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When government-led experimentation meets social resistance? A case study of solar policy retreat in Shenzhen, China

Ping Huang [a,*]

[a] *Urban Institute, Interdisciplinary Centre of the Social Sciences (ICOSS), University of Sheffield, UK*

* Corresponding author at 219 Portobello, Sheffield, S1 4DP, UK
E-mail addresses: p.huang@sheffield.ac.uk (P. Huang).

Abstract: Low-carbon energy transitions envision deep decarbonization of the consumption, distribution, and production of the energy system. Urban areas are the frontier for low-carbon transitions. Despite increasing attention on the role of urban politics in urban energy transitions, transition governance in China still follows a rather functionalist and instrumentalist logic that highlights the government's leadership in resource mobilization. Disproportionate report of successful cases has reinforced this governing logic, while shadowed the political dynamics of transition processes, particularly the role played by local communities. Through a failed case of solar experimentation in Shenzhen, China, this article shows that the success of low-carbon experiments is not necessarily guaranteed by the strong governance capacities of local governments. Strong social resistance can produce a countering effect on the outcome of low-carbon experiments. The study calls for future research to adopt a more dynamic and holistic perspective of urban energy transitions and to take account of the mediating or even countering effects of urban politics.

***Keywords*:** urban experimentation; transition governance; social resistance; building-integrated solar thermal (BIST) technology, China

1 Introduction

Sustainability transitions envision long-term and fundamental transformations of the socio-technical systems towards more sustainable and environmentally friendly ones [1]. The proliferation of socio-technical experimentation in a variety of contexts worldwide represents cross-national and cross-sectoral commitments to sustainability transitions. In concomitant with a 'spatial' turn in transition studies [2, 3], cities are emerging as new and focal locales of low-carbon transitions. In China, for instance, the past decade has witnessed the proliferation of pilot schemes in cities to experiment solutions for deeper decarbonization of the energy system, including the "Low-carbon City Initiative", the "New Energy Demonstration City Program", and the "National Ecological Civilization Demonstration City/County Project". In particular, under the national strategy of "Ecological Civilization Construction", urban energy transition is framed as a key step to achieve green and coordinated urban development.

Urban energy transition is a multidimensional process that entails reconfiguration of the technical, physical, institutional, and social systems [4]. From an evolutionary perspective, transition theories depict this process as the emergence and the cumulation of technological niches, which ultimately replace the incumbent socio-technical regimes [5]. Socio-technical experimentation in many cities represents such actions for incubating innovations. Recent years have witnessed increasing attention paid to the messiness of transition processes and the interactions between different actors [6], giving birth to an expanding body of literature on the politics of urban energy transitions [7]. This strand of literature uncovers the intrinsic political nature of urban energy transitions [8], manifested as the conflicts, negotiations, tradeoffs, and compromises between different actors embedded in complex power relations. As portrayed by Meadowcroft (2011):

> *"Politics is the constant companion of socio-technical transitions, serving alternatively (and often simultaneously) as context, arena, obstacle, enabler, arbiter, and manager of repercussions."* [9, p. 71]

Local government, as a key player in urban low-carbon transitions, is inevitably part of this transition politics, confronted with uncertainties, conflicts, and very often resistance [10, 11]. There is a trend in transition literature that takes a functionalist and instrumentalist view of transition governance and highlights the steering role of the government in initiating transition actions and shaping transition trajectories [12-14]. The perception is that as long as key elements are put in place through proper governing approaches, a transition would just naturally happen. This logic of transition governance is particularly prevalent in China, where transition governance follows an authoritarian and command-and-control style with the dominance of governmental leadership. Nevertheless, this has, to a great extent, shadowed the political dynamics of transition processes. Questions such as how do transition politics unfold between actors, what are the reactions and the responses of local communities, and what are the ramifications of urban politics on the broader outcome of low-carbon experimentation remain largely unanswered. This article presents a rare failed case of solar experimentation in Shenzhen, China. In this case, the Shenzhen municipal government, with strong governance capacities, had followed a top-down instrumentalist style in the governance of urban experimentation but encountered strong social resistance, which served as a main reason for the eventual policy retreat of the solar technology.

The remainder of the article proceeds as follows. Section 2 reviews literature on urban energy transitions. A special focus is placed on the politics of transitions. Section 3 provides a brief introduction of the study area, data, and methodology, followed in section 4 by an empirical case of solar experimentation in Shenzhen, China. Conclusions are drawn in section 5.

2 Literature review

In transition studies, socio-technical niches, defined as protected spaces for the development and

application of novel technological innovations, serve as the starting point for deeper and broader changes [15]. Urban experimentation, as a new and more flexible approach to transition governance, describes the deliberate efforts of introducing innovations into the urban contexts. It aims at not only nurturing innovation niches but also inducing further diffusion of novel innovation and transition practices [16]. Although entrepreneurs remain the main transition initiators and system builders, recent years have seen a more engaging role of city governments in low-carbon experimentation [17-19]. This trend is represented by the proliferation of global coalitions such as the C40 League and the International Council for Local Environmental Initiatives (ICLEI) that emphasize the leading role of city governments in sustainability transitions. In a comprehensive review of 627 urban experiments in 100 global cities, Bulkeley and Castán Broto (2013) [20] identify the prevalence of government-led partnerships, and particularly, the important role played by local governments. Similar patterns of the leadership of governmental authorities in urban low-carbon initiatives have also been observed in countries such as UK [17], China [21] and Australia [11].

This body of literature emphasizes the capacity possessed by local governments in channeling and mobilizing key resources into arenas of novel experimentation [22]. These resources include specialized technological knowledge, financial investment, niche market, and technology legitimacy [23]. Knowledge creation and diffusion is a key process in socio-technical transitions. Different types of knowledge (e.g., scientific, technological, production, deployment) can be obtained through different sources such as R& D, learning and imitation [24]. Financial capital is a vital but scarce resource in socio-technical experimentation, particularly in the early stage of niche formation [25]. In government-led experiments, the government often acts as a key mobilizer for financial resources through economic instruments such as subsidies or tax incentives. In addition to knowledge and financial resources, legitimacy is also considered an intangible resource. The level of technology legitimacy can have a significant influence on social acceptance of the technology and further on the expansion of the emerging market [26]. Technology legitimization and institutionalization are two mutually reinforcing processes in which political support enhances legitimacy, and the formation of legitimacy further contributes to the embeddedness of the technology into local regulations and institutions [23, 24]. Lastly, market access refers to the creation of protected space for new technologies [23]. Access to new market segments is an asset possessed by transition actors, particularly at early-stage niche formation. In government-initiated experimentation, demand for the new technology can be created through regulatory instruments such as mandatory regulations.

Public policies and local government intervention are increasingly considered as key facilitators for deliberate socio-technical experimentation in cities [10, 13]. This point of view has not only been

incorporated conceptually in various transition governance approaches such as transition management [27] and policy mixes for sustainability transitions [28], but also been applied empirically in transition practices [11]. The assumption is that as long as the core elements are put in place, the technological niche can be cultivated and eventually scaled up. This confident view of the government's determinant role in socio-technical experimentation has fostered an established instrumentalist and policy-focused literature of transitions governance, with overwhelming attention paid to institutional arrangements, the design of policy strategies, and the composition of instrument mixes [29, 30]. Nevertheless, as noted by Jaenicke (1999) [31], the choice of policy instruments alone does not determine the outcome of environmental policies. In fact, more and more evidence suggests that urban experimentation is innately a site of politics [20]. The introduction of new energy innovations into a city inevitably induces multiple urban political processes, manifested as a continuous process of bargaining, compromise, and tradeoffs. Lee and Hess (2019), for instance, identify the phenomenon of 'regime resistance' in the development of distributed solar energy in the United States. They show how incumbent utilities tried to frame the public discourse around the adverse effects of solar energy so as to slow or halt the growth of the emerging sector. Kungl (2015) [32] shows how in German's energy transitions, incumbent industrial actors conducted lobbying activities to change public policies on renewable energy.

Recent years have seen increasing interest in the role of politics in energy transitions. The emergent popularity of the political perspective in transition studies is represented by the proliferation of special issues/sections on relevant topics in mainstream journals such as *Journal of Environmental Policy & Planning (Volume 18, Issue 5, 2016)*, *Environmental Innovation and Societal Transitions (Volume 18, 2016)*, *Energy Policy (Volume 78, 2015)* and *Urban Studies (Volume 51, Issue 7, 2014)*. This strand of literature has developed a good grasp of the interactions between different parties in an energy transition and enriches the knowledge of transition politics through uncovering, for instance, the agency of transition actors, particularly non-state actors [4] and the conflicts around the reconfiguration of urban materiality [33-35]. Politics are being incorporated in the theoretical framing of energy transitions. Geels (2014) [36], for instance, introduces politics and power into the multi-level perspective framework. Huang and Broto (2018) theorize urban political processes as a key dimension of urban energy transitions. The importance of politics is also increasingly recognized in transition policymaking, because it can influence the outcomes of socio-technical experimentation through, for instance, shaping the discourses around low-carbon experimentation, determining the scope and pace of actions, and ultimately defining the pathways toward fundamental reconfigurations of the socio-technical system [20, 37].

The body of energy-related Social Sciences and Humanities (energy-SSH) research, in particular, has documented extensively how different actors get involved in energy transitions, either passively or

actively [38]. It is emphasized in energy-SSH literature that social acceptance is crucial for the success of renewable energy policies [39, 40] and that low-carbon energy projects need to be embedded in specific local contexts [41-43]. The rise of concepts such as "energy citizenship" [44, 45] and "energy communities" [46, 47] in energy-SSH research exemplifies growing recognition of the importance of public participation in transition governance. Participatory methods are increasingly used in policymaking to reach consensus and improve policy effectiveness [38, 48, 49]. Scott et al. (2016) [50] compare two types of energy intervention to engaging local communities in New Zealand. The authors recommend a combination of community engagement events and the provision of personalized and tailored advice. DellaValle and Sareen (2020) [51] discuss the use of behavioral economics in energy decision-making to enhance individuals' cognitive capacity and engagement, particularly those in a more disadvantaged position.

Contrary to this trend, in China, the instrumentalist and functionalist approaches still prevail in transition governance [52, 53]. This is partly a result of China's political system, where environmental governance largely follows the paradigm of authoritarianism with limited transparency in policymaking and a general lack of public participation [54]. In urban low-carbon experimentation, local governments are often supposed to take a leading role, and the focus of transition governance is placed on the choice of various policy instruments to mobilize key resources. Binz et al. (2016) [23], for instance, show how the local government manages to create a protected space for technology experimentation of on-site water recycling in Beijing. Similarly, Goess et al. (2015) [55] uncover that the proactive support from local governments through the introduction of various policy instruments has acted as strong drivers for the success of solar experimentation in Shandong province. Research on energy transitions in China disproportionately reports the successful practices of instrumentalist transition governance. A general impression gained is that the command-and-control approaches utilized by local authorities are effective and efficient and remain largely unchallenged. This, in turn, has reinforced the authoritarian style of transition governance and the instrumentalist interpretation of transition dynamics in China. Because of this situation, it remains unclear whether and to what extent politics play a role in the transition processes. In particular, little knowledge has been gained on the response of local communities in government-led initiatives. A failed case of government-led solar experimentation in Shenzhen, China, has offered an opportunity to examine the significance of politics, particularly social resistance, in shaping the outcome of government-led experimentation.

3 Study area, material, and methodology

Shenzhen is a coastal city located in the southeast of China, immediately to Hong Kong. As of 2019, it had a population of 13.44 million, and the GDP was around RMB 2.69 trillion [56]. Among Chinese

cities, Shenzhen leads in initiatives of urban low-carbon transitions with a strong governance capacity. It launched China's first carbon trading pilot scheme in 2013, and statistics by 2015 showed a significant reduction in carbon emissions of enterprises included in the system [57]. Shenzhen was among the eight low carbon pilot cities selected in 2010 by the National Development Reform Commission. This was one of the first national-level programs for low-carbon urban development in China, under which the Shenzhen municipal government has committed to increasing the share of natural gas, solar PV, biomass, and wind energy to at least 60% of the total primary energy use in 2020 [58]. Shenzhen is also the world's first city to realize the full electrification of the bus fleet. As regard to the BIST technology, as early as 2006, the municipal government of Shenzhen promulgated the mandatory installation of BIST systems in newly built buildings. Later in 2010, the "Solar Rooftop Scheme" was launched, promoting the installation of roof mounted BIST systems. A total of 250 BIST projects have been completed. Nevertheless, in 2014, the municipal government lifted the mandatory regulation for the installation of BIST systems and terminated the subsidy for BIST projects [59]. This research intends to investigate the political dynamics underlying this unusual solar policy retreat in Shenzhen, particularly the response from local residents and communities.

In the governance of BIST projects in Shenzhen, the General Office of Shenzhen Municipal People's Government (GOSMPG) represents the municipal government, oversees the overall implementation of BIST projects, and provides general instructions to department agencies and district governments. The principal responsible department for BIST implementation is the Housing and Construction Bureau of Shenzhen Municipality (HCBSM), supported by other departments such as the Bureau of Finance of Shenzhen Municipality and the Development and Reform Commission of Shenzhen Municipality. Under the leadership of GOSMPG, HCBSM formulates specific plans and instructions for BIST implementation. The primary empirical materials were collected during a field trip to Shenzhen in 2017. The research applies a snowballing method based on personal contacts to reach potential interviewees, completed by on-site interviews with local residents. A total of 37 semi-structured interviews were conducted with government officials (2), local media (2), industry experts (1), and end-users (32). For government officials, the interviews focused on their logic of policymaking, the difficulties encountered in policy implementation, and the measures taken to address various problems; while interviews with other actors gain information on the outcome of the government's solar policy, the impacts on business and the everyday life of end-users, and the politics incurred between different stakeholders. Interviewing materials are complemented with document analysis based on data sources of government reports, policy documents, and local newspapers.

4 Empirical analysis

4.1 Government-led solar experimentation and resource mobilization

Among Chinese cities, Shenzhen is pioneering in taking action to transform its energy production and consumption system. The urban priorities of Shenzhen align with the ones of the central government in addressing challenges such as climate change, environmental pollution, and energy shortage. Out of this alignment, Shenzhen was designated as the pilot city for a variety of national low-carbon initiatives, particularly in the building sector. For instance, Shenzhen was selected as the "Pilot City for the Application of Building Energy Saving Regulation in Hot Summer and Warm Winter Zone", the "Pilot City for the Scaling-up of Renewable Energy (Solar Energy) Buildings", and the "National Pilot City for the Modernization of Housing Industry". These national designations have contributed to the legitimization of the deployment of renewable energies, particularly solar energy, in Shenzhen. In terms of the BIST implementation, as early as 2006, Shenzhen required the mandatory installation of BIST systems in residential buildings of 12 floors or below [60]. In 2009, Shenzhen was selected as the "Demonstration City for the Implementation of Renewable Energy Buildings", in which specific and strict requirements were set by the central government to achieve a total application area of 7.12 million m^2 for renewable energies within a period of two years (2010 to 2011). To accomplish this "political assignment", a key move taken by the municipal government was to launch the "Solar Rooftop Project" [60, 61]. Under this initiative, critical resources have been channeled into the operationalization of this city-wide solar experimentation through a variety of instrumentalist governance approaches.

Table 1 provides an overview of the key policies under the "Solar Rooftop Project" and the market segments and financial resources that have been directly mobilized by this scheme. Under China's authoritarian institutions, governmental support *per se* often represents a strong source of legitimacy. Also, through mandatory installation regulations, the municipal government managed to create new market segments for BIST technology. Specifically, 3.07 million m^2 of newly built buildings and 3.95 million m^2 of existing buildings were required to install BIST systems. Moreover, both the municipal government and the central government have allocated substantial funding for the deployment of BIST technology.

Table 1. An overview of the "Solar Rooftop Project" in Shenzhen

Key policies	• Working Plan on the Demonstration City of Renewable Energy Application in Buildings and the Solar Rooftop Project in Shenzhen (2010) • Notice on the Implementation of the Working Plan on the Demonstration City of Renewable Energy Application in Buildings and the Solar Rooftop Project in Shenzhen (2011)

- Guidelines on the Application and Disbursement of Subsidy for the Demonstration City of Renewable Energy Application in Buildings and the Solar Rooftop Project in Shenzhen (2012)

	Niche market		From December 1st, 2010, all newly built civic buildings that are suitable for the installation of BIST systems and that have stable hot water demand should install BIST systems. All newly built public housing should install BIST systems. The total construction area of newly built buildings with BIST systems should reach at least 3.07 million m^2. All existing factory dormitories, student dormitories, hospitals that are suitable for the installation of BIST systems should install BIST systems. Existing residential buildings are encouraged to install BIST systems. The total construction area of existing buildings with BIST systems should reach 3.95 million m^2.
Key resources	Financial support	Central government funding	The central government allocated a special fund with a total of 80 million RMB for the application of renewable energy in buildings in Shenzhen, of which 10 million will be used for BIST application in newly-built buildings, 60 million for BIST application in existing buildings, 4 million for the application of other types of renewable energy, 6 million for project supervision, evaluation, research, and standard compilation.
		Local government funding	The municipal government allocated a special fund with a total of 0.12 billion RMB for the application of renewable energy in buildings in Shenzhen, of which 15 million will be used for BIST application in newly-built buildings, 90 million for BIST application in existing buildings, 6 million for the application of other types of renewable energy, 9 million for project supervision, evaluation, research, and standard compilation.

Back to the early 2000s, the BIST technology was not yet fully mature, particularly for the application in high-rise buildings. Nevertheless, in Shenzhen, most of the residential buildings are high-rise buildings. To gain more specialized knowledge on the application of BIST technology, the municipal government launched a series of pilot projects. For instance, in 2006, in a social housing community called Qiaoxiang village, a large roof-mounted BIST system was designed and installed. The main aim of the project was to pilot the application of BIST technology in high-rise buildings to generate operational knowledge and experience for further city-wide application of BIST systems in high-rise buildings. The channeling of external knowledge is equally important as the production of internal knowledge. The Shenzhen municipal government actively engaged in national and international cooperation. In September 2007, HCBSM conducted a five-day field trip to Singapore, in an attempt to learn the city country's advanced experiences in urban planning. Out of this field trip, the municipal government published several government documents regarding the building of eco-city [62]. Industry associations and alliances played a central role in knowledge coproduction. In December 2008, Shenzhen Green Building Association was

founded in Shenzhen, and later in December 2010, the Green Building Alliance for Tropical and Subtropical Climate Zone was established. Both represent the institutionalization of national and international cooperation. Conferences and workshops are also effective platforms for knowledge exchange and diffusion. In 2008, when BIST technology was radically deployed in Shenzhen, the "Chinese and International Conference on the Use of Renewable Energy Sources in Urban Buildings" was held in the city [63]. The main aim was to share and exchange knowledge between policymakers and researchers on the application of renewable energy in buildings.

4.2 Social resistance to the BIST technology

The initiation of the "Solar Rooftop Project" represents the commencement of the radical application of BIST technology in Shenzhen. Particularly, mandatory installation regulation had been more strictly and vigorously enforced in social housing projects. For instance, in 2010, a notice on energy efficiency in social housing was published by the municipal government, in which it required the installation of BIST systems in all newly built social housing in Shenzhen [61]. Nevertheless, the radical strategy adopted by the municipal government has incurred various problems. A reporter recalled that:

> *"We did a city-wide investigation and found that in a number of social housing communities, there were problems regarding the BIST system, including insufficient hot water, low water temperature, and so on."*

A common issue is the high utility costs of the BIST system, compared to widely accepted electric water heaters and gas water heaters in the market. As complained by one interviewee:

> *"Compared to gas water heaters, it is more expensive to use the BIST system. The expense is actually doubled, or more than doubled.".*

Another resident described a similar situation in more detail:

> *"The hot water is expensive. I doubt if the water meter is accurate. Last time I topped up 200 RMB in my account, which only lasted for two months. That means every month I have to pay 100 RMB merely for taking showers."*

Interviewees also mentioned other problems such as unstable hot water, waste of water, and noises. For example, they had to leave cold water running before hot water arrived. Because the main body of the BIST system was usually based on the rooftop, residents living near bottom floors had to wait for a longer time. As complained by one interviewee:

> *"There is a huge waste of water. I live on the 21st floor, and hot water is coming from the 35th floor. You can imagine. If I want to use hot water at a time not many residents are using it, which means that the water pipe is filled with cold water… There can be several buckets of cold water. It is too inconvenient and wasteful."*

A similar situation was encountered by many other end users. For instance, an interviewee reported:

"Normally, I have to leave the water running, and the cold water can fill a large bucket when hot water finally comes out."

Another issue is unstable hot water, or more specifically, low water temperature. As described by one interviewee:

"In a city like Shenzhen, especially in the spring (March or April), it rains a lot. The water temperature would be relatively low. Sometimes it is entirely cold. But we do not have other options since we were not allowed to install other water heaters."

For residents living on the higher floors, they also suffer from the noise problem, due to the functioning of the equipment on the rooftop. A resident reported:

"There is another problem with the BIST system. For those who live on the top floor, the noise is really large."

Radical BIST implementation incurred various problems and provoked substantial resistance from stakeholders. Many real estate developers chose cheaper BIST products instead of more qualified ones, because their priority was to make their real estate projects greenlighted by the government. As described by an industrial expert:

"They [real estate developers] do not care about the design. They just asked us to install the BIST system and to keep the costs to the lowest level, because the system was not intended to really put into use. Some even asked us to dismantle the system right away after they passed the government's completion inspection."

For residents, the majority took a more passive form of resistance by refusing to use the BIST system and installed gas water heaters or electric water heaters instead by themselves. A resident reported:

"I know many neighborhoods have installed BIST systems. But because of the high utility costs, many were left unused. The residents used gas water heaters instead."

This 'silent' resistance of both developers and residents manifested at the city scale as the high idleness rate of installed BIST systems. According to official statistics, till the end of 2016, 250 BIST projects had been completed. Nevertheless, at least 56 projects were left unused, involving a total investment of more than 90 million RMB. Of the 56 projects, 14 were invested by the government (11 were social housing projects), involving a total investment of more than 30 million RMB [64]. An industrial expert criticized that this situation has led to a huge waste of resources:

"The whole point of the (solar rooftop) project was to save energy. Nevertheless, because many installed systems were left unused, we spent more money without saving any energy. It is actually wasting energy in the name of saving energy."

Compared to passive resistance, some residents took more proactive actions to challenge the decisions of government authorities. Initially, to pressure the government, residents resorted to local media to

cover the problems of BIST systems. Since 2013, the problems of BIST technology application in Shenzhen were more frequently reported in the media. Table 2 provides a summary of media coverage on the emergent problems. As can be seen, the issues of mandatory installation of BIST systems in Shenzhen were not only covered by local media but also attracted the attention of national media platforms such as CCTV. In China's political context, when a social issue draws the attention of national media, the media coverage often exerts considerable pressure upon local governments to address the problem. In addition to more indirect actions such as reporting to the media, some residents also tried to communicate and negotiate directly with the government. For instance, a resident expressed that she once wrote to the mayor about the issue through the so-called "Mayor Hotline" and even reported to superior institutions such as the central inspection group. In Qiaoxiang village, residents invited a third-party research institute to evaluate the performance of the BIST system and discussed with the government about possible technical solutions for the problems of the BIST system. Under pressure from various parties, the municipal government had to rethink the radical solar experimentation that had been implemented in Shenzhen and to reevaluate the policy implications for the broader society.

Table 2. A summary of media coverage on the emergent problems regarding BIST systems in Shenzhen

Date	Media	Media Information	Main content
21/05/2013	Southern Metropolis Daily	Regional level newspaper	Complaints of some residents on the BIST system (mandatory installation, inconvenience, unstable hot water, and noise)
06/08/2013	Daily Sunshine	Local-level newspaper	Complaints of some residents on the high utility costs of the BIST system.
07/08/2013	Shenzhen Economic Daily	Local-level newspaper	Complaints of some residents on the high utility costs of the BIST system.
13/02/2015	City Channel	Local-level TV media	Complaints of some residents on the BIST system (mandatory installation, inconvenience, unstable hot water, and noise)
11/12/2015	City Channel	Local-level TV media	Complaints of some residents on the BIST system (mandatory installation, inconvenience, unstable hot water, and noise)
12/12/2015	Daily Sunshine	Local-level newspaper	Malfunction of the BIST system resulted in unstable, or even no, hot water in cold winter.
18/12/2015	Shenzhen Economic Daily	Local-level newspaper	Malfunction of the BIST system resulted in unstable, or even no, hot water in cold winter.
05/05/2016	Southern Metropolis Daily	Regional level newspaper	Questioning the huge investment of the BIST system and whether this project is a so-called vanity project by the government.

06/05/2016	Southern Metropolis Daily	Regional level newspaper	Questioning the huge investment of the Qiaoxiang village BIST system and whether this project is a so-called vanity project by the government.
08/05/2016	CCTV financial channel	National level TV media	Emergent problems (noise, leakage, etc.) of BIST systems.
09/05/2016	Southern Metropolis Daily	Regional level newspaper	Investigating the abandonment of installed BIST systems in two communities in Shenzhen.
09/05/2016	Southern Metropolis Daily	Regional level newspaper	Questioning the huge investment of the Qiaoxiang village BIST system; presenting investigation results on another two social housing neighborhoods in Shenzhen with similar issues.

4.3 The policy retreat of BIST implementation in Shenzhen

In face of mounting problems regarding the radical implementation of BIST technology in Shenzhen, in 2014, the municipal government terminated the mandatory regulation for installing BIST systems, along with the subsidy program [59]. This sudden policy change implies difficulty in the further implementation and reflects the government's adjustments in low-carbon policymaking. As revealed by one interviewee:

> *"A government official told me privately that currently the technology is not yet fully mature and is not suitable for large-scale application. So, the government terminated some ongoing projects and no longer mandated the installation of BIST systems."*

Table 3. An overview of BIST projects funded under the "Solar Rooftop Project"

Year	Batch	Number of projects	BIST application area (10^4 m^2)	Amount of subsidy (10^4 RMB)
2013	1	4	36.2	376.5
	2	7	23.9	388.6
2014	1	3	23.9	126.8
	2	5	40.8	238.7
	3	5	27.9	248.1
	4	5	32.8	225.9
	5	8	29.6	237.2
	6	2	12.8	92.7
2015	1	2	4.7	52.2
Total		41	232.4	1986.6

The "Solar Rooftop Project" was officially terminated in May 2015. Table 3 presents an overview of the funded projects under this solar implementation scheme. From 2013 to 2015, a total of 41 projects received government funding in BIST application, involving an application area of more than 2 million

m^2 and a total subsidy of approximately 20 million RMB. Notably, the claimed number of subsidies was substantially lower than the allocated funding as presented in Table 1.

Seen from the resource flows, initially, multi-level governments intended to use financial subsidies to create a niche market for BIST technology, while after several years of implementation, this experimentation has proved to be unsuccessful. The financial resources have failed to cultivate a niche market and further to trigger technology scale-up and market expansion. In fact, the solar experimentation to a certain extent even harmed market cultivation of the BIST technology in Shenzhen because with intensive media coverage of the problems of installed BIST systems, consumers have already gained a rather negative impression on the performance of BIST products.

Moreover, local government's efforts in knowledge and experience generation through various pilot projects have also proven to be unsuccessful. For instance, the pilot BIST project in Qiaoxiang village, designed as a role model for the application of BIST technology in high-rise buildings, has largely failed. As revealed by one interviewee:

> *"Seen from the outcome, we can hardly say that this pilot project [the Qiaoxiang village] is successful. The government initiated city-wide implementation of the BIST technology before they are fully prepared."*

The termination of the "Solar Rooftop Project" marked a complete policy retreat in the experimentation of BIST technology. In 2016, when replying to the inquiry of the Standing Committee of the Shenzhen Municipal People's Congress on quality issues regarding the construction of social housing in Shenzhen, the main responsible department for BIST implementation, the HCBSM, admitted that there were considerable complaints regarding the mandatory installation of BIST systems in social housing, and they decided to cease further implementation of immature green technologies such as the BIST technology in Shenzhen [65]. HCBSM also urged property management companies of residential projects to inform and negotiate with the owners to sign an agreement before putting the installed BIST system into use.

5 Discussion and conclusion

Urban energy transition is a multifaceted process that requires the orchestration of a wide range of actors in translating transition visions into concrete actions. In transition literature, increasing attention is paid to the political facet of urban energy transitions. Nevertheless, in China, transition governance still follows a rather instrumentalist logic that the success of low-carbon experiments relies on governments' ability to mobilize key resources through the adoption of various policy instruments. Disproportionate report of successful cases in the literature has reinforced this governing logic, while shadowed the role played by politics in the transition processes, particularly the response of local communities.

The study reports a failed case of solar experimentation in Shenzhen. Initially, the municipal government,

with strong governance capacities, took a very proactive role in mobilizing key resources such as knowledge, capital, and market access into the solar experiment. Nevertheless, radical and large-scale implementation of the BIST technology through the "Solar Rooftop Project" incurred many unintended consequences, and the government was confronted with increasing resistance of and criticism from industrial actors, end-users, and the media. On the one hand, passive resistance from both developers and residents led to a low utilization rate of installed BIST systems and a huge waste of the mobilized resources; on the other hand, active resistance from some residents managed to exert substantial pressure on the municipal government to address the problems of BIST projects. After merely several years of implementation, the government terminated the mandatory installation regulation of BIST systems, marking a policy retreat of the solar experimentation in Shenzhen. The results show that urban politics did play a significant role in transition processes, and strong social resistance produced a countering effect on the outcome of the project.

A direct cause of strong social resistance is the immaturity of the technology, which generated a variety of problems in daily use. Because of the short-term political calculations behind the project (i.e., to become a role model in low-carbon development among Chinese cities), the technology was implemented in Shenzhen at the city scale rather hastily. If the municipal government chose to first pilot the technology in several small neighborhoods, fully collect information on the operational problems of BIST systems to develop technical solutions before large-scale implementation, and make institutional arrangements to guarantee timely and reliable technical support, the BIST technology might have gained greater and wider social acceptance in local communities.

Echoing the body of energy-SSH research, the empirical case demonstrates the importance of social acceptance in low-carbon experimentation. The success of low-carbon experiments is not necessarily guaranteed by strong governance capacities of local governments under an instrumentalist governing logic, and material embeddedness of a new technology does not naturally produce embeddedness in social practices. For transition governance, the lessons gained from the case of Shenzhen are as follows. First, the policymakers need to have good control of both the speed and the scale of urban low-carbon experiments before they can proceed further and deeper in the transitional trajectory. This means that new technology must be fully tested in an urban laboratory before it is adopted on a larger scale. Second, in government-led experiments, the adaptivity of the governance approach is imperative. When problems emerge and conflicts are incurred, the government needs to be responsive and be able to offer timely solutions. Third, the engagement of various stakeholders, particularly at earlier stages of experimentation, is conducive to more informed and wiser decision-making of energy transitions. As noted by Wittmayer and Loorbach (2016) [66], the leadership of governments has to be complemented with effective

engagement of and collaboration with various stakeholders in order to steer meaningful transition outcomes. This study calls for future research to take a more dynamic and holistic inquiring into the governance of urban energy transitions, by taking account of the mediating or even countering effects of urban politics. Only by so doing can we situate transition politics within the broader process of energy transitions and distill more general lessons.

Reference

[1] J. Markard, R. Raven, B. Truffer, Sustainability transitions: An emerging field of research and its prospects, Research policy 41(6) (2012) 955-967.

[2] R. Raven, J. Schot, F. Berkhout, Space and scale in socio-technical transitions, Environmental Innovation and Societal Transitions 4 (2012) 63-78.

[3] J. Rutherford, O. Coutard, Urban energy transitions: places, processes and politics of socio-technical change, Sage Publications Sage UK: London, England, 2014.

[4] N. Frantzeskaki, A. Dumitru, I. Anguelovski, F. Avelino, M. Bach, B. Best, C. Binder, J. Barnes, G. Carrus, M. Egermann, Elucidating the changing roles of civil society in urban sustainability transitions, Current Opinion in Environmental Sustainability 22 (2016) 41-50.

[5] F.W. Geels, Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study, Research policy 31(8-9) (2002) 1257-1274.

[6] V. Castán Broto, Climate change politics and the urban contexts of messy governmentalities, Territory, Politics, Governance 8(2) (2020) 241-258.

[7] H.A. Bulkeley, V. Castán Broto, G.A.S. Edwards, An urban politics of climate change: experimentation and the governing of socio-technical transitions, Routledge2014.

[8] B. Truffer, L. Coenen, Environmental innovation and sustainability transitions in regional studies, Regional studies 46(1) (2012) 1-21.

[9] J. Meadowcroft, Engaging with the politics of sustainability transitions, Environmental Innovation and Societal Transitions 1(1) (2011) 70-75.

[10] J. Markard, The next phase of the energy transition and its implications for research and policy, Nature Energy 3(8) (2018) 628-633.

[11] P. McGuirk, R. Dowling, C. Brennan, H. Bulkeley, Urban carbon governance experiments: the role of Australian local governments, Geographical research 53(1) (2015) 39-52.

[12] K. Lo, How authoritarian is the environmental governance of China?, Environmental Science & Policy 54 (2015) 152-159.

[13] M.-B. Quitzau, J.S. Jensen, M. Elle, B. Hoffmann, Sustainable urban regime adjustments, Journal of Cleaner Production 50 (2013) 140-147.

[14] Z. Yu, D. Gibbs, Unravelling the role of green entrepreneurs in urban sustainability transitions: A case study of China's Solar City, Urban Studies 57(14) (2020) 2901-2917.

[15] R. Kemp, J. Schot, R. Hoogma, Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management, Technology Analysis & Strategic Management 10(2) (1998) 175-198.

[16] T. Von Wirth, L. Fuenfschilling, N. Frantzeskaki, L. Coenen, Impacts of urban living labs on sustainability transitions: Mechanisms and strategies for systemic change through experimentation, European Planning Studies 27(2) (2019) 229-257.

[17] S. Fudge, M. Peters, Motivating carbon reduction in the UK: the role of local government as an agent of social change, Journal of Integrative Environmental Sciences 6(2) (2009) 103-120.

[18] K. Sperling, F. Arler, Local government innovation in the energy sector: A study of key actors' strategies and arguments, Renewable and Sustainable Energy Reviews 126 (2020) 109837.

[19] A.M. Levenda, Mobilizing smart grid experiments: Policy mobilities and urban energy governance, Environment and Planning C: Politics and Space 37(4) (2019) 634-651.

[20] H. Bulkeley, V. Castán Broto, Government by experiment? Global cities and the governing of climate change, Transactions of the institute of British geographers 38(3) (2013) 361-375.

[21] L. Westman, V. Castán Broto, Climate governance through partnerships: A study of 150 urban initiatives in China, Global Environmental Change 50 (2018) 212-221.

[22] J. Rutherford, S. Jaglin, Introduction to the special issue - Urban energy governance: Local actions, capacities and politics, 78 (2015) 173-178.

[23] C. Binz, B. Truffer, L. Coenen, Path creation as a process of resource alignment and anchoring: Industry formation for on-site water recycling in Beijing, Economic Geography 92(2) (2016) 172-200.

[24] A. Bergek, M. Hekkert, S. Jacobsson, Functions in innovation systems: A framework for analysing energy system dynamics and identifying goals for system-building activities by entrepreneurs and policy makers, in: T. Foxon, J. Köhler, C. Oughton (Eds.), Innovation for a Low Carbon Economy: Economic, Institutional and Management Approaches, Edward Elgar Publishing2008.

[25] M.P. Hekkert, R.A.A. Suurs, S.O. Negro, S. Kuhlmann, R.E.H.M. Smits, Functions of innovation systems: A new approach for analysing technological change, Technological Forecasting and Social Change 74(4) (2007) 413-432.

[26] S. Rohe, The regional facet of a global innovation system: Exploring the spatiality of resource formation in the value chain for onshore wind energy, Environmental Innovation and Societal Transitions 36 (2020) 331-344.

[27] F. Ehnert, F. Kern, S. Borgström, L. Gorissen, S. Maschmeyer, M. Egermann, Urban sustainability transitions in a context of multi-level governance: A comparison of four European states, Environmental Innovation and Societal Transitions 26 (2018) 101-116.

[28] K. Reichardt, S.O. Negro, K.S. Rogge, M.P. Hekkert, Analyzing interdependencies between policy mixes and technological innovation systems: the case of offshore wind in Germany, Technological Forecasting and Social Change 106 (2016) 11-21.

[29] P.M. Falcone, A. Lopolito, E. Sica, Instrument mix for energy transition: A method for policy formulation, Technological Forecasting and Social Change 148 (2019) 119706.

[30] A. Fløysand, S.-E. Jakobsen, The complexity of innovation: A relational turn, Progress in Human Geography 35(3) (2011) 328-344.

[31] M. Jaenicke, Policy patterns and innovation impacts: an international comparison, The International Conference' Innovation-oriented Environmental Regulation – Theoretical Approaches and Empirical Analysis', Potsdam, 1999.

[32] G. Kungl, Stewards or sticklers for change? Incumbent energy providers and the politics of the German energy transition, Energy Research & Social Science 8 (2015) 13-23.

[33] M. Hodson, E. Burrai, C. Barlow, Remaking the material fabric of the city:'Alternative'low carbon spaces of transformation or continuity?, Environmental Innovation and Societal Transitions 18 (2016) 128-146.

[34] C. McFarlane, J. Rutherford, Political infrastructures: Governing and experiencing the fabric of the city, International Journal of Urban and Regional Research 32(2) (2008) 363-374.

[35] J. Monstadt, O. Coutard, Cities in an era of interfacing infrastructures: Politics and spatialities of the urban nexus, Urban Studies 56(11) (2019) 2191-2206.

[36] F.W. Geels, Regime resistance against low-carbon transitions: introducing politics and power into the multi-level perspective, Theory, Culture & Society 31(5) (2014) 21-40.

[37] R. Raven, F. Kern, A. Smith, S. Jacobsson, B. Verhees, The politics of innovation spaces for low-carbon energy: Introduction to the special issue, Environmental Innovation and Societal Transitions 18 (2016) 101-110.

[38] L. Ingeborgrud, S. Heidenreich, M. Ryghaug, T.M. Skjølsvold, C. Foulds, R. Robison, K. Buchmann, R. Mourik, Expanding the scope and implications of energy research: A guide to key themes and concepts from the Social Sciences and Humanities, Energy Research & Social Science 63 (2020) 101398.

[39] S. Batel, P. Devine-Wright, T. Tangeland, Social acceptance of low carbon energy and associated infrastructures: A critical discussion, Energy Policy 58 (2013) 1-5.

[40] R. Wüstenhagen, M. Wolsink, M.J. Bürer, Social acceptance of renewable energy innovation: An introduction to the concept, Energy policy 35(5) (2007) 2683-2691.

[41] H. Bulkeley, V. Castán Broto, M. Hodson, S. Marvin, Cities and low carbon transitions, Routledge2010.

[42] M. Hodson, S. Marvin, Can cities shape socio-technical transitions and how would we know if they were?, Research Policy 39(4) (2010) 477-485.

[43] P. Huang, V. Castán Broto, Y. Liu, H. Ma, The governance of urban energy transitions: A comparative study of solar water heating systems in two Chinese cities, Journal of Cleaner Production 180 (2018) 222-231.

[44] P. Devine-Wright, Energy citizenship: psychological aspects of evolution in sustainable energy technologies, in: J. Murphy (Ed.), Governing Technology for Sustainability, Routledge2012, pp. 74-97.

[45] M. Ryghaug, T.M. Skjølsvold, S. Heidenreich, Creating energy citizenship through material participation, Social Studies of Science 48(2) (2018) 283-303.

[46] G. Dóci, E. Vasileiadou, A.C. Petersen, Exploring the transition potential of renewable energy communities, Futures 66 (2015) 85-95.

[47] E.M. Gui, I. MacGill, Typology of future clean energy communities: An exploratory structure, opportunities, and challenges, Energy Research & Social Science 35 (2018) 94-107.

[48] J. Chilvers, N. Longhurst, Participation in transition (s): Reconceiving public engagements in energy transitions as co-produced, emergent and diverse, Journal of Environmental Policy & Planning 18(5) (2016) 585-607.

[49] J. Chilvers, H. Pallett, T. Hargreaves, Ecologies of participation in socio-technical change: The case of energy system transitions, Energy Research & Social Science 42 (2018) 199-210.

[50] M.G. Scott, A. McCarthy, R. Ford, J. Stephenson, S. Gorrie, Evaluating the impact of energy interventions: home audits vs. community events, Energy Efficiency 9(6) (2016) 1221-1240.

[51] N. DellaValle, S. Sareen, Nudging and boosting for equity? Towards a behavioural economics of energy justice, Energy Research & Social Science 68 (2020) 101589.

[52] K.S. Gallagher, The globalization of clean energy technology: Lessons from China, MIT press2014.

[53] J. Nahm, E.S. Steinfeld, Scale-up nation: China's specialization in innovative manufacturing, World Development 54 (2014) 288-300.

[54] P. Huang, Y. Liu, Toward just energy transitions in authoritarian regimes: indirect participation and adaptive governance, Journal of Environmental Planning and Management 64(1) (2021) 1-21.

[55] S. Goess, M. De Jong, W. Ravesteijn, What makes renewable energy successful in China? The case of the Shandong province solar water heater innovation system, Energy Policy 86 (2015) 684-696.

[56] Statistics Bureau of Shenzhen Municipality (SBSM), Shenzhen shi 2019 nian guomin jingji he shehui fazhan tongji gongbao [Statistical Communique of Shenzhen's Economic and Social Development (2019)], 2020. http://www.sz.gov.cn/zfgb/2020/gb1149/content/post_7350867.html.

[57] People's Daily, Shenzhen tan jiaoyi: jingji fazhan de tongshi tan paifangliang he tan qiangdu chixu xiajiang [Carbon trading in Shenzhen: with economic development, carbon emissions and carbon intensity continue to decline], 2017. http://shoudian.bjx.com.cn/news/20170327/816732.shtml.

[58] N. Khanna, D. Fridley, L. Hong, China's pilot low-carbon city initiative: A comparative assessment of national goals and local plans, Sustainable Cities and Society 12 (2014) 110-121.

[59] Housing and Construction Bureau of Shenzhen Municipality (HCBSM), Guanyu tiaozheng taiyangneng guangrejianzhu yingyong gongzuo jihua de tongzhi [Notice on Adjusting the Working Plan on the Application of Solar Thermal Technology in Buildings], 2014. http://www.szjs.gov.cn/csml/bgs/xxgk/tzgg_1/201412/t20141217_2760579.htm.

[60] General Office of Shenzhen Municipal People's Government (GOSMPG), Shenzhen shi kaizhan kezaishengnengyuanjianzhu yingyong chengshi shifan shishi taiyangneng wuding jihua gongzuo fangan [Working Plan on the Demonstration City of Renewable Energy Application in Buildings and the Solar Rooftop Project in Shenzhen], 2010. http://www.szjs.gov.cn/csml/zcfg/xxgk/zcfg_1/jngl/201310/t20131011_2221040.htm.

[61] Housing and Construction Bureau of Shenzhen Municipality (HCBSM), Guanyu guanche zhixing "Shenzhen shi kaizhan kezaishengnengyuanjianzhu yingyong chengshi shifan shishi taiyangneng wuding jihua gongzuo fangan" youguan shixiang de tongzhi [Notice on the Implementation of the 'Working Plan on the Demonstration City of Renewable Energy Application in Buildings and the Solar Rooftop Project in Shenzhen], 2011. http://www.szjs.gov.cn/csml/zcfg/xxgk/zcfg_1/jngl/201310/t20131011_2221045.htm

[62] Shenzhen Daily, Tamen zhanchu de shi yizuo lvse zhidu [They exhibit a green city], 2008. http://www.szass.com/skkx/skpj/200810/t20081015_10461957.htm.

[63] SZnews, Shenzhen 12 ceng yixia zhuzhai jianzhu xu anzhuang taiyangneng reshui xitong [Residential buildings below 12 floors of Shenzhen must be installed solar water heating system], 2008. https://newenergy.in-en.com/html/newenergy-188703.shtml

[64] Audit Bureau of Shenzhen Municipality, Shenzhen shi 2015 niandu jixiao shenji gongzuo baogao [Annual performance audit report of Shenzhen in 2015], 2015. http://audit.sz.gov.cn/zxbs/sjgzbg/jxsjgzbg/content/post_1909760.html.

[65] Southern Metropolis Daily, Chushouxing baozhangfang jinhou maopi jiaolou buzai tuiguang taiyangneng liyong [Roughcast delivery for sell-type indemnificatory apartment in the future, no longer promote the use of solar energy], 2016. http://shenzhen.sina.com.cn/news/s/2016-07-14/detail-ifxuapvs8370657.shtml.

[66] J.M. Wittmayer, D. Loorbach, Governing transitions in cities: fostering alternative ideas, practices, and social relations through transition management, in: D. Loorbach, J.M. Wittmayer, H. Shiroyama, J. Fujino, S. Mizuguchi (Eds.), Governance of Urban Sustainability Transitions, Springer2016, pp. 13-32.