systems” (2006) promotes GHP installation in new buildings and retrofits, offers subsidies to GHP projects, grants full-cost coverage for government-backed constructions, and regulates what the responsibilities of government agencies are. “Regulation on GHP Application Procedure and Management Requirements” (2007) and “Note on Strengthening the Management of Water Source Heat Pump in the City” (2008) set standards and technical specifications for GHP projects.

The analysis shows that Beijing has applied a mixed mode of GHP governance, including *governing by provision* and *governing by regulation*. First, the local authorities act as the main consumers of GHP technology. Most of the buildings (57 percent) equipped with GHPs are government-backed constructions (Wang et al. 2010). Second, the government has offered financial support to developers that utilize GHPs.

As for *governing by regulation*, Beijing has provided control for projects at the planning stage but seems to lack the mechanisms that would inspect and evaluate projects at the operational one. However, the city government does not use its resources to educate citizens and officials about GHP technology, or to involve nongovernmental actors in the promotion of GHP use.

GHP application in Beijing has proved to be pro-safeguard and risk averse. The local government conducted a series of research studies to provide an overview of GHP-suitable areas, which helped to avoid problems in operation later on. However, it did not set firm targets in any of its regulations, thus avoiding potential pressure from failing to meet targets.

The analysis of GHP implementation in Beijing shows that the chosen modes of governance have supported slow but steady growth. This type of initiative alone can hardly alter existing heating patterns in the city. Nonetheless, the thorough planning and preliminary assessment of GHP projects’ viability guaranteed environmental sustainability and eliminated the possibility of later GHP dysfunction.

GHP governance in Shenyang

Like in Beijing, local authorities in Shenyang have applied a combination of different governance modes. First, as a result of *governing through enabling*, all GHP-related activities and news were widely reported by the local media, which led to a general awareness about the technology among the local population and officials.

Second, *governing by provision*, Shenyang government initiated the establishment of the Shenyang Ground Source Heat Pump Promotion Office. Its responsibilities include planning and policymaking, GHP project management, technical support, preparation of standards and codes, managing subsidies, and promoting GHP within

the public sector (Geng 2013). Besides this, the Shenyang authorities have applied no fees for GHP's use of groundwater. They have also set an electricity price for operating GHP at the residential rather than the commercial rate. *Governing by regulation* was demonstrated through the "Implementation Ordinance on Fully Promoting the Application of GSHP in Shenyang" announced in 2006. The document requires every urban district to launch a certain number of GHP projects. Noncompliance with the regulation by district leaders may result in denial of further career promotions.

Taking into consideration that initially the city had little or no experience with GHPs, the innovation can be characterized as pro-experimental. Shenyang's efforts at large-scale GHP implementation can be described as high-risk, meanwhile. This is due to the general prior ignorance about and distrust of the innovative technology among local officials and citizens alike. Thus, Shenyang local government has utilized available tools — including administrative, political, and financial ones — to achieve remarkable results in GHP implementation. However, the hasty approach taken led to issues with equipment installation — caused by workers' lack of professional training as well as by the malfunctioning of GHPs positioned geographically too close to each other.

According to the analysis, the variation in the dynamics of GHP implementation between Beijing and Shenyang might be explained by differences in chosen modes of governance and types of initiative. The exponential growth in Shenyang is a result of the municipality using a mixed mode of governance, whereas Beijing has shown less commitment to GHP popularization and has picked its governance modes selectively. Nonetheless, Beijing's pro-safeguard approach has guaranteed a more sustainable form of development in the long run.

Public bicycle system — a low-carbon transport strategy

The transport sector is one of the fastest-growing ones in terms of fossil fuel consumption as well as CO₂ emissions. The total energy consumption for the transport sector accounts for nearly 30 percent on global scales (Lin and Benjamin, 2017). The transport sector in China includes road, rail, air, and water transport. In 2005 road transport made up nearly 80 percent of the energy consumption and CO₂ emissions of the transport sector in China (IFEU 2008, p.11). This was due, among other things, to the increasing degree of automobile ownership by Chinese citizens.

Policies for reducing CO₂ emissions in the transport sector have three dimensions to them: avoid, shift, and improve (ASI) (Bongardt 2013). The "avoid" package means to reduce unnecessary trip amounts and lengths. The "shift" aspect refers to a change in travel mode to a low-carbon one such as rail, bus, metro, bike, or walking. The "improve" element contains policies of reducing the carbon intensity of all modes of transport, for example, electrification-based renewable energy application in the vehicle fleet.

The idea of developing the public transport system in Chinese cities came relatively late. In 2005, the six ministries⁶ jointly released the document “Opinions on the Priority Development of Urban Public Transport” (State Council 2005). This was the first time that the national government had highlighted the importance of public transport development in cities. Following the central government’s 12th Five-Year Plan, the MoT also released its own 12th Five-Year Plan — which clearly states that cities are encouraged to each develop a public bicycle system (PBS) (Wang and Li 2014). Following this plan, 30 cities have been chosen to participate in the Public Transport System Metropolis Program (MoT 2011).

In 2012 the MoHURD, NDRC, and MoF issued a joint regulation “Guiding Opinions on Strengthening the Construction of the Urban Pedestrian and Bicycle Transportation System” so as to promote biking and walking infrastructure planning in cities (MoHURD 2012). This was also incorporated into national planning regulations, namely “The State Council Opinions on Strengthening the Construction of Urban Infrastructure” (State Council 2015), which pointed out the need to develop infrastructure for biking and walking in the country’s cities. Following these national-level policies, cities are now taking action to promote biking and walking facilities.

The PBS’ contribution to low-carbon transport

The public transport system is an integrated one that require bringing together different modes of transport to form a complete network. This means not only high-speed mobility modes such as railways and subways, but also slow ones such as biking and walking. Since high-speed trains cannot reach every spot in a city, in order to expand the service zones of those high-speed modes then the integration with them of the slower buses, minibuses, and public bikes is necessary. These are the “feeder modes” in the public transport system. The PBS is, indeed, one of the important ones; as such, the promotion of PBS development is an ideal low-carbon transport strategy for a city’s development agenda.

Many Chinese cities are now taking action to promote PBS development in response to the national government’s development guidelines. However, their systems of operation show variation in governance modes. Beijing is a company-oriented system that consists of many small-bike enterprises; Hangzhou is a government-oriented one in which the municipality is the most powerful facilitator; the PBS in Shanghai, meanwhile, is a public–private partnership-based system, which means that the municipality is cooperating with a private company in offering PBS services (Pan et al. 2010). Shenzhen first promoted PBS in 2011; the planning results of PBS

6 Ministry of Housing and Urban–Rural Development (MoHURD), the National Development Reform Commission (NDRC), Ministry of Science and Technology (MoST), the Ministry of Public Security (MoPS), the Ministry of Finance (MoF), and the Ministry of Land and Resources (MoLR).

in two districts (Nanshan and Yantian) of the city showed fundamental differences due to varying governance modes.

PBS in Nanshan District (Shenzhen)

In 2011 Shenzhen released the “Shenzhen Urban Transport White Paper,” demonstrating the municipality’s commitment to public transport system development — including a PBS. Currently there are six districts in Shenzhen offering a PBS service. However, the governance modes in these districts vis-à-vis PBS vary in fundamental ways, which leads to different planning results.

The governance modes in Nanshan District appears to be of a mixed type, including *governing through enabling* and *governing by regulation*. The Nanshan government has cooperated with two local private actors to establish a public–private partnership in the PBS operation system in Nanshan District. Shenzhen Shekou Industrial Zone and Forever Public Bike Intelligent System Shanghai Co. Ltd (FPBISS) are involved in the early phase of PBS planning. The first round of investment from the FPBISS helped to provide 16 rental spots and 350 public bicycles. The company FPBISS has established its sub-company: Shenzhen City Public Bicycle Rental Ltd. (SCPBR) in Shenzhen. In 2016, the SCPBR aimed to install 500 new rental spots with more than 20,000 bicycles (SCPBR 2012).

Through *governing by regulation*, the Nanshan government has planned bike lanes to support the system’s development and authorized the SCPBR to operate the PBS. Under such cooperation modes, the service network has expanded rapidly within only a short space of time. In return, the company must invest in the bicycle facilities as well as meet the maintenance costs of the PBS. The PBS in Nanshan District tends to a pro-experimental type of initiative, undertaken to fulfill the related development target set by Shenzhen Municipality. However, the Nanshan government seems to have unclear goals regarding the PBS’s overall development direction.

In the planning agenda of PBS, the Shenzhen Municipality’s original goal is to integrate the PBS into the city’s public transport network, so the PBS service points should be around the public transport network (metro and bus stations) and its costs be relatively low. However, given the strong investment from the private sector in the PBS, the main interest of the SCPBR is to generate profit and reduce operating costs. As a result, PBS utilization in Nanshan District is relatively expensive and the rental spots tend to be located around commercial areas rather than residential ones. Although this governance mode has released the Nanshan government from the financial burden of the PBS’ operation, it is still far away from the original goal defined in the low-carbon transport planning agenda of the municipality. The Nanshan government appears to be risk averse then, since less effort is paid to the original planning goal in terms of supporting the public transport network.

PBS in Yantian District (Shenzhen)

Another example of PBS development is in Yantian District, which has been based on a top-down planning approach. The government invested in 160 rental spots and 5,000 public bikes in 2011. The governance mode is *governing by provision*. The local government thus directly delivers services and resources for PBS development. The planning goal of the Yantian government was to provide a public service that supports residents' slower mobility options. The PBS in Yantian is efficient in terms of fulfilling the goal of enhancing the public transport system's development. It is integrated with local subway stations; therefore, it is convenient to use and costs relatively little due to governmental subsidies.

The governance mode has enabled public sector control in terms of service quality distribution; however, since it has not integrated private sector participation and lacks a sustainable financing scheme, the service zones of the PBS in Yantian are much smaller than those in Nanshan are. The innovation initiative here seems, then, to be pro-safeguard in comparison with Nanshan's approach. The PBS in Yantian has been carefully integrated with the electronic card service (which is connected with bus and metro service cards), and it has well-planned PBS service spots that connect with subway and bus stations.

The comparison of PBS governance structures in Nanshan and Yantian shows that different governance modes lead to different outcomes. The government's goal in PBS development was to make the public transport network into an integrated system. By following this goal, the Nanshan case is efficient in terms of expanding PBS service zones and relieving the government's financial burden regarding PBS implementation. The chosen governance mode in Nanshan has helped establish public-private partnerships in PBS implementation. However, because arrangements between the private and the public sector are not clearly defined then the results show that the PBS in Nanshan did not prioritize the residents' mobility demands as their primary goal. Rather, the aim has been to develop PBS into a profit-making scheme — which is contradictory to the original goal of promoting the public transport system.

The promotion of PBS development in Shenzhen needs for its success a mixture of governance modes in terms of balancing service quality standards and financial sustainability. A more coordinated public-private partnership could help to improve the current situation. The municipality needs to formulate more elaborate policies hereon, as it has until now merely authorized private companies to be directly responsible for the PBS' operation. In light of the public transport system development goal, the municipality needs to pay more attention still to integrating the PBS therein — to achieve this will require coordination between different public transport service providers.

Conclusion

Rapid urbanization is one of the key features of China's modern development. On the one hand, cities are the drivers of the country's economic development. On the other, their carbon footprint and energy consumption are causing serious environmental issues that must be addressed. The Chinese government has recognized the need for energy efficiency and carbon emission reduction. The low-carbon transition suggests a fundamental change in the way that energy is produced and consumed. Governance identifies which actors use which tools to achieve the collective goal of carbon emission reduction, thereby defining the success or failure of the low-carbon transition.

Low-carbon governance arrangements in China have a hierarchical structure to them. The central government issues strategic development plans and targets, and provides the relevant legal framework. The local government, in turn, bears responsibility for the actual implementation of these. The steps that the municipality takes can be analyzed from two perspectives: mode of governance and type of initiative. Mode of governance refers to the governing capacities of the local government; in other words, which tools and resources the government utilizes in order to achieve carbon emission reductions. A distinction has been made in this paper between three such modes: governing through enabling, governing by provision, and governing by regulation. Types of initiative allow the activities to be evaluated in terms of time taken and actors' attitudes toward them.

Case studies of low-carbon governance in the building and transport sectors show that the mixed mode of governance, meaning a complex use of governance tools, is characteristic of both sectors. Yet specific combinations of modes lead to different results. Risky and quick decisions made by the government lead to fast results. However, these projects are prone to being unsustainable over the course of time. Although private stakeholders are more involved in the low-carbon transition process in the transport sector, a lack of participation by non-state actors in low-carbon governance in China is a key challenge for a successful transition and effective reduction of carbon emissions.

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