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Local governments' incentives and governing practices in low-carbon transition: A comparative study of solar water heater governance in four Chinese cities

Abstract

Urban sustainability transitions have been increasingly imperative to address global environmental challenges, and local governments are expected to play a critical role. There is a pressing need to explore local governments' underlying motivations and their impacts on governing practices. Taking China as an example, this paper builds an incentive matrix to distinguish the levels of local governments' economic interest and environmental interest in specific low-carbon innovations and investigates how different incentive typologies affect their governing practices. By comparing four Chinese municipal governments' incentives and governing practices in promoting solar water heater adoption, this paper finds that Chinese local governments' environmental incentive is still not compelling or stable enough, while governments that are motivated by economic interests would resort to more substantial governance practices to promote the low-carbon innovations. These results indicate potential in latecomer cities in developing both economic and environmental incentives towards low-carbon innovations because green activities could also be favored if they are well aligned with local economic development.

Keywords: local government, urban transition, incentive matrix, governing modes, China.

1 Introduction

Urban sustainability transitions have been increasingly imperative to address global environmental challenges (Bulkeley, Broto, Hodson, & Marvin, 2013). The core inquiry of sustainability transition research is how environmental innovations take place and what factors facilitate or impede them to gain momentum in niches, and to adapt, grow and become mainstream in various geographical contexts (STRN, 2010). Low-carbon innovations are attractive on the collective environmental criteria but are usually inferior to their substitutes in terms of cost performance. Besides, pricing and subsidy often favor existing approaches, and there are often enormous upfront costs of investment. Consequently, private sectors have little incentive to develop low-carbon innovations, and state intervention is believed to be essential (Horbach, 2016; Rennings, 2000).

The rise of the so-called low-carbon urbanism responds to the pressing need for local governments to align environmental objectives and local economic development (Bulkeley et al., 2016). A variety of governance initiatives for low-carbon urbanism have proliferated in the world. Prominent examples are the "Transition Towns Movement" originated from UK (Connors and McDonald, 2010) and the "Low Carbon City Initiative" in China (Yu, 2014; Liu and Qin, 2016). Local governments resort to

different governing strategies in advancing low-carbon urbanism (Lo, 2014). Bulkeley and Kern (2006) identify four governing modes of local governments in low-carbon transitions, namely, self-governing, governing by authority, governing by provision, and governing by enabling. These modes are not exclusive to each other, and in many cases, they are used together to deal with specific issues. The difference lies in the priority assigned to these modes of governing in different places. For instance, Bulkeley and Kern (2006) find that the local governing related to climate protection in the UK and Germany is mainly through self-governing and governing by enabling, such as reducing energy consumption in municipal buildings and promoting awareness about the energy use and its impacts. Mans and Meerow (2012) compare the governance of renewable energy clusters in five different cities worldwide (Baoding, Calgary, Hamburg, Piracicaba, San Diego) and find that while governing through enabling is the most commonly used mode in western countries, governing by authority is the most prominent in China's practice. It is not uncommon to see governments resort to these governing modes in promoting low-carbon innovations, but there exist vast differences in the performance of each governing mode, which we believe has much to do with local governments' incentives towards the specific innovations.

Previous research has provided mounting evidence of how local governments support low-carbon innovations (e.g., Mans & Meerow, 2012; Cowell *et al.*, 2016), but there is so far very limited knowledge about why governments in different places show different levels of commitment to comprehensive governance approaches (Lee & Painter, 2015). It is problematic to simply compare local governments' governing practices without understanding their interests towards particular low-carbon innovations. Low-carbon technologies not only differ in their modes of innovation (e.g., based on codified knowledge or experience) and valuation (e.g., customized market or standardized market) (Binz, Gosens, Hansen, & Hansen, 2017), but also vary in what and how much benefit they could bring to a place. Depending on the characteristics of the focal low-carbon innovations and territorial priorities, local governments may exhibit very different interests and thus adopt distinct governing strategies.

Therefore, this paper aims to explore whether and why local governments show different interests in particular low-carbon innovations and how these differences affect their governing practices. Local governments' incentives are deeply structured by a country's political set-up, especially the relationship between local governments and the central government (Zhuravskaya, 2000). Taking China as an example, local government as a whole aims to increase the economic, social and environmental well-being of the society, but it is also an organization run by rational officials pursuing personal political achievements (Chen, Lin, & Xue, 2010). This paper builds a technology-specific incentive matrix to differentiate local governments' economic interest and environmental interest in low-carbon innovations and investigates their

impact on local governments' governing approaches in China's context. To illustrate this framework, we compare four Chinese municipal governments' motivations and governing practices in promoting solar water heater (SWH) adoption.

China has committed to the development of renewable energy since the beginning of the 21st century. In 2005, China's National People's Congress passed the Renewable Energy Law, highlighting the strategic significance of renewable energy in meeting China's sustainable development target and energy demand. Based on this law, subsequent plans, policies, and regulations at both the national level and local level were issued to encourage renewable energy development. At the Copenhagen Climate Change Conference in 2009, China's then-Premier Wen Jiabao pledged to reduce carbon intensity by 40-45% by 2020 and to increase the share of non-fossil energy in primary energy consumption to 15% by 2020. Besides, environmental criteria are gaining more weight in the evaluation of local governments' performance. Through these efforts, energy-saving and emission reduction ('jie neng jian pai') has become a widely accepted political discourse across different levels of governments.

So far, China has been the leading country in the production and consumption of SWH (Weiss, Spörk-Dür, & Mauthner, 2017). Compared to other low-carbon technologies such as solar PV, the role of solar thermal heating in low-carbon transitions has long been neglected. In fact, globally, solar thermal heating yields much more green energy than solar PV (Weiss, Spörk-Dür, & Mauthner, 2017). Nevertheless, SWH suffers from the image as a low-end, low-tech, unreliable technology in many places (Yu & Gibbs, 2018a). Although the initial development of China's SWH industry was basically market-driven, recent years have seen growing governmental interests in this technology. SWH is rediscovered as an environmental product, and policy interventions at various governance levels have been initiated to promote its diffusion. While national and provincial governments play a significant role in the formulation of orientative policies, urban governments are primarily responsible for the translation of higher-level strategies and for delivering SWH adoption on the ground. It is observed that governing approaches of local governments vary and have reached very different outcomes among Chinese cities. Therefore, it would be intriguing to probe the governing dynamics behind the implementation of SWH in urban China.

The paper is structured as follows. Section 2 introduces the incentive matrix to differentiate local governments' interests towards specific low-carbon innovations in China's context and develops a framework to analyze the relationship between the government's interests and governing practices. Section 3 describes the method and the four case cities. Section 4 presents the four municipal governments' interests towards SWH and their governing modes. Section 5 discusses the results and Section 6 concludes the paper with implications for policy-making and future research.

2 Local governments' incentive typology on low-carbon innovations in China's context

2.1 Decentralisation, cadre performance evaluation, and incentives

The commitments and autonomy of local governments in low-carbon transitions differ with different political systems. The different designs in power devolution or decentralization from central governments significantly affect local governments' interests and capacities in governing environmental sustainability (Brown, Hart, Small, & de Oca Munguia, 2016; Cowell et al., 2016; Jiang, 2006; Pini, River, & McKenzie, 2007). Accompanying China's economic liberalization since the 1980s was the decentralization of political power from the central government to subnational governments. Provincial and urban level governments gradually gained more administrative autonomy and responsibility to govern the social-economic activities within their territories (Oi, 1992). Notably, China's fiscal contracting reform caused a significant transformation in the relationship between the central government and local governments (Jin, Qian, & Weingast, 2005). The tax reform in 1994 devolved more administrative responsibility to local governments, but largely decreased their proportion in national tax revenue distribution. With the rise of administrative responsibility and the decrease in tax revenue from national distribution, local governments have developed an inherent interest in increasing their fiscal revenue by enlarging the local economic base. The economic decentralization in China, to a certain extent, has created a quasi-federal structure, providing local governments incentives and a roadmap for change (Thun, 2004).

Despite the political devolution, the central government backed by the Chinese Communist Party is able to exert considerable influence over the governance at the subnational levels through the cadre performance evaluation system, in which higher-level governments decide the appointment, promotion, and dismissal of local cadres (Tsui & Wang, 2008). Local governments' interests are primarily determined by local political leadership (Hu & Hassink, 2017). Hence, China's local governments are neither complete agents of public interests nor pure self-interested politicians, but rather a mix of the two roles (Zhao, Chen, & Xue, 2013). Zhou (2004) argues that economic interests are not so motivating as political interests among local governments, because economic performance is mainly a means to achieve political achievement. The central government steers local cadres towards its national agenda by setting explicit political performance targets in social and economic development. For a long time, economic growth has been a dominant indicator in deciding local officials' political performance, hence, a GDP-oriented evaluation system. This incentive scheme stimulates China's fast local economy development at the cost of environmental degradation because it provides little incentive to local governments for the full implementation of central government's environmental policies, resulting in poor implementation or non-

implementation (Ran, 2013).

In recent years, environmental sustainability is becoming an important issue in international and national agendas. Both the central government and the public are placing increasing pressure on China's urban leaders to address environmental problems such as air pollution (Zheng, Kahn, Sun, & Luo, 2014). Environment quality has also gained more weight in cadre performance, and it seems that a regime shift is taking place such that local political leaders are increasingly incentivized by environmental performance (ibid.). However, in many cases, the fulfillment of environmental targets is in conflict with the realization of economic goals. Therefore, "the political incentives are still not effective enough to encourage widespread implementation of environmental policies at local levels" (Ran, 2013: 26).

2.2 An interest typology on low-carbon innovations

Existing studies on local governments' incentives have not differentiated the expectations towards different industries. Facing the emergence of low-carbon sectors in recent years, local governments have exhibited various interests (Chen et al., 2010). While the economy-environment tension has been a widespread concern, the idea of the green economy opens up the possibility of reaping both economic and environmental benefits (Gibbs, Jonas, & While, 2002). Through promoting environmental innovations, local governments facilitate the development of green industry, hence, obtaining the benefits in the forms of, e.g., employment and tax revenue. In terms of environmental benefits, the broad adoption of environmental innovations could help to relieve local ecological challenges. Low-carbon development also helps to earn a green image and to win more political credits and legitimacy from both higher-level governments and the civil society. Therefore, specific to a particular low-carbon innovation, local governments can expect to gain either economic benefits or environmental benefits, or both.

Concurring with Zhou (2004), we argue that political interest is the overarching incentive of local governments in China and performance in economic or environmental development mainly serves as a channel for them to achieve political interest. Subject to the focal low-carbon innovations and the local development priorities, local governments' economic and environmental interests may differ significantly. Depending on the level of interest in economic and environmental dimensions, we identify four typologies of local governments' interest combination in low-carbon innovations (Figure 1): a) economy-driven, when economic interest is strong and environmental interest is weak; b) environment-driven, when economic interest is weak and environmental interest is strong; c) economy-environment overlap, when both economic and environmental incentives are at the high level; and d) status quo, when

there is a lack of both economic and environmental incentives to change the status quo.

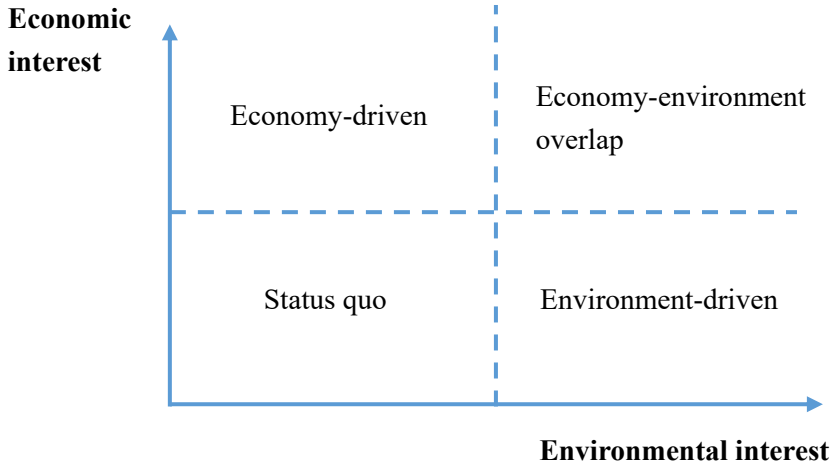

Figure 1. Typology of local governments' interest in low-carbon innovations

A local government's interest combination in a specific low-carbon innovation may locate in one of the typologies, but it may also move to another quadrant overtime when the local development priorities have shifted. In many cases, environment improvement can also bring economic interest through, for instance, building a green image and attracting green investment.

2.3 The role of interest typologies in the performance of low-carbon governance

Different incentive typologies would affect local governments' governing practices. In their study of China's new energy automobile industry, Chen et al. (2010) find that when only motived by political (environmental) interest, local governments tend to adopt superficial industry strategies without genuine investment and strict implementation, while under strong economic incentives, local governments will take substantial actions in promoting the industry. However, there still lack studies specifying how incentive combination affects local governments' choice and performance of governing approaches.

The performance of low-carbon governance can be analyzed through the variety and intensity of different governing approaches. Bulkeley and Kern's (2006) conceptualization of the four governing modes can serve as an analytical framework for the elucidation of the performance of low-carbon governance. Self-governing is the approach that the local government governs its own activities, such as the procurement of green technologies. The government can invest in sustainable technologies and apply them in public facilities to induce a demonstration effect. In governing by authority, the government uses its authority over other actors to promote green standards through, e.g., planning and regulations. Governing by provision means providing particular forms of services and resources such as financial subsidy so that green investment could

be encouraged. As to governing through enabling, the local government acts as the core actor in facilitating and coordinating the private-public partnership and community engagement to take green actions. In this scenario, persuasion, argument, and incentives are the primary means of action. In many cases, these governing modes are used jointly to deal with specific issues.

Using governments' incentive matrix of low-carbon innovations on the one hand, and Bulkeley and Kern's (2006) framework of governing modes on the other, this study tries to not only differentiate local governments' performance levels of governance but also investigate how different interest typologies define their governing strategies. Four cases of SWH adoption in urban China are presented as an illustration of this analytical framework.

3 Methods

3.1 Context

The focal low-carbon innovation of this research is SWH. In 2015, the production and consumption of solar thermal energy in China respectively represented more than 80% and 67% of the world's capacity (Weiss et al., 2017). China's outstanding success in the solar thermal application is primarily rested on low-temperature SWH collectors, which are widely employed for hot water and heating. The most commonly used SWH collectors are the evacuated-tube collector and flat-plate collector. China's SWH industry began from the 1980s and witnessed a dramatic growth since early 1990s when an indigenous breakthrough in evacuated-tube technology significantly reduced the cost and happened to meet the fast-growing demand for economic hot water during China's unprecedented urbanization (Hu et al., 2012).

After 2006, China's Renewable Energy Law explicitly encouraged the adoption of SWH in the urban market, and many provincial and municipal governments initiated various measures to encourage SWH incorporation with urban buildings. These measures cover different policy fields, such as industrial policy for solar thermal industry and energy policy for renewable energy application, and encompass different instrument types (e.g., economic instruments and regulatory instruments) to fulfill purposes of technology push, demand pull and system building (Borrás and Edquist, 2013). Government-subsidized demonstration projects for SWH application are typical examples of economic instruments. In terms of regulatory instruments, the most influential approach is the mandatory installation policy, which requires estate developers to incorporate SWHs into new residential buildings. Since then, the SWH-incorporated building project market has grown rapidly, and the flat-plate SWH has gained increasing popularity as it enjoys many advantages in incorporation with high-

rise buildings.

3.2 Case cities

Table 1 summarizes the key characteristics of the four case cities, Dezhou, Rizhao, Beijing, and Shenzhen. These cities are selected based on the following considerations. First, the four municipal governments have adopted strategies to facilitate SWH popularisation at a different time and reached very different outcomes. Second, the four cities have diversified motivations to support the SWH industry. It is particularly interesting to see how cities at different economic development stages demonstrate diverse interests in this low-tech green innovation. Dezhou and Rizhao are economic latecomers compared to Beijing and Shenzhen, but they have been the pioneers in SWH utilization in the urban market, both known as *Solar City*. Though the different diffusion outcomes have been previously explained from the infrastructure, user preference and industrial perspectives (Huang, Ma, & Liu, 2018; Li, Song, Beresford, & Ma, 2011; Yu & Gibbs, 2018a, 2018b), the incentives and governing practices of the local governments also significantly matter.

Table 1. Key characteristics of the four case cities (2016)

	Dezhou	**Rizhao**	**Beijing**	**Shenzhen**
Population (million)	5.63	3.00	21.73	11.91
GDP per capita (thousand RMB)	57.9	62.36	114.7	167.4
Urbanization rate (%)	53.8	56.9	86.5	100
Share of tertiary industry in GDP (%)	42.1	44.6	80.2	60.1

This research applied a qualitative investigation of local governments' incentives and governing practices. The primary data was collected during fieldwork in the four cities, including 71 semi-structured interviews with government officials (9), firms (32), intermediary actors (12), and consumers (18), as well as secondary materials such as policy documents, industry reports, and news media coverage. Interviewees were asked about their knowledge of SWH implementation in the corresponding city. Sampling continued until new interviews did not provide additional information on the key topic concerning the approaches and performance of low-carbon governance.

4 Results

4.1 Dezhou

4.1.1 Dezhou government's interest towards SWH

Located in west Shandong, Dezhou is a typical developing city in China. With fast industrialization since the 1980s, the manufacturing industry becomes the central pillar of Dezhou's economy, accounting for 51.6% of Dezhou's GDP in 2014 (Dezhou Statistics Bureau, 2015). Equipment manufacturing, food, chemical, and textile

industries are the four competitive industries in Dezhou. Dezhou's central air-conditioning industry is of national importance (Dezhou Government, 2006), but is dominated by small enterprises without well-known brands and is criticized for being highly polluting.

Meanwhile, the solar industry is emerging in Dezhou and has become the most frequently promoted city image of Dezhou. Dezhou's solar industry was born with the establishment of Himin. By the early 2000s, Himin quickly developed into the world's largest SWH manufacturer, and the market developed by and technology spillovers from Himin stimulated further local entrepreneurship in the solar industry. In 2010, the city was home to more than 120 enterprises engaging in solar-related industries, achieving more than 50 billion RMB sales revenue. Around 800 thousand people in Dezhou were employed in the solar industry, representing one-third of the city's workforce (Tyfield, Jin, & Rooker, 2010). Moreover, the green industry brought with Dezhou increasing national and international recognition. In 2005, the city was designated as China's Solar City by China's Solar Association. In 2009, Dezhou was designated as one of China's first Renewable Energy Demonstration Cities by the Department of Housing and Urban-Rural Development. Dezhou boosted its international reputation when it hosted the 4th International Solar City Congress in 2010.

The municipal government believed that the solar industry would be promising and decided to incorporate solar energy into Dezhou's future vision. In 2005, Dezhou municipal government put forward the *Solar City Strategy*, aiming to promote solar energy as Dezhou's new leading industry and to build Dezhou as the solar city of China and even the world. Apparently, the government shows a high level of economic interest in the SWH industry, and the green image is a bonus that can trigger further investment.

4.1.2 Governing practices

With a strong economic incentive in the SWH industry, Dezhou's government has adopted a comprehensive approach in promoting the industry and SWH diffusion. The government has been active in *governing by provision*. To build a solar city, the municipal government and county-level governments together provided more than 80 million RMB annually for the demonstration projects of solar energy. In 2008, Dezhou's Solar City Office was established to promote the application of solar energy in Dezhou and to help solar enterprises extend new technologies with demonstration projects (Dezhou Government, 2014). In 2009, Dezhou was awarded the National Demonstration City for the Application of Renewable Energy in Buildings and received 60 million RMB to subsidize more than 60 demonstration projects. Further policy packages, such as subsidies for rural residents and land use privileges for SWH firms, were introduced to encourage the SWH sector. As a government official put it:

> …the municipal government was rigorous in approving the land use, (but) the government supported solar industry, so when they applied for new projects in new development zones, their projects were regarded as key projects, and their demand for land use was prioritized. [Interviewee from Dezhou government].

In terms of *self-governing*, since the early 2000s, Dezhou municipal government has been a role-model of SWH use. Dezhou government first experimented with SWH-building integration in its employees' residential community before it officially encouraged this practice. After Dezhou being awarded as China's Solar City, the municipal government deployed many demonstration projects in municipal buildings and urban public facilities such as museums, stadiums, hospitals, and schools. These efforts have not only strengthened the image of the solar city but also increased citizens' awareness of solar energy.

As for *governing by authority*, Dezhou was among the first group of cities that officially encouraged the integration of SWH in buildings by issuing the *Notice on the Comprehensive Application of SWH in Construction Projects* in 2005. In 2008, the municipal government enacted the mandatory installation policy, explicitly requiring new construction projects to integrate SWH in design and construction. Projects that fail to comply with the requirement will not be given permission for construction or completion inspection. Conversely, projects that meet the requirement will enjoy some privileges, such as priority in land use, a simplified approval process, and mitigation in building urban supporting facilities. In 2009, Dezhou government developed the *Dezhou Renewable Energy Application in Construction Special Planning*, which clearly stated the long-term objectives of the application of renewable energy in the construction sector.

In terms of *governing by enabling*, a Solar City Strategy Committee was established to promote and implement the solar city strategy in 2005 (Dezhou Government, 2014). Dezhou is the only city in China that has such a specialized institution to promote the development of solar energy. Solar thermal energy is not only encouraged in local industry policy but also integrated into its local strategic vision to build Dezhou as China's solar city. This strategic vision goes beyond merely giving a clear signal to the local community, but has been realized with concrete measures, including hosting the World Solar City Congress and promoting and marketing Dezhou as a solar city nationally and internationally. Other events such as Solar Expo and Solar Thanksgiving Day are held regularly to enhance the communication between Dezhou and foreign countries and inspire residents' enthusiasm for solar energy. A government official illustrated the government's motivation:

> Dezhou's government departments that are related to economic development…all highly cherish the achievements made by Dezhou's solar industry. We hold the International Solar Expo every two years to promote our products on the one hand, and to attract international experts to guide our practices on the other. [Interviewee from Dezhou government]

4.2 Rizhao

4.2.1 Rizhao government's interest towards SWH

Rizhao is located on the eastern coast of Shandong Province in China. Leading industries in Rizhao are metallurgical industry, motor vehicles and parts, petrochemical industry, cereals, oils, and foodstuffs industry, pulp and paper industry, building materials industry and textile and garment industry. Together they contribute more than 80% to the city's economy. In contrast to these dominant industries, the SWH industry has played a relatively minor role in Rizhao's economy. For example, in the list of key government-supported enterprises in 2016, of the 97 above-scale enterprises, there was only one SWH manufacturer. This has partially explained the government's lack of economic incentives in supporting the SWH industry, particularly during the early stage of development.

In fact, the popularization of evacuated-tube SWHs in Rizhao exhibits significant bottom-up diffusion characteristics, driven by unmet social needs for domestic use of hot water (Huang, Ma, et al., 2018). It was not until 2004 that the SWH industry started to gain attention from the Rizhao government. Early at the beginning of the 21st century, the popularization rate of SWH in Rizhao had already reached 70% (Southern Weekly, 2009). Local residents and enterprises played a leading role in the diffusion process. The situation seems to change after Rizhao's winning of the "World Clean Energy Awards" in 2007. With an increasing international reputation in SWH application, this UN Award has in a sense given the local government a strong environmental incentive in supporting the industry. This environmental incentive is well illustrated in a speech given by a governmental official (Rizhao Construction Committee, 2010):

> For many years, Rizhao leads in the application of SWH in buildings among Chinese cities, whose achievements have been widely lauded ... However, because we do not mandate the installation of SWHs in high-rise buildings… there is a tendency of decreasing SWH application rate. If things continue this way, soon Rizhao will lose its leading position in the application of solar thermal technology.

The government official expressed the government's concerns on whether Rizhao can maintain its leading position in the application of solar thermal technology. This green image is also well aligned with Rizhao's vision to build a coastal tourist city. In recent

years, mandatory installation of SWHs in high-rise buildings has helped the opening up of a new market segment for flat-plate SWHs and thus the drastic growth of a large local flat-plate SWH manufacturer in Rizhao. This has, in a sense, increased the economic incentive of the municipal government in supporting SWH application.

Overall, for Rizhao, the government's interests in supporting SWH application are mainly environment-oriented, though also with a certain level of economic interest at the later stage.

4.2.2 Governing practices

Governing by provision, particularly in financial terms, has not been very intensively used by the municipal government of Rizhao. This is reasonable considering its relatively limited public financial resources as a small city. However, the government did engage actively in applying for external subsidies for SWH application provided by provincial and national governments. Similar to Dezhou, in 2011, Rizhao was awarded the *National Demonstration City for the Application of Renewable Energy in Buildings,* and a total of 60 million RMB subsidies was provided by the national government. Although Rizhao spent more than half of the subsidy on the application of SWH in buildings, it was far from sufficient. As indicated by a government official:

> The subsidy was given to real estate developers to install SWHs... but it is definitely not enough. For every square meter of construction area, they get a subsidy of 2 RMB, and for a hundred square meters, there are only 200 RMB. So the subsidy is more a kind of encouragement. [Interviewee from Rizhao government]

In addition to national funding, the municipal government also actively applied for subsidy provided by the Shandong provincial government for the application of SWH in public buildings such as schools, hospitals, and geracomiums.

Activities of *self-governing* and *governing through enabling* have also been limited in Rizhao. Although the government implemented SWH installation in some public buildings, these were mainly a part of the demonstration program supported by provincial or national governments. Moreover, the government played a limited role in coordinating between key actors to facilitate the diffusion of SWHs, and effective communication platforms were absent in Rizhao.

Due to the lack of robust economic incentives and limited public financial resources, the Rizhao government resorted more to *governing by authority*. In 2007, after winning the UN award, the Rizhao municipal government issued the regulation for the

mandatory installation of SWHs in newly-built low-rise and multi-story residential buildings. In 2008, Rizhao adopted the new *Building Energy Saving Standard of Shandong Province*, which technologically guaranteed the large-scale implementation of SWHs in high-rise buildings. In late 2009, the Shandong provincial government introduced the mandatory installation regulation to implement the application of SWHs, aiming to increase the application rate of SWHs in urban areas in Shandong province from 20% to 40% within the coming three years (Shandong Provincial Government, 2010). Later in 2010, driven by environmental pressures from higher-level governments and also, as aforementioned, to maintain its own SWH application rate, the Rizhao government extended the original mandatory regulation from low-rise buildings to high-rise buildings. To ensure the enforcement of this regulation, the government did a thorough investigation of all the high-rise buildings that had been approved for construction. A list of 83 real estate projects was published, and the developers were required to revise the construction design to integrate SWHs in buildings.

4.3 Beijing

4.3.1 Beijing government's interest towards SWH

As China's capital, Beijing is one of the most developed cities in China. Before the mid-1990s, Beijing's economy was dominated by heavy industries, such as steel, petrochemical and automobile industries. In 1997, Beijing's government carried out the *Capital Economy Strategy* to transform the economy from a manufacturing-dominated one to a service-based economy, which grew to represent 76% of the city's GDP in 2013 (Beijing Statistics Bureau, 2015). However, the negative legacy of heavy industrialization and fast urbanization remains. Beijing is confronted with severe environmental problems, with air pollution being the most serious social concern in recent years. The Beijing government thus strives to improve the environment by increasing the share of clean energy in its energy mix, which was only 1.5% in 2006 but targeted to be 8.1% by 2020.

The beginning of Beijing's solar thermal research was in response to the global energy crisis in the 1970s. The concentration of national research institutes and universities, as well as national support, enabled Beijing's role as an innovation center of China's solar thermal technology. Beijing accommodates one of the largest SWH clusters in China (150 firms in 2010) (Luo, Huo, and Xie, 2013), but the scale of the industry is still comparatively small in terms of GDP output. Moreover, the SWH industry is often deemed as a low-end industry, which contradicts Beijing's pursuit for high-end industries. This indicates that Beijing lacks economic incentives in promoting the SWH industry. It was not until 2012 that the government issued the mandatory installation policy as a way to combat air pollution. As observed by an SWH entrepreneur:

> As for the driving force of SWH deployment in Beijing in recent years, the

> foremost factor is the haze. You can easily feel the seriousness of this problem, and then some national policies such as energy-saving and emission reduction, and local policies such as Beijing's clean air plan, came into force. [Interviewee from an SWH firm]

Because of Beijing's special role as the nation's capital, the Beijing government suffered substantial political pressure from both the central government and the civil society in combating air pollution. SWH, though without a high-end profile, is expected to play a role in reducing buildings' energy consumption. Apparently, the support of SWH in Beijing is primarily environment-driven, but it seems that the government is not so confident that such a simple technology will play a prominent role in addressing Beijing's environmental challenges.

4.3.2 Governing practices

As for *governing by provision,* Beijing's solar thermal energy industry did receive government support in technology development in the early phases. For instance, since the 1980s, the central government and the Beijing government have granted many key research projects in solar thermal technologies. Nevertheless, this support mainly went to universities and research institutes, and private enterprises did not receive much incentive from the government. It should be noted that much of Beijing's research funding on solar thermal energy was actually assigned by the national government, rather than by the Beijing municipal government. Considering this, the Beijing municipal government's role in governing by provision is even smaller.

The Beijing municipal government has also shown some activities of *self-governing* concerning SWH application. However, demonstration projects were somewhat constrained to several dispersed sites, such as public sports facilities for the Olympic Games. In terms of *governing by enabling*, Beijing has seemed merely to give the signal to encourage the use of solar thermal energy through its Five-Year Plan. The municipal government also helped mobilize financial resources to state-owned SWH enterprises. For instance, in 2002, when Beijing started to promote green development and Capital Steel, a large state-owned steel enterprise, was about to move out Beijing, the political leaders of Beijing built a bridge between Capital Steel and green firms. One of the actions was that Capital Steel invested 100 million RMB to an SWH firm, Tsinghua Solar. However, this is not a common practice and is limited to a few state-owned enterprises.

Governing by authority has played a vital role in Beijing's case when compared to other modes. Building standards and mandatory SWH installation regulations are the most prominent approaches in this mode of governance. Beijing's building standards place

more emphasis on reaching a certain level of energy efficiency, which is among the highest in China. This energy efficiency performance can be achieved mainly through insulation technologies, and the use of renewable energy only plays a minimal role. These standards, to a certain extent, promoted the SWH installation, but they are not as specific and clear as Dezhou's building standards that explicitly require to reserve installation space for SWHs. While many cities had implemented mandatory policies earlier, Beijing was much more cautious in carrying out mandatory policies. Beijing's SWH industry had started lobbying the government for a mandatory installation policy since 2005, but only after 2012, when air pollution became so severe, that the government decided to adopt the policy, with adaptions to Beijing's context. For instance, Beijing required that the complementary energy for solar water systems should be gas, rather than electricity. This was believed to have better performance in energy saving. Besides, for high-rise buildings, it was not required to use SWH to cover all the households in the building, but at least, a certain portion of the building should have access to SWH.

However, the policy was not well implemented. SWH-integrated building projects did witness an apparent increase since 2012, but the majority of the installation was in government-led projects such as public rental housing. The core problem was that an inspection system of SWH incorporation was not well established, so estate developers only used inferior SWH to cope with the regulation. This, in turn, led to a lack of trust in the quality of SWH products among users. The mandatory policy is now nearly paused in Beijing.

4.4 Shenzhen

4.4.1 Shenzhen government's interest towards SWH

Shenzhen is a city in Guangdong province, immediately adjacent to Hongkong. In 1979, it was designated as a protected economic zone, and ever since the city has had unprecedented rapid urban development. In 2016, Shenzhen's GDP ranked fourth in China. Shenzhen has four pillar industries, namely, cultural and creative industry, high-tech industry, modern logistics industry, and financial industry. Unlike Dezhou or Beijing, a cluster of SWH industry has not been formed in Shenzhen. After years of industrial upgrading, Shenzhen's economic priority has been oriented towards the development of high-value-added, high-tech, and high-end industries. The SWH technology, with relatively limited added-value, is not a focus of development. This is similar to the situation in Beijing. From an economic perspective, Shenzhen lacks strong incentives in implementing SWH application.

However, Shenzhen does possess significant environmental incentives in applying

environmentally friendly and energy-efficient technologies, including SWH. Although Shenzhen has become one of the four first-tier cities in China, as a very young city, it is eager to establish its own identity. Beside 'city of innovation', 'livable city' is another notable label that has been propagated by the municipal government. Shenzhen's air quality is the best among the four first-tier cities. To maintain its identity as a livable city, Shenzhen has been very active in the utilization of low-carbon technologies in different sectors, including the transportation sector (new energy vehicles) and the building sector (green buildings). Therefore, the Shenzhen government's interests in supporting SWH application are mainly environment-driven.

4.4.2 Governing practices

Shenzhen is a city with strong governance capacities. *Governing by provision* has been very frequently applied by Shenzhen municipal government. In 2009, Shenzhen was among the first to be designated as the *Demonstration City for the Implementation of Renewable Energy Buildings*, under which the *Solar Rooftop Project* was launched in 2010 (GOSMPG, 2010). For this two-year (2010-2011) demonstration program, Shenzhen received 80 million RMB of national subsidy, of which 70 million was used to support SWH installation. Besides, the municipal government allocated 120 million RMB as special funding for the application of renewable energy in buildings, of which 105 million was spent on SWH (GOSMPG, 2010). The frequent use of economic governance instruments has been supported by Shenzhen's strong financial capacity.

Self-governing has been demonstrated through the prioritizing of the installation of SWH in public buildings. Many public hospitals and universities in Shenzhen installed SWHs. In particular, the SWH system installed in the Universiade Athletes' Village was one of the biggest SWH systems in China. Another typical project was the Shenzhen Universiade Sports Centre. This project applied different renewable technologies. These projects were expected to have a demonstration effect on the public.

The Shenzhen government has also conducted many activities through *governing by enabling*. In Shenzhen's 12th Five-Year Plan, specific goals were set up for the application of SWH in buildings. SWH technology was also emphasized in Shenzhen's *12th Five-Year Plan for the Application of Renewable Energy in Buildings* and the *12th Five-Year Plan for Building Energy-saving and Green Buildings*. The Shenzhen Solar Energy Society was established in 2006, the primary mission of which was to bring together different stakeholders to implement SWH technology and industry. Besides, the municipal government also frequently organized conferences and training workshops (HCBSM, 2013).

Similar to other cities, *governing by authority* has been primarily represented by the mandatory installation regulation of SWHs. As early as 2006, Shenzhen was designated as the *Demonstration City for the Scaling-up of Renewable Energy (Solar Energy) Buildings*. In the same year, Shenzhen enacted the first mandatory installation regulation of SWH in residential buildings of 12 floors or below. After Shenzhen's designation as the *Demonstration City for the Implementation of Renewable Energy Buildings* in 2009, the municipal government launched the *Solar Rooftop Project*, extending the mandatory installation regulation from buildings of 12 floor or below to high-rise buildings (GOSMPG, 2010). As the demonstration city for renewable energy buildings, specific and strict requirements were set by the central government, such as to achieve a total application area of 7.12 million m^2 within two years (2010 to 2011). Compared to commercial housing, the mandatory SWH installation seemed to be more strictly and vigorously enforced in social housing projects in Shenzhen. In 2010, a notice on energy efficiency in public housing was published by the municipal government, in which it required the installation of SWHs in all newly-built public housing in Shenzhen (HCBSM, 2010). Around 52,300 affordable apartments built in 2010 were all equipped with SWHs.

Overall, a combination of different governance approaches has been used in SWH application in Shenzhen. However, in 2014, Shenzhen was the first city in China that officially abolished the mandatory SWH installation policy. Similar to Beijing's situation, a mismatch between technological characteristics and local contextual factors have resulted in the failure of SWH implementation in Shenzhen (Huang, Broto, Liu, & Ma, 2018; Yu & Gibbs, 2018a). Particularly, local residents' social practices have formed around gas and electric water heaters, and they have much less tolerance to the unreliability of SWHs.

5 Discussion

An illustrative overview of the evolving dynamics of the government's incentive mode of the four cities is presented in figure 2. Dezhou government was mainly motivated by the economic interest at the early stage, but it also developed an environmental interest as the city gained more national and international green reputations, which in turn helped to mobilize more global investment to Dezhou's SWH industry. In recent years, as the SWH industry suffered from stagnation in the retail market and with the rise of other industries, the role of SWH in Dezhou's economy is declining. Even so, Dezhou government still shows an economy-environment overlap incentive model to the SWH industry. The municipal governments of Rizhao, Beijing, and Shenzhen all lack significant economic incentives in supporting the SWH industry. In the case of Rizhao, although initially the municipal government was mainly motivated by environmental incentives, a certain level of economic incentive has managed to develop. On the one hand, the mandatory application of SWHs in high-rise buildings has fuelled the rise of

a local flat-plate SWH industry; and on the other hand, national and international recognition of the city's green development has helped the thriving of the tourism industry.

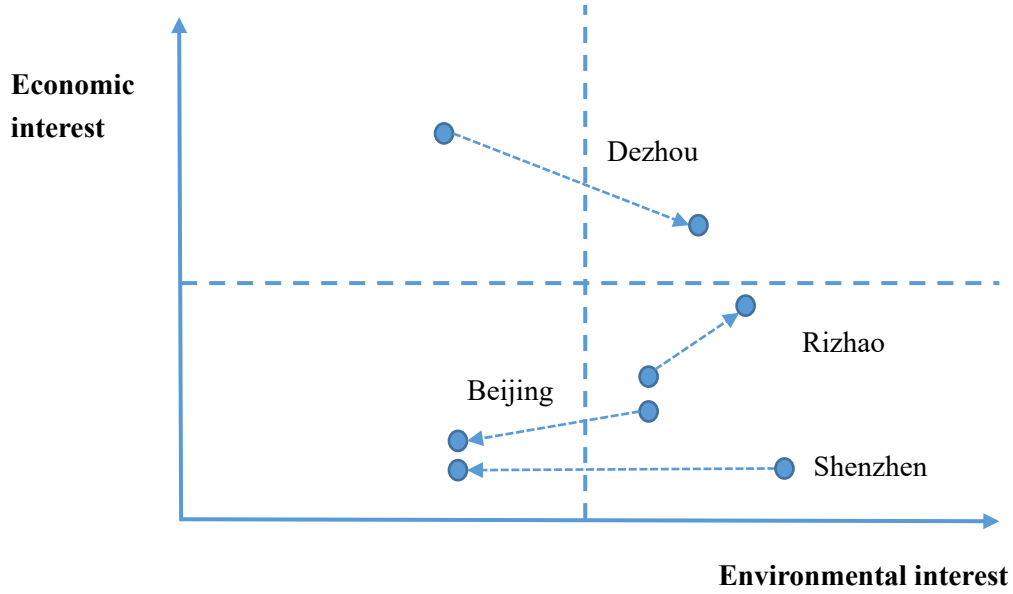

Figure 2. Dynamics of the four governments' incentive mode on SWH

In contrast, the government's incentives of SWH implementation in both Beijing and Shenzhen have followed a trajectory from the environment-driven mode to the status quo. The two municipal governments were mainly motivated by the environmental interest when deciding to support SWH installation, but apparently, the Shenzhen government had a more proactive attitude towards the technology at first while the Beijing government was much less decisive from the very beginning. It seems the Beijing government had little confidence in SWH's technical performance, and thus only passively responded to the central government's and the public's environmental expectation by issuing a mandatory installation policy, which currently almost exists only in name because of the absence of an effective inspection system. While in Shenzhen, the municipal government modified its position in SWH implementation from mandating to encouraging. As the market was damaged by inferior projects, both municipal governments lost faith in the SWH technology and chose to turn to other low-carbon technologies to fulfill similar environmental commitments.

Therefore, local governments' incentive in low-carbon innovations is contingent to not only the characteristics of the focal technology but also the city's specific territorial contexts. As mentioned, SWH is generally recognized as a low-end and low-tech industry with low added-value. Compared to other technologies such as solar PV, the relatively low economic output of the SWH industry provides little economic incentive to local governments. In Dezhou, the presence of the leading enterprise Himin has played a significant and unique role in incentivizing the local government's support for

the SWH industry. However, this can hardly be the case for other cities, especially for the more developed cities such as Beijing and Shenzhen. Moreover, China's political and economic context exerts different pressures on cities at different development stages. For forerunners of economic development, they suffer more pressure on the transformation of industrial structure and have a higher imperative to green the economy, while latecomers still view economic development as the first priority. When cities reach more advanced development phases, economic incentives go beyond the sole calculation of the contributions to GDP but embrace more nuanced meanings. For cities like Beijing and Shenzhen, the central priority is economic restructuring. Under this rationale, high-tech industries are prioritized over low-tech ones.

Incentive typologies affect governing performance (Table 2). It is no surprise to see that the four governments were most active in the approach of governing by authority, as all the four cities have an environmental incentive but the market lacks inherent incentive to incorporate SWHs into buildings. In governing by authority, regulatory instruments were most frequently adopted. As noted by Borrás and Edquist (2013), regulatory instruments are obligatory in nature. They are deeply rooted in the normative authority of governments. Obligatory regulations define rules of innovation processes and activities and help the nurturing of a niche market, one typical example of which is the mandatory installation policy. Other than that, Rizhao and Beijing were not active in other governing approaches. Although both Dezhou and Shenzhen demonstrated a more comprehensive governing mode, Dezhou's supporting measures were more substantial and lasted for a more extended period. Specifically, Dezhou municipal government applied different types of policy instruments to promote the uptake of SWH. For instance, various government-subsidized demonstration projects represented economic instruments for technology push. Different from Dezhou, Shenzhen eventually lost its faith in SWH and canceled the mandatory installation policy.

Table 2. Performance in each governance mode

	Dezhou	**Rizhao**	**Beijing**	**Shenzhen**
Self-governing	*****	*	*	***
Governing by authority	*****	****	***	***
Governing by provision	*****	**	*	****
Governing through enabling	*****	*	*	***

The performance of governance approaches pertains to governments' incentive typologies. In promoting low-carbon innovations, governments only motivated by environmental incentives may not adopt genuine governing approaches, while those motivated by economic interests would resort to more substantial supporting measures.

A key issue at stake here is whether the government's motivations are endogenous or exogenous. In many cases, environmental interest is merely a passive political response to pressures from higher-level governments or the public and is thus exogenous. Under China's current discursive landscape, environmental issues are still viewed as less important than issues such as education, employment, and healthcare among urban middle-class (Li & Tilt, 2017). Besides, environmental performance, unlike economic performance, is challenging to evaluate in the short term as it often involves trans-territory coordination. For local governments, environmental achievements to some extent are more like fancy clothes, which often only please others but wear uncomfortable. It is particularly true when facing low-end low-carbon innovations, whose technical performance and environmental benefits remain uncertain.

In contrast, the economic incentive is apparently far more endogenous as it not only meets the GDP-oriented cadre performance evaluation system but also brings local governments with a stronger financial capacity to govern many public issues. In practice, to what extent an industry receives official support often has much to do with its role in the local economy (Zhu & He, 2015). Surely, governing approaches are also conditioned by local governments' resources (e.g., fiscal volume) and capacities (supervision of policy implementation and knowledge). However, in Dezhou's case, we see how a strong endogenous (economic) incentive has mobilized a wide variety of governmental resources, even when the Dezhou government has relatively limited governance capacities compared to that of Beijing and Shenzhen. This indicates that green activities could also be favored in latecomer cities if they are well aligned with local economic development.

6 Conclusion

An open-ended and uncertain process of urban sustainability transitions that is underway has posed new challenges to urban governance (Frantzeskaki et al., 2012). Local governments that exhibit different patterns in the choice of governing strategies are often motivated by different interests in the focal low-carbon innovations. Previous studies on the incentives of local governments have been too general and have failed to account for the particularity of specific technologies. This paper contributes to the literature by identifying a more industry-specific incentive model of local government. We find that, under the Chinese context, the government's incentive towards a particular low-carbon innovation largely depends on the technology's economic value and environmental value, as well as whether they match local development priorities.

Another contribution of this research is to link local governments' industry-specific incentives with their governing practices. Previous studies find that local governments are both the agent of higher-level government and representatives of local interest, and this dual identity largely affects their governing practices (Zhao et al., 2013). This study

goes one step further to investigate how this dual identity is played in local governments' governing practices towards a specific low-carbon innovation. Compared to the environmental incentive, the economic interest seems to be a more endogenous incentive for local governments. Even though the global and national policy narratives are imposing greater pressure/ incentive to local governments in green transitions, environmental incentive alone is still not effective enough to motivate local governments to invest in low-carbon innovations genuinely. In contrast, if sufficient economic incentives are provided, local governments are more likely to deliver long-term commitments and to adopt comprehensive governing approaches to support low-carbon innovations.

The research findings offer important implications for urban governance for low-carbon transitions, particularly for latecomer cities where economic development still outweighs environmental issues. Both local contexts and technology characteristics condition whether alignment could be reached between the focal low-carbon innovations and local economic development priorities. It is therefore crucial that low-carbon governance is sensitive to local socio-economic contexts and aims to seek common ground between both environmental and economic objectives.

This study proposes two avenues for future research. First, this study is situated within the Chinese context, and drivers of low-carbon policy could be very different in other countries' contexts. Considering that local governments' incentives are significantly shaped by a country's political regime, other potential incentives for low-carbon innovations (e.g., energy cost and pressure from civil society) can be explored through comparative studies of different political systems. Apparently, the role of citizens is currently less presented in China's low-carbon policy-making process, but it could be a very different story in western countries where citizens have more power of discourse and higher environmental awareness. Second, this study has captured the relevance of both technology features and a city's place-based contexts in shaping local governments' incentives. In particular, we see great potential in latecomer cities in developing both economic and environmental incentives towards low-carbon innovations, since economic growth is usually their development priority and environmental achievement could further legitimize their economic development, leading to a virtuous cycle (Yu & Gibbs, 2018c). Future research could explore the co-evolution pattern of economic and environmental incentives by comparing local governments' incentives towards low-carbon innovations for cities at different development stages.

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