

## **The role of the local government in China's urban sustainability transition: A case study of Wuxi's solar development**

**Abstract:** Recent studies on socio-technical transition have elaborated the multi-level perspective through a power-sensitive view of agency and a symmetrical approach to niche-regime relations. This paper adopts this modified framework of the multi-level perspective to unpack the mechanisms of urban sustainability transition in China. It develops two arguments through a case study of the role of the local government in solar development in Wuxi city. First, the evolving alignments between niche, regime and landscape processes of the socio-technical systems of Chinese cities are mediated by conflicts between local governments and their upper-level counterparts as they share power over urban development. Second, instead of identifying them as either regime supporters or niche advocates, Chinese local governments are best described as embodying both roles in urban sustainability transition as they struggle to balance their economic and environmental objectives. These two arguments point to a need to examine sustainability transition in Chinese cities with attention to the leadership of the local government in aligning the actions of various actors in and beyond the city who can stabilise and disrupt existing socio-technical configurations.

**Keywords:** urban sustainability transition; multi-level perspective; agency; niche-regime relations; place-based leadership; solar development

## 1. Introduction

Informed by studies of socio-technical transition, recent inquiries on the governance of urban sustainability have focused on the theme of urban sustainability transition. They unpack the city as a socio-technical system in need of reconfiguration to facilitate a transition towards environmentally more sustainable trajectories of urbanisation (Bulkeley et al., 2015; Frantzeskaki et al., 2017). In this emerging strand of research, a notable number of studies have analysed the drivers and processes of this transition through the multi-level perspective (MLP). This perspective explains the ebbs and flows of the mainstreaming of green technologies as a function of the interaction between emerging *niches* of innovation, socio-technical *regimes* preserving the status quo, and slow-changing exogenous *landscape* factors (Geels, 2002, 2004; Rip & Kemp, 1998).

Although MLP has been praised for ‘provid[ing] a relatively straight-forward way of ordering and simplifying the analysis of complex, large-scale structural transformation’ of socio-technical systems (Smith et al., 2010, pp. 441–442), its expanding applications is not without its critics. First, in terms of the ontology of socio-technical transition, the MLP’s analytical emphasis on alignments between different levels of structuration tends to obscure the will and power of individual actors in shaping the trajectory of transition (Lawhon & Murphy, 2012; Smith et al., 2005). Second, in terms of the directionality of socio-technical transition, the MLP’s analytical bias toward novelties from niches tends to obfuscate the interests and initiatives of regimes in promoting the adoption of new technologies (Geels & Schot, 2007; Hansen & Coenen, 2015). These concerns warrant new MLP-based accounts of urban sustainability transition to cast a more critical light on the agency of individual actors and the dynamics of niche-regime interactions in the course of socio-technical transition.

Taking into account these conceptual refinements, this paper applies the MLP to develop a better understanding about the mechanisms of urban sustainability transition in China, where an increasing number of cities have experienced an ‘environmental turn’ in their development agenda (Zhang et al., 2020). Two arguments, each addressing one of the above criticisms to the MLP, underpin our analysis. First, regarding the question of agency, we argue that the evolving alignments between niche, regime and landscape processes of the socio-technical systems of Chinese cities are mediated by conflicts between local (i.e. municipal) governments and their higher-level (i.e. provincial and national) counterparts as they share power over urban development. Second, regarding the question of niche-regime interactions, we contend that, instead of identifying them as either regime supporters or niche advocates, Chinese local governments are best described as embodying both roles in urban sustainability transition as they struggle to balance their economic and environmental objectives. Our emphasis here on the local governments reflects our interest in their role in place-based leadership (Sotarauta et al., 2017), i.e. how they lead the transition of local socio-technical developments through orchestrating the actions of various actors.

Our arguments are illustrated through a case study of Wuxi, a Yangtze River city in Jiangsu Province. Since the early 2000s, Wuxi has renewed its industrial reputation with a ‘solar turn’,

featuring a fast-growing niche of photovoltaics (PV) panel producers. One estimate puts the city's contribution to the total output value of China's PV manufacturing sector in 2015 at 10% (Tong et al., 2017). This niche has benefitted from the growth in solar product consumption in Wuxi since circa 2010 in the forms of expanding practice of distributed PV power generation and increasing use of solar water heaters (SWH). As our analysis will show, the local state has actively intervened the alignment of trajectories between niche, regime and landscape levels of Wuxi's energy sector. Wuxi's solar niche has benefitted from the landscape pressure for environmental protection articulated by the central and provincial governments on the city, and the planning and economic initiatives launched by the local government to retrofit the energy regime. However, the window of opportunity for the solar transition is being narrowed by spatial conflicts of solar developments with the real estate regime and the weakened fiscal support from the upper rungs of government for private consumption of solar products.

The rest of this paper is organised as follows. Section 2 elaborates how the MLP is refined by a power-sensitive view of agency and a symmetrical approach to niche-regime relations. Section 3 discusses how these views can be applied in empirical research on urban sustainability transition with a focus on the local government as a place leader of innovation. Section 4 contextualises our research in China through a cursory account of the political-economic context within which the country's urban sustainability transition is embedded. Section 5 presents our MLP-based analysis of the development of Wuxi's solar sector. Conclusions are given in Section 6.

## **2. Multi-level perspective for urban sustainability transition: Towards a more political and dynamic understanding**

The MLP is a middle-range theory of the 'overall course of development of an innovation' (Poole & Van de Ven, in Geels & Schot, 2007, p. 414). It posits technological transition as a non-linear process produced by the interplay of developments at three analytical levels: niche, regime and landscape (Geels, 2002, 2004; Rip & Kemp, 1998). These levels are differentiated by the stability of the composition and alignment of social and technical elements involved. The niche is a small and emerging network of actors generating novel technologies, known as 'niche-innovations' in the MLP literature, and striving to push them into the mainstream. The regime is a semi-coherent set of socio-technical rules which, binding a large group of actors, consolidate the dominance of prevailing mainstream technologies and impose limits on the range of novel technologies that can be mainstreamed. The landscape is a constellation of social and physical conditions which, by virtue of their stability over time and the major disruption their infrequent change may bring, form the exogenous context of interaction between niches and regimes. Among these three levels, technological transition is defined as the shift from one regime to another. It unfolds as landscape changes provoke doubts on the superiority of the technologies supported by the prevailing regime, and create windows of opportunities for niche-innovations to expand their influence.

As the MLP gains prominence in transition studies, various proposals for its refinement have emerged, including many from Frank Geels (2011), one of the theory's leading advocates. Two

major refinements, to which this paper subscribes, merit elaboration. The first one is a politically informed understanding of the role of agency in socio-technical transitions. The MLP represents transition as changes in relations between the niche, regime and landscape levels. Although this representation insightfully identifies various possible processes through which transition is triggered, promoted and obstructed, it has been criticised for leaving out the question on ‘how, why, and through whose agency’ these processes are realised (Lawhon & Murphy, 2012, p. 360). Against this criticism, Geels rebutted that ‘agency is always present in the MLP’ (Geels & Schot, 2007, p. 29) because its three analytical levels are meant to distinguish structures ‘that differently influence local practices where actors (inter)act’ (p. 29), and ‘are continuously reproduced and enacted by actors in concrete activities’ (Geels, 2011, p. 29). Nonetheless, Geels admitted that the original conception of agency in the MLP was too narrow – it assumes actors are boundedly rational, acting based on their limited information processing capacity (Geels, 2011). By contrast, the theory has been less embrasive of a power-sensitive view of agency, which stresses how actors with different political-economic capacities, goals and interests shape transition pathways in a series of conflicts and contestations.

This power-sensitive view is especially needed for the study of urban sustainability transition. As Smith et al. argued (2005), many historical examples of socio-technical transitions ‘have an apparently autonomous logic’ (p. 1501) in the sense that they were driven by spontaneous scientific or entrepreneurial interests in innovations. However, urban sustainability transition unfolds as the upshot of ‘an explicit set of societal expectations or interests’ (p. 1502) imposed upon all members of an urban socio-technical system. Disagreement and debates about the end-point and, in turn, the means of transition because of the diverse ways sustainability is deliberately interpreted by and for different interests. It is then desirable to apply the MLP with an ‘actor oriented’ approach (Späth & Rohracher, 2012), analysing how through concrete activities actors actively work along or around existing balance of power among them to articulate tensions and complementarities between processes at different socio-technical levels to instantiate particular trajectories of urban transitions.

The second refinement is a symmetrical approach to niche-regime relations, which recognise the possibilities for both niches and regimes to promote socio-technical transitions proactively. In its initial formulation, the MLP explains regime adjustment as a result of ‘new configuration break[ing] through’ (Geels, 2004, p. 915). Accordingly, much attention has been paid to the hard work of niche actors in building up their momentum through improving the technical and economic performance of their innovations and expanding their social network (Berkhout et al., 2004). However, this explanation was criticised for privileging a bottom-up view of socio-technical transition which only recognises the niches as drivers of transformation. To be sure, the MLP also suggests that the presence of ‘windows of opportunities’ (Geels, 2002) at the regime level is a prerequisite of successful mainstreaming of niche-innovations. However, the concrete forms of such ‘windows’ have been subject to much less scrutiny. More problematically, by attributing such windows to a result of landscape pressures, the MLP tends to relegate regime actors to a passive barrier to the transition process. Detailed analysis of regime-level responses to pressures for change is found wanting (Hansen and Coenen, 2015).

Several insightful interventions have in fact been made to clarify the agency of regime actors, though until recently they have informed few MLP-inspired empirical accounts. First, by means of a typology of different pathways of transition, Geels and Schot (2007) demonstrated that regime actors may also facilitate changes when they adopt niche-innovations that ‘offer considerable positive feedbacks’ (Smith, 2007, p. 430) to them as ‘add-ons’ to their solution set to emerging problems. Moreover, Smith and Raven (2012) argued that regimes may create ‘protective spaces’ which shield niches from prevailing selection pressures (e.g., technical standards and user preferences) and empower niches by transforming the selection environment in their favour. Both interventions remind us of the *semi*-coherent nature of regimes – some regime insiders may be, whether in the interest of the commons or their continued political dominance only, more willing than others to adjust existing regime rules along environmentally friendlier lines.

### **3. The role of the state in urban sustainability transition**

Our interest in the role of agency in urban transition is shared by economic geographers who seek to explain why some regions are more successful in developing new growth paths than others despite sharing similar structural preconditions. Emerging from their work is a relational approach to agency, which stresses that actors cannot avoid confronting intentions and effects of others when seeking to realise theirs (Grillitsch & Sotarauta, 2020). Agency, therefore, is located ‘not in the attributes of individual agents but in the relationships connecting agents’ (p. 716). This approach echoes the MLP’s view that niche-innovations can break through the existing socio-technical regime when their ‘elements become aligned’ (Geels, 2007, p. 28). Nonetheless, economic geographers endorsing this relational approach do not deny that some actors may be better endowed and more committed to be leaders mobilising and coordinating other actors to chart new paths for a place. They have instead developed an interest in ‘place-based leadership’ in local economic development, with the agency of the leaders of a place – or ‘place-based leaders’ as known in the literature – understood as exercised by influencing others’ decisions rather than imposing a plan as one wishes (Sotarauta et al., 2017).

In this paper, we engage with the literature of place-based leadership to guide our response to the two aforementioned directions of refinement of the MLP. Compared to the prevalent firm-oriented approach in economic geography, we turn to the state, especially the local government, (Hu & Hassink, 2017), as the point of entry into the development of place-based leadership for urban sustainability transition. First, regarding the concern for power and politics in transition processes, we join Bentley et al. (2017) in arguing that power relations among different tiers of the state is a critical determinant of the direction and capacity of the local government in coordinating interventions to the local socio-technical system. As underscored by works on multi-level governance (Hooghe & Marks, 2003), the local government is both enabled and constrained by the sharing of power with its higher-level counterparts over local development. Variation in the extent of decentralisation in such aspects as goal setting, policymaking and fiscal management across places means that some local governments enjoy greater flexibility and capacity in orchestrating local actors for concerted actions. Struggles for power between

local and higher-level state actors arise when they cannot agree on the same transition trajectory (Späth & Rohrer, 2012). While the MLP proposes that socio-technical transition is a result of the alignment of activities at three analytical levels (i.e. niche, regime and landscape), the concept of multi-level governance explain such alignment in terms of the interplay between different levels of government (e.g. local, regional and national).

Second, regarding the concern for niche-regime interaction as a two-way process, we interpret place-based leadership of the local government in socio-technical transition as to steer niche and regime actors to adjust some of their practices to accommodate each other's interests. The state is often thought as a regime supporter *per se* who stabilises dominant structures and practices with its institutional power (Avelino & Wittmayer, 2016). However, recent studies have shown that the state is rather a 'hybrid actor' who may also open up regimes to niche innovations (Elzen et al., 2012). It can manipulate regime elements under its direct control (e.g. regulations) to favour the niches, and modify policy incentives (e.g. financial ones) to regime actors to stimulate niche-supportive changes from them. As the scholarship of technological innovation system suggests, these direct and indirect state interventions are often directed at the alignment of actions of actors from across the niche-regime divide to facilitate the formation of four key resources for niche development: technological *knowledge*, financial *investment*, niche *markets*, and socio-political *legitimacy* (Binz et al., 2016). The formation of these resources contributes to the anchoring – the process of developing solid links – of actors and networks of innovations in a city, both physically and institutionally (Elzen et al., 2012).

#### **4. Chinese state and urban sustainability transition**

In China, as a proactive and influential player in urban development, the state plays a critical role in urban sustainability transition. The Chinese central government has introduced various measures to compel its local counterparts to pursue greener forms of urbanisation. One of its expectations is the growing use of renewable energy, including solar power, in cities. National targets have been set on urban production and consumption of renewable energy. Competitive funding on the urbanisation of renewable energy is offered by the central government through the 'Model City in Renewable Energy Applications in Construction' programme, under which each local government can apply for a maximum of RMB 80 million based on how successful and innovative they are in promoting renewable energy development. The National New-Type Urbanisation Plan, China's latest national urbanisation blueprint, also underscored raising the ratio of new energy and renewable energy uses as a key strategy in the nation's quest for green city building. Chinese cities are therefore under increasing pressure not only to incorporate green technologies in their development but also to be sources of innovation (Zhang & Wu, 2019).

While a growing body of literature has drawn attention to the expanding development of solar power in China, few inquiries have addressed this solar transition at the urban scale, and still fewer to analyse the politics at play in promoting and constraining the solar sector rather than simply rehearsing local solar policies (but see Huang et al., 2018; Yu & Gibbs, 2018). In this regard, studies on Chinese eco-cities have shed important lights on the politics of urban

sustainability in China. Emblematic of China’s recent environmental turn, eco-cities refer to urban developments which vow to serve as living laboratories of the wide range of green technologies and planning approaches for sustainable urbanism. Without denying their effort in trialling and testing a variety of resource-saving features, studies have been critical of the economic motives of such projects. They found that local governments are interested in eco-city development as a means to inscribe a green image for their cities, whose interurban competitiveness can then be enhanced (Pow & Neo, 2013). They also revealed that some local governments put forward eco-city projects to secure more space for urban development than what would usually be permitted under the hitherto tight land regulation at the central level (Wu, 2012). In other words, the support of Chinese local governments to green initiatives is conditional upon their complementarities to economic goals. This phenomenon can be explained by the eagerness of local officials to fix the emerging national policy and popular demands for environmental improvements without missing the top-down economic growth targets which determine their career prospects (Pow & Neo, 2013).

While the construction of eco-city involves a range of experiments, the foregoing concern for economy-environment relations in the local ambitions on eco-city has rarely been brought to bear upon the scholarship of sustainability transition in Chinese cities. This paper takes a step in addressing this lacuna by examining the solar development in the city of Wuxi. We do so according to our two propositions in the last section on synthesising the MLP and the idea of place-based leadership to examine local socio-technical transition. The Wuxi cases illustrates two points. First, regarding political agency, China’s urban sustainability transition is mediated by its local governments which struggle to reconcile top-down environmental obligations with local entrepreneurial ambitions. While the central government’s pro-environment policies create landscape pressures for green niche-innovations in general at the urban level, the local government would consider its economic agenda to back certain niche-innovations which can serve as win-win solutions to local environmental and economic objectives. Second, regarding niche-regime interactions, as a place leader for innovation, the local government may coerce and incentivise supporters of the incumbent socio-technical regime to contribute to the formation of key resources for green novelties (Table 1). With the above two points in mind, we now examine why and how the Wuxi municipal government has led a solar transition in its city, and how effective its leadership has been.

**Table 1: Resource formation for Wuxi’s solar niche under local government’s leadership**

Key resource	Evidence of place-based leadership of the Wuxi government in resource formation
Technological knowledge	<ul style="list-style-type: none"> <li>• Fostered links between Wuxi’s solar PV sector and universities from elsewhere to import more technological knowledge and nurture more solar-related start-ups</li> <li>• Hosted high-profile conferences and exhibitions to put local producers into contact with external experts and consumers</li> </ul>

Financial investment	<ul style="list-style-type: none"> <li>• Mobilised government-affiliated enterprises to invest in the creation of Suntech Power Corporation</li> </ul>
Niche market	<ul style="list-style-type: none"> <li>• Introduced planning codes mandating the use of solar water heaters in many residential and public buildings</li> <li>• Offered subsidies to users of locally-produced solar PV products and emission reduction rewards to businesses using solar power generated in their production plants</li> </ul>
Socio-political legitimacy	<ul style="list-style-type: none"> <li>• Took the lead to use solar power conspicuously in public works</li> <li>• Supported the local solar PV sector to run a series of city-wide and neighbourhood promotion campaigns</li> </ul>

## 5. Wuxi's solar transition: Roots, enablers and barriers

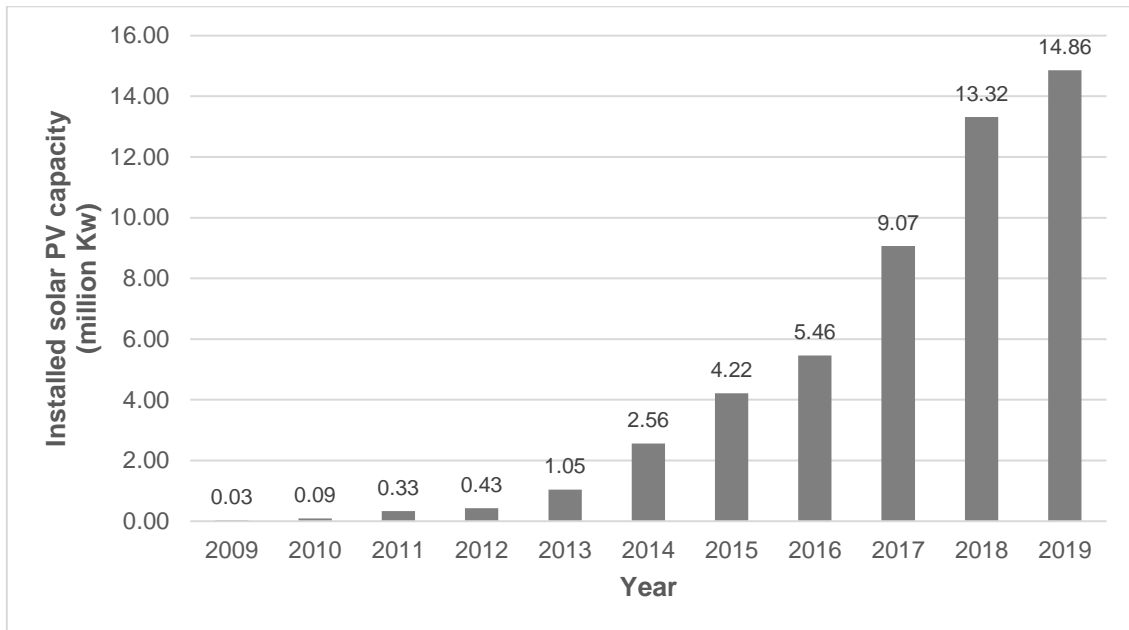
### 5.1 Overview of the case

Wuxi is a second-tier city located in southern Jiangsu Province. The city hosts 6.4 million population, and functions as a major economic growth pole in the Yangtze River Delta region. Wuxi provides an intriguing site for urban sustainability transition research due to two reasons. First, the city has been a hub for PV panel manufacturing since the beginning of 2000 and was well-known for breeding the world largest PV panel manufacturing company – Suntech Power Corporation ('Suntech' thereafter) – in the early 2000s. Second, Wuxi has achieved obvious energy decarbonisation for the use of solar energy in the industrial sector. In recent years, clean economy has become a focus of Wuxi's urban development. The city came first for solar PV consumption among cities in Jiangsu, which ranked the first (18.2% of national total) and the six (6.3% of national total) in terms of distributed PV grid-connection capacity and PV generating capacity, respectively, among 31 provincial-level units (CEPYEC, 2015; NREC, 2015). Figure 1 shows the significant growth of Jiangsu's installed solar PV capacity in recent years.

The findings reported in this paper were derived from a combination of primary and secondary research on Wuxi between 2016 and 2019. We made multiple field trips to Wuxi in to observe the local development and consumption of solar products. We also conducted 26 semi-structured interviews with various stakeholders of the local energy system, including nine government officials, six urban planners, five owners of PV manufacturing businesses and six local residents. Questions were posed on what actions the Wuxi government has taken to mobilise actors to support the local solar niche, and how effective these actions have been in bringing about changes. Complementing these interviews, we inspected policy documents on local PV development provided by municipal bureaus of municipal bureaus of economy, urban planning, development and reform, and science and technology, as well as the committee overseeing local eco-city development. We also reviewed public documents pertinent to Wuxi's solar development, including statistics yearbooks, land use plans, technical guidelines, and catalogues of Wuxi's PV producers. The data collected from these sources were triangulated to construct a chronology of Wuxi's solar-oriented sustainability transition for



deduction of the temporal order and causal relations among various changes in the governance, economy and energy use of Wuxi.



**Figure 1 Installed solar PV capacity in Jiangsu, 2009–2019**

Compiled based on CEPYEC (2015) for 2009–2014, and [guangfu.bjx.com.cn](http://guangfu.bjx.com.cn) (2020) for 2015–2019

## 5.2 When green niche met landscape shocks

Wuxi’s solar PV sector dates from 2000, when Shi Zhengrong knocked on the door of the Wuxi government for investment into his solar PV manufacturing venture. Born in Jiangsu, Shi left China in the 1980s for doctoral studies in Australia, where he became a successful researcher in solar cell. However, a global push for renewable energy ignited Shi’s interest in returning to his homeland, where low labour costs facilitate large-scale manufacturing, to commercialise his innovations. Optimistic and ambitious about the solar PV sector, he returned to China in 2000 to approach several local governments with the bold promise that ‘give me 8 million US dollars, and I will return you with the world’s largest enterprise’. At that time, the government of Wuxi was searching for a new pathway to maintain the city’s growth trajectory after a large number of local township and village enterprises succumbed to challenges posed by further marketisation and increasing competition from foreign-invested firms (Yuan et al., 2014). It embraced Shi’s proposal with great enthusiasm as a lynchpin to reorient Wuxi’s economy to high-tech industrial development. The government mobilised its seven affiliated enterprises, including four of its financing vehicles and three local state-owned enterprises, to raise USD 6 million for Shi to establish Suntech (Hopkins & Li, 2016). During the 2000s, Suntech expanded both its production and sales of PV panels rapidly. It took advantage of Wuxi’s low-cost environment to produce cheaper PV panels and exported them to such overseas markets as Germany, Japan and the United States, whose national energy regimes have become more favourable to solar energy development. The company was so successful that it was listed in

the New York Stock Exchange in 2005, and at one point became – as Shi promised – the world’s largest manufacturer of PV panels.

Suntech’s miracle ascent to the global solar market led to a mushrooming of firms in Wuxi along the supply chain of PV panel production. This trend encouraged the Wuxi government to lend greater support to the local solar PV niche in two aspects, thereby consolidating the city’s leadership in China’s green energy economy. The first aspect is the learning of technical and business expertise by the niche actors. In 2009, the Wuxi government entered into collaboration with University of New South Wales, Shi Zhengrong’s alma mater, to train more talents for the local solar PV sector. In 2012, it also invited the Northeast University, known for its research excellence in material science, to establish a research institute in Wuxi as an incubator of more start-ups in solar PV production. The second aspect is the building of social networks for an expanded resource base for niche innovation. The Wuxi government has hosted a series of conferences and exhibitions to enhance the visibility of its solar PV firms and products. A notable example is the Chinese Renewable Energy Conference and Exhibition, which has been held annually since 2009 as a key platform of dialogue and deal-making among officials, planners, technicians, manufacturers and potential buyers of solar products across China. By 2011, the output of Wuxi’s PV industry reached its all-time high of over RMB 60 billion, making up more than 9% of the city’s annual GDP (Tong et al., 2017).

Up to this moment, the Wuxi government’s support for the niche-innovation of solar PV panel was primarily about promoting local *economic* transition, namely, to upgrade Wuxi’s economy to one dominated by high-tech manufacturing, of which solar PV production is an important sector. However, two subsequent landscape shocks compelled the Wuxi government to engage in local *sustainability* transition in energy consumption. The first shock was an ecological one. Wuxi sits at the shore of Lake Tai (*Taihu*), one of China’s largest freshwater lakes. For decades, Lake Tai was polluted by untamed wastewater discharges from Wuxi’s large number of chemical companies. The lake reached its tipping point in May 2007, manifested as an unprecedented cyanobacteria bloom. To the Wuxi government, this ecological disaster dropped a political bombshell. At the provincial level, soon after the bloom, the People’s Congress of Jiangsu made water pollution control a key governance target of the local governments of Wuxi and other cities around the lake. At the national level, in 2009, the then premier Wen Jiabao inspected Wuxi’s pollution control effort around Lake Tai and ordered the city to be built as ‘an ecological city, a tourism service city, a high-tech city, a liveable city. It must do a good job in ecological protection’ (www.gov.cn, 2009).

These interventions compelled the Wuxi government to align the local socio-technical regime of production and consumption along greener lines. The second shock was an economic one – an abrupt reversal in the expanding Western market for PV panels. In 2011 and 2012, authorities in both the United States and European Union imposed anti-dumping duties on PV panels produced in China (Shubbak, 2019). Moreover, demand for PV panels plummeted in European countries as their governments reduced their solar subsidies, justified by the lowering price of Chinese PV panels (Ball, 2013). These changes came as a crushing blow to Wuxi’s PV panel manufacturers, whose business was export-oriented. Between 2011 and 2013, the

output level of Wuxi's PV panel sector slumped by over RMB 200 million, and their share of Wuxi's GDP dropped to below 6%. Many firms, including Suntech, ran into financial difficulties with inventories piling up.

Confronted with these two landscape shocks, the Wuxi government accelerated its pace in promoting solarisation of the local energy regime. This was a stone to kill two birds. On the one hand, increased local use of solar energy would improve the image, if not also the material quality, of Wuxi's environment in the aftermath of the cyanobacteria outbreak. On the other hand, a new local market could be created for Wuxi's PV panel manufacturers so as to save the local solar niche, as a potential new growth pole of the city. Either way, the Wuxi government opened a window of opportunity for solar power, as a niche alternative, to compete for influence in the energy regime.

### 5.3 State-led market building for solar niche survival

Formal commitment of the Wuxi government to help solar PV firms overcome selection pressure began in 2008 with the introduction of the 'Implementation Plan for Promoting Solar PV Power Application in Wuxi'. The plan stressed the need to promote the development of the PV production sector by creating a local market of solar PV consumption. To achieve this goal, the Wuxi government has taken various steps to adjust the technical and economic rule sets of the local energy regime to promote the use of solar products.

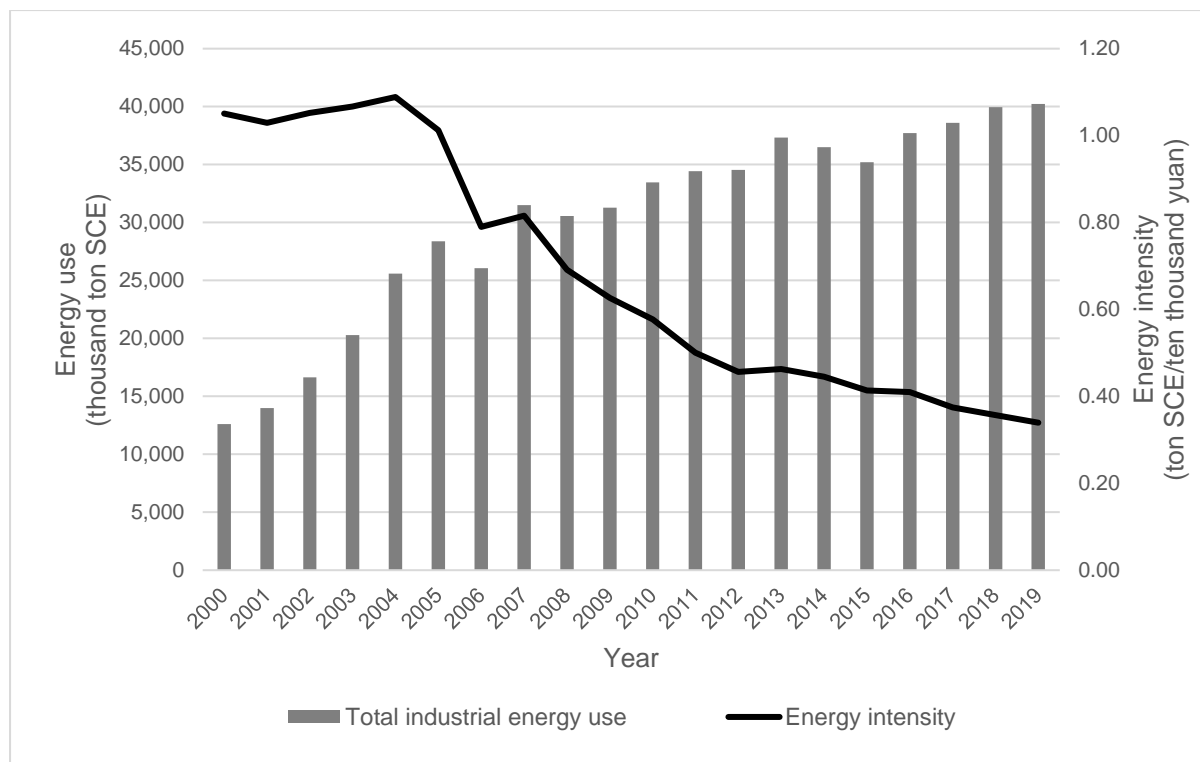
The first set of regime adjustments take place in urban planning as a command-and-control tool to create space – in both a physical and policy sense – in Wuxi for solar products. The local government turned its major project of urban expansion, Taihu New Town, into the bastion of the city's solar PV niche. With 150 km<sup>2</sup> and expected to house a million residents by 2020, Taihu New Town was first proposed in 2002 with little environmental concern. However, when it broke ground in 2010, it was repositioned as an eco-city eyeing on energy decarbonisation through the use of solar power, including household consumption of distributed PV systems and SWH. Specifically, the local government has rendered the use of solar power a technical norm in the new town. In its 'Decision on Accelerating the Construction of Taihu New Town – National Pilot Low-Carbon Eco-City' issued in November 2010, and a complimentary set of planning targets and implementation guidelines, the Wuxi government introduced a range of planning requirements to ensure the uptake of solar power. At the building level, it is mandated that 24% and 10% of the energy consumed by residential buildings and public buildings (e.g. schools, hotels and office blocks) respectively should be derived from renewable sources, one of which is solar power. Moreover, targets were set for SWH uses. For residential buildings, all those with 12 or fewer stories should be installed with centralised SWH at their rooftop, while 25% of those taller ones should install either centralised or balcony-mounted SWH. For public buildings with hot water demands, 80% of them should be installed with SWH. Moreover, solar PV and wind turbines should make up 8% or more of the new town's installed electricity generation capacity. Many of these planning codes were extended to the rest of Wuxi by the local government in 2013. At the land use level, many residential areas in the new town were planned as low-density gated communities with detached houses. Residents in these

communities represent an important group of end-users of solar products because, built in low density, their homes have less blocking loss due to their surrounding and can capture sunlight more efficiently.

The second set of regime adjustments aims at holding market competition pressures off the solar products, which tend to be more expensive than products using conventional fuels. In 2009, as part of its measures to resuscitate China's economic growth after the 2008 financial crisis, the Ministry of Finance started subsidising the installation of solar PV systems in buildings to nurture domestic market demand for China's solar power industry. Feed-in tariff policies for solar electricity were introduced by the central and Jiangsu governments (Ye et al., 2017). Given the dire business prospect of its solar niche, the Wuxi government has topped up the top-down financial support to accelerate local installation of distributed PV systems. In 2013, the 'Advice on Promoting the Health Development of Photovoltaic Industry' was adopted by Xinwu District, Wuxi's industrial stronghold where many PV panel manufacturers clustered. To encourage local consumption of local PV products, for any new PV systems with over 50% of their PV panels sourced from producers in Xinwu, the district government would provide a one-off subsidy of RMB 200,000/GW of installed capacity derived from locally produced PV panels. Moreover, as a new form of business emerging with the solar turn, solar service providers specialising in the operation and maintenance of solar energy system have been encouraged to collaborate with manufacturing industries in generating solar electricity with PV panels installed at the rooftop of the latter's production plants. These solar service providers are entitled to a 20% subsidy on their upfront cost in establishing the PV system, with a cap of RMB 1 million, while businesses powering their production plants with *in situ* solar electricity can receive emission reduction rewards corresponding to their solar electricity consumption level (Interview, Xinwu District economic bureau official, December 2016).

Beyond these financial instruments, the Wuxi government also seeks to shape user preference in favour of solar producers by boosting the visibility and legitimacy of their products. On the one hand, the Wuxi government has taken the lead to use solar power, starting with its projects in Taihu New Town. Public works in the area gradually adopted solar PV to power-up streetlamps. The local government required main roads and promoted secondary roads to use solar PV lamps. Main roadways connecting the administration centre to the rest of the new town, were equipped with solar streetlamps. Many local PV manufacturers sought to provide their products at discounted prices as an advertising approach to the general public and competed to work with the local government providing this type of public goods. On the other hand, since 2014, it has supported the local solar PV business community to run a series of city-wide and neighbourhood promotion campaigns. Under the slogan of 'PV electricity generation for ten thousand houses' (*guangfu fadian jin wanjia*), these events not only perform an educational function of disseminating knowledge about the environmental benefits of using solar power, but also publicise the economic benefits one can reap from using PV systems and SWH, such as everyday cost reductions and additional income for selling surplus electricity to the utility. Local solar PV producers have valued these opportunities to promote their products to potential residential and commercial consumers face-to-face. All these measures have lent

support to Wuxi’s development of a cleaner energy regime during the 2010s, a time at which Wuxi’s energy intensity has – as Figure 2 shows – sustained its improvement since 2004.



**Figure 2 Industrial energy use and the energy intensity in Wuxi, 2000–2019**  
Source: Wuxi Statistical Yearbook (2016).

#### 5.4 Emerging regime barriers to further achievements

A lack of detailed statistics on Wuxi’s electricity consumption prevents us from ascertaining the exact share of solar power in the city’s energy mix. Nonetheless, anecdotal evidence has suggested that the local consumption of solar products is on the rise. For SWH installation, as of 2018, every 100 urban households in Wuxi owns 41.61 units of SWH (Wuxi Statistical Bureau, 2019). This ratio is higher than the estimated national penetration rate of 30%. For the use of PV systems, various reports point to an expanding local market. For instance, between 2016 and 2017, the number of PV systems installed in Wuxi for electricity generation increased by almost fourfold from 360 to 1,395 (Sina Finance, 2017). Moreover, according to Wuxi Power Supply Company, 359 distributed PV systems in the city has been connected to the national power grid, producing over 100 million kWh in 2016 (Century New Energy Network, 2016). Approximately 200 households made an average of RMB 5,000 per annum by selling their surplus solar electricity to the national power grid. As of 2019, the installed PV capacity in Wuxi that has been connected to the national power grid reached 1,240 MW, contributing to about 8% of the total installed PV capacity of Jiangsu province (Chinese Renewable Energy Conference and Exhibition, 2019).

However, parallel to the abovementioned progress in Wuxi is growing tensions among different local stakeholders over the desirability and viability of further solarisation of the city’s energy

regime. Three aspects of these tensions can be identified. The first one concerns the curtailment of the spatial conditions for solar power generation by the city's real estate regime in the living laboratory intended to support solar development. Since the Taihu New Town has become the seat of Wuxi's municipal administration, the price of its residential units has soared significantly from RMB 8,000/m<sup>2</sup> in 2010 to RMB 18,000/m<sup>2</sup> in 2018. The large amount of land reserved in the new town for residential development began to attract enormous investments from real estate developers. To maximize their profit, these developers have favoured building high-rise apartment towers. In contrast to the low-density communities developed earlier, these high-density developments tend to block more sunlight and do not favour the use of solar products (Interview, technician of a PV firm in Taihu New Town, April 2017). Lax enforcement by officials in the construction sector, who was not responsible for drafting the pro-solar planning codes, means that real estate developers have been able to circumvent the requirements on making room for the use of PV products in their buildings. In contrast, the development of PV systems has been successful in Wuxi's industrial parks. Since industrial land is leased at a much lower price than residential and commercial land, Wuxi's manufacturers are incentivised to lease more land for implementing more extended distributed PV systems, economies of scale in PV production and self-consumption.

The second tension stems from the physical maintenance of PV products installed earlier. As our field observation suggests, effective maintenance of solar energy products is more likely to take place in properties owned by the public sector, such as state-owned industrial parks, public museums, schools and administrative centres, because of their closer links with the municipal government, and hence compliance with its solar power goals. This stands in contrast to private properties, where some of their developers as well as users are concerned about the physical implications of the use of solar energy to their buildings. For instance, some property developers forbid arbitrary installations of distributed PV plants by residents because they consider such plants as unsightly features which may translate into lower property prices (Interview, Taihu New Town Development Corporation engineer, November 2016). Moreover, in the expanding communities of high-rise apartments, individual households may run into disputes for using SWHs. According to China's Property Law, the use right of a building's rooftop is shared by all homeowners in the building, such that some households in multi-storey buildings have installed their SWH on the rooftop of the building in which they live. However, property management companies oppose this practice because it raises questions about the distribution of responsibility for repairing the rooftop in the case of inappropriate uses caused by individual SWH installations. (Interview, Taihu New Town resident, April 2017).

The third and most recent tension lies between the energy end-users and the state regarding the former's financial risks associated with the use of solar power in the long run. Apart from financial support from the Wuxi government, subsidies from the upper-level governments have constituted a main driver for the expansion of distributed PV plants installations among the domestic and business energy end-users, mainly out of the desire to reap the profit of selling self-generated electricity back to the state power grid (Interview, Wuxi Development and Reform Commission official, November 2016). However, there are questions if the trend of expanding PV installations in Wuxi may decelerate. In 2018, both the central and Jiangsu

governments radically rolled back their various PV-related subsidies, including feed-in tariff of solar electricity. They argued that PV products are getting cheaper, so their fiscal support is no longer essential to keep these niche-innovations competitive. As one source published in 2017 (Sina Finance, 2017) suggested, the cost of installing a distributed PV system in Wuxi ranges between RMB 40,000 and 60,000, while it could take as long as ten years to recover such cost in full. Since PV systems have a lifespan of 20 to 25 years only, even small reductions in financial support may significantly undermine the profitability of installing PV systems. With many of our interviewees living in Wuxi citing economic benefits as the main motivation for them and their local acquaintances to adopt solar products, more has to be done to safeguard Wuxi's solar future.

## **6. Conclusion**

In the study of sustainability transition, the emergence of the MLP as a popular approach has been accompanied by various attempts to nuance its theorisation on transition dynamics. Contributing to this debate, this paper develops a refined version of the MLP which stresses two aspects: the role of power-mediated (*vis-à-vis* rational) agency in the transition process, and the bidirectional (*vis-à-vis* unidirectional) links between emerging socio-technical niches and incumbent regimes. Applying these arguments to examine Wuxi's solar development, we reveal the significance and limitations of the Chinese local government in exercising place-based leadership in urban sustainability transition. In the following, we first summarise how the Wuxi case lends support to our two refinements to the MLP, before proposing future research directions on China's urban sustainability transition.

For the aspect on agency, the case of Wuxi provides ample evidence on the political, contested nature of urban sustainability transition. The scope for the Wuxi government to work with, by and through various actors to anchor the solar niche in Wuxi's energy system has been shaped by initiatives from the higher levels of government. On the one hand, upper-level governments can be a source of pressure for urban sustainability transition. Through their forceful orders for environmental improvements, the central and Jiangsu governments were instrumental in bringing the landscape shock of Lake Tai's cyanobacteria bloom to bear upon Wuxi's energy regime as a pressure for solar transition. They helped articulate the urgency for the Wuxi government to make greater efforts in promoting local solar consumption. On the other hand, higher-level governments can also be a source of constraint to the transition. In Wuxi, the constraint has come in the form of the blow to local demand for solar products owing to the sudden reduction of national and provincial subsidies to the installation and use of solar PV systems. These incentives pose continuous challenge for the local government as a factor by and large beyond its control while it seeks to shepherd all actors towards a common transition vision. While much criticism for the sluggish development of greener socio-technical regimes in China's eco-cities has been directed – and often rightly so – at the local governments, the Wuxi case draws our attention to the influence of actors beyond the local scene whose normative and material commitment to steering the regime shift are no less important.

For the aspect on niche-regime interplay, our empirical findings suggest that changes to the incumbent regime promoted by its supporters are no less important than niche developments in promoting urban sustainability transition. As the Wuxi case demonstrates, the local government may lead the anchoring of the niche through modifying those aspects of the socio-technical regime under its control and engaging other regime actors for behavioural changes, so that key resources for niche development can be formed. On the supply side, the Wuxi government channelled state-affiliated investment to the solar sector so it could capture business opportunities arising from the global landscape shift towards green energy. It also promoted the import of knowledge on solar technology to Wuxi through collaboration with universities from other regions. On the demand side, the Wuxi government created a market for its solar niche by mandating and subsidising the use of solar products in various occasions, and supported campaigns for the local solar sector to build up legitimacy of its products among local users. Nonetheless, the complex linkages between the energy system and other aspects of urban development have hindered further transition in Wuxi. A notable problem is the incompatibility between the low-density setting required for solar power generation and the high-density environment created by real estate developers to maximise returns from their land assets, whose handsome conveyance fees constitute a primary source of fiscal income for many Chinese local governments. As this contradiction shows, the difficulty for the local government to steer socio-technical transition is not only about motivating other actors to work for it, but also about coordinating its diverse yet interlocking pursuits and interests.

Based on Wuxi's experience, we propose two themes which warrant more research attention for a better understanding of China's urban sustainability transition. The first one is the multiple governing approaches through which Chinese local governments steer transitions. Given that China's environmental governance is often characterised as authoritarian (Gilley, 2012), it is tempting to conclude that Chinese local governments would simply sanction socio-technical transformations with their authority. However, the case of Wuxi suggests the contrary. Besides imposing new plans and standards mandating solar product adoption, the Wuxi government has also been active in what Bulkeley and Kern (2006) called 'governing by provision' (e.g. investing in Suntech) and 'governing by enabling' (e.g. supporting marketing efforts of solar product manufacturers) – an observation echoing Yu and Huang's (2020) findings in other Chinese cities. It is worth probing further under what circumstances would Chinese local governments give more weight to these two forms of governing, which are more prominently featured in Western cases of urban sustainability transition (for a review, see Smedby and Quitzau, 2016).

Another theme is the multiple forms of spatialities underpinning transitions of Chinese cities. As a focus of recent geographical interventions of sustainability transition (Hansen & Coenen, 2015), scale stands out in Wuxi as a crucial spatial mediator of its solar transition. As the recent conflict between the Wuxi government and its higher-level counterparts on subsidies to solar product adoption reflects, urban sustainability transition is prone to disruption by actors who have a direct bearing on the city but who act based on the interests of a different scale (e.g. regional or national). Nonetheless, we shall not neglect that Wuxi's solar transition is also embedded in multiple networks. Wuxi's solar sector benefited from Suntech's leading position



in the global production network in attracting support from the local government, while its development was facilitated by its networking with Australian researchers. It is through tracing these manifold spatial relations in which a city is situated can we account for the geographically diverse sources of influence to urban sustainability transition.

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