AESC Working Paper 20

Community solar energy initiatives in urban energy transitions: A comparative study of Foshan, China and Seoul, South Korea

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Publication Date: 10-2018

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Community solar energy initiatives in urban energy transitions: A comparative study of Foshan, China and Seoul, South Korea

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Abstract:

Urban community solar energy initiatives have flourished around the world, suggesting that community energy can be an important pathway for energy transitions. The deployment of solar energy has however remained limited. The complexity of these community-level transition processes has not been well understood and conceptualised. By advancing studies on community energy and socio-technical energy transitions, this paper proposes an integrated framework to conceptualise community-level energy initiatives from a systemic perspective. The framework builds the linkages among five critical processes and their associated contexts and outcomes, and is applied in a comparative study of two cities in Asia: Foshan and Seoul. Based on 19 semi-structured interviews in the case cities, this study has three major findings. First, the two cities' solarisation pathways exhibited similarities as well as differences that could be understood within our conceptual framework. Second, distinctive modes of community solarisation can be identified in the two cities. Foshan's model was a top-down, state-led and entrepreneur-driven approach, whereas Seoul developed a bottom-up grassroots-driven transition. Third, the actual impacts of community solarisation on regime shifts appeared to be very modest, but we identify important reinforcing effects between some processes and local contextual factors. This paper concludes that community energy can play an important role in urban energy transitions, but that sufficient policy attention must be given to complex interactions in the critical processes.

Keywords: community solar energy, urban socio-technical transitions, China, South Korea

1. Introduction

Solar energy has been widely regarded as an energy source that can play a major role in accelerating a deep decarbonisation effort towards a more sustainable future (Deng et al., 2015; WEC, 2017). A large gap remains, however, between solar potential estimates and the actual scale of deployment. Whereas the International Energy Agency (IEA) estimates that by 2020, solar photovoltaic (PV) systems could provide 11% of global electricity production (IEA, 2014), they contributed only 1% of all electricity used globally with a total installed capacity of 227 gigawatt (GW) in 2015 (WEC, 2017).

How, then, can the potential of solar PV systems be realised in energy transitions? On a global scale, the driving forces of renewable-orineted energy transitions are diverse (Inderberg et al., 2018), with differing pathways (Cowell et al., 2017; De Laurentis et al., 2016; Foxon and Pearson, 2010) and outcomes (Hultman et al., 2012; Kemp et al., 2008). Urban community energy, or community-level energy initiatives, have received increasing attention from scholars and policy-makers as one of the integral pathways, along with utility-scale renewable developments, for realising energy transitions (Brummer, 2018).

Empirical studies on energy suggest that cities have proactively developed community-based solar initiatives, using different approaches to engage their communities (see, for example, Byrne et al., 2015; Colucci & Horvat, 2012; Hammer, 2008; Hodson & Marvin, 2010). The solar cooperatives and social enterprises in Sungdaegol in Seoul, and crowd-funded solar projects in social housing estates in Brixton in suburban London are good examples that show the great diversity of possible approaches to engaging communities (Fuller & Bulkeley, 2014; Kim, 2017). These empirical developments of urban community energy imply that the transition processes need to be better studied.

Community energy, which originated in Europe as a concept and a practice, has been extensively studied over the past decades. Alongside other theoretical concepts in more recent years, most notably the multi-level perspective (MLP) of the socio-technical transition literature, previous studies have provided useful approaches for understanding the roles, forms, and processes of community-level energy initiatives (Späth et al., 2012). The MLP sheds light on the roles of communities as a niche actor which may facilitate niche innovations and foster regime shifts (Hodson & Marvin, 2010). The literature has not, however, given sufficient attention to a systemic perspective of those local initiatives. How are the key elements of community-level energy initiatives linked, and what impacts do they have on energy transitions? This paper therefore aims to advance community-energy and multi-level perspective studies by proposing an integrated framework for conceptualising the transition processes of community-level solar initiatives, from a systemic perspective. By applying the framework to Foshan and Seoul, we aim to provide a better understanding of how community initiatives evolve, develop, and impact energy transitions.

This is a comparative study of Foshan city in Guangdong, a southern province in China, and Seoul, the capital of South Korea. Foshan and Seoul were chosen as our case cities for three reasons. First, China and South Korea have significant roles to play in the global energy challenges. China and South Korea are the world's major greenhouse gas emitters (IEA, 2018) but they have also developed major climate change-related policies such as emission trading and smart grids, offering potential solutions to these global problems (EIA, 2015; Korea Energy Agency, 2015b). Second, Foshan and Seoul have been the first-movers of various energy innovation initiatives in their respective countries. In 2012, Foshan was selected as one of the four national pilot cities of demand response programmes (Li et al., 2016), followed by the designation of Foshan's Sanshui Industrial Park as one of the first national solar PV Demonstration Zones two years later in 2014 (People's Government of Sanshui, 2014). Seoul, a leader among Korean cities in addressing climate change, has been awarded by the C40 Cities Climate Leadership Group as one of the 11 best cities in 2016 (C40, 2016). Third, Foshan and Seoul exhibit diversity in their community solar pathways. This study examines two specific communities, Luonan in Foshan and Sungdaegol in Seoul. Whereas Luonan is an urban village residential area that has been selected as one of the first "Chinese household solar PV demonstration villages" in China (Liu & Su, 2016), Sungadegol is an old suburban neighbourhood that has been widely regarded as the most successful energy self-reliant community in Seoul (Kim, 2017). As we will discuss in more detail in Section 3, Luonan's pre-existing entrepreneurship and geographical proximity to a solar PV cluster in Sanshui Industrial Park contrasts markedly with Sungdaegol's grassroots movement, which first started with energy saving and then extended its efforts to solar PV deployment (Kim, 2017; Li & Luo, 2017). A growing body of literature on energy transition has shown that transition pathways can vary, involving differing patterns of transition processes (Foxon and Pearson, 2010; Inderberg et al., 2018). Most of the literature is however from the Western context. An examination of that diversity in the Asian context will make an important contribution to enrich our understanding of the scale and nature of such diversity.

The following section provides a review of the theoretical perspective of community energy. It then proposes an integrated framework within which to specify the processes, contexts, and outcomes of community solar energy initiatives. Section 3 discusses the methodological approaches adopted in this study, and the case contexts. Section 4 presents the two case studies, Foshan and Seoul, and Section 5 provides a discussion from a comparative perspective. The final section offers concluding thoughts and policy recommendations.

2. Theoretical perspectives on community solar energy initiatives

2.1. Community energy as a global trend in cities

Cities across the world have been widely regarded as key sites for energy transition activities (see, for example, (Hammer, 2008; Hodson & Marvin, 2010). Cities explore a great variety of alternative energy transition pathways. In their search for different supply-side (e.g., nuclear expansion, wind power) and demand-side technology choices (e.g., through smart grid technologies) for meeting global and local climate objectives, a number of reasons motivate many cities to introduce solar initiatives at the community level.

First, solar PV technology has achieved substantial cost reduction, and those technologies are readily available. Second, policy-makers have increasingly recognised that untapped solar resources can be a feasible energy option to complement other energy approaches for delivering ambitious climate and energy targets. Third, community solar projects are often regarded as a complementary approach to government-led, utility-led, or private-developer-led renewable projects (Brummer, 2018). Community solar projects have the strengths of opening up new options (in terms of technological choices, architectural designs, and financing options) and of achieving aggregate impacts that could only be offered by collective efforts at the community level (Seyfang et al., 2013; Tarhan, 2013). Engaging communities in energy governance has the potential to enhance policy legitimacy and public trust and to create an inclusive society that is supported by a shared goal and a collective perception of solutions (Brummer, 2018; Cleland et al., 2016; Stagl, 2006). Fourth, policy-makers are also attracted by the prospects of green growth and attaining other economic and social benefits (most prominently, by providing local jobs and enabling community benefit projects). Such green growth strategies are also regarded as a key for cities to maintain competitiveness at the global level (Vazquez-Brust, 2014). An international review of selected cases of community solar initiatives also suggests that a variety of strategies and models has been utilised to maximise the benefits for sustainable urban development (Table 1).

Table 1: Selected cases of community solar initiatives around the world

Solar communities	Key actors	Initiatives	Strategies	Illustrations	References
Saskatoon, Canada	NGO: Saskatchewan Environmental Society (SES)	Building a "renewable energy future for Saskatchewan" by setting up community-based SES Solar Co-operative Ltd.	Crowdfunding	• Crowdfunding by selling solar co-op membership to community members to setup solar power plant • Gains from solar electricity sales will be rebated to co-op members	Saskatchewan Environmental Society (2015)
Colorado Springs, US	Solar company: SunShare	Community solar garden initiated by private company	Solar leasing	• Leasing solar panels to community members for 20 years at an upfront cost • Community members leasing solar panels get credits for electricity generated	Craven (2011)
Banbury, UK	Social enterprise: Low Carbon Hub	Community-owned solar roof project by inviting enterprise participation	Loans and shares	• Solar roof of a motorsport company headquarters offered for community investment • The motorsport company enjoys discounted electricity expenses and bears no installation costs • Investors buying shares of the solar roof project with projected returns	Low Carbon Oxford (2016)
Milwaukee, US	Government: City of Milwaukee	City government solar program "Milwaukee Shines"	Group purchasing	• Community members use collective purchase power to save on total costs of going solar through bulk purchasing • Tax incentive, cash-back incentive and solar loans are also available for solar installers in this program	City of Milwaukee (n.d.)
Yackandandah, Australia	Community group: Totally Renewable Yackandandah	To achieve "100% renewable by 2022"	Donation	• A fund was setup by donations to reinvest in solar projects within the community • Aimed to achieve 100% renewables for the town by 2022 with electricity sharing enabled through commercial mini grids	Bloch (2017)

Brixton, UK	Government: Greater London Authority	Setting up Low Carbon Zone	Public private partnership	• Delivered community owned solar project through sale of shares to community members to install solar panels in the community • Providing building retrofit solutions to drive long-term carbon savings •	Fuller (2014)
Iida, Japan	Social enterprise: Ohisama Shimpo Energy	Ohisama 0 Yen System for household solar panel installation	Citizen fund raising	• Community solar installer established through fund raising among citizens • Solar household entering a power purchase agreement with installer for 9 years without paying any upfront costs	Ohisama Shimpo Energy (2015)
Newstead, Australia	Community group: Newstead 2021	Setting up Newstead 2021 Inc. to develop solar energy	Collaboration among interested community members	• Entering into memorandum of understanding with network company • Enabling community to understand community's energy load profile, assess local generation on grid stability, reliability, and financial models available as well as providing technical advices	Hinchliffe (2016)
Ashiya, Japan	Private sector: Panasonic	Development project of "Shioashiya Solar-Shima" emphasising solar homes	Residential community development	• Creating an energy resilient and self-sufficient community microgrid by installing solar PV and lithium-ion battery energy storage systems in 117 homes • Integrating solar energy with smart, energy efficiency technologies and energy management systems to develop smart city	Burger (2017)

2.2. Community energy as a concept

The notion of community solar energy has its roots in the concept of community energy – which originated in Europe, spread around the world, and has been extensively studied during the past two decades (see, for example, Walker, 2008; Gui & MacGill, 2018; Hasanov & Zuidema, 2018). Community energy is a highly dynamic concept, and it still lacks a well-defined definition (Gui and MacGill, 2018). A community is generally referred to as a space in which collective action happens due to geographic proximity (Haggett & Aitken, 2015; Kim, 2017). A community can also refer to social relations within a particular place (Haggett & Aitken, 2015). Community energy is often associated with terms such as energy community (Gui and MacGill, 2018), citizen energy (Hasanov & Zuidema, 2018), community energy initiatives (Kim, 2017), and community energy actions (Kim, 2017). Some scholars have improved the conceptual clarity of community energy by making an important distinction between "community energy" and "energy community" (Gui and MaGill, 2018), and between "community of locality" and "community of interest" (Walker, 2008). As such, a community of shared interest can be a group of people who share interests and visions, even though they are not local residents in the same vicinity (Kim, 2017). On the other hand, in its broadest sense, community energy can be referred to as communities that are engaged in energy-related activities for various reasons and in various forms (Brummer, 2018), from awareness-raising programmes on energy (Wolfram, 2018), to energy projects that involve community ownership (Walker, 2008), to community-driven energy cooperatives (Kim, 2017). In this study, we adopt a broad perspective of community energy and define it as community-based initiatives for the reorganisation of local energy systems to foster the deployment of distributed energy resources and of energy saving and efficiency.

Another theme of the community energy literature is the extensive study of the critical processes and contextual factors involved. Visioning (Hodseon & Marvin, 2010; Späth and Rohracher, 2012), leadership (Wolfram, 2018), networking (Gui & MacGill, 2018; Acosta et al., 2018), institutionalisation and government organisations (Acosta et al., 2018), and realignment of incumbents' incentives to facilitate grid connections to distributed energy sources (Walker, 2008) are some of the key processes identified in the community energy literature. In terms of contextual factors, along with the socio-economic and political contexts, are trust (Walker et al., 2010), local traditions, community cohesion, and local practices that predate community energy initiatives and are critical contexts for the success of community-level energy innovations (see, for example, Martiskainen, 2017; Ornetzeder & Rohracher, 2013; Seyfang et al., 2013, 2014; G. Seyfang & Longhurst, 2015).

2.3. Community solar energy from a socio-technical perspective

The socio-technical perspective enriches our understanding of community energy by shedding light on the multi-level perspective of energy transition. The literature conceptualises energy transition as a multi-level process that involves the co-evolution of technological innovations, as well as social, cultural, and institutional changes that take place at the landscape, regime, and niche levels (Geels, 2002; Geels et al., 2018). The literature argues that the interplay of niche and regime actors in the energy landscape may influence the trajectories and the extent to which niche innovations (such as the deployment of renewable energy) can be scaled up and destabilise energy regimes (Geels, 2002).

Empirical studies (see, for example, Hodson & Marvin, 2010; Mah et al., 2013) suggest that communities can function as important niche actors that may facilitate niche accumulation processes, but that regime actors, such as incumbent utilities, may act as a fundamental block to regime shifts. Work by Wolfram (2016, 2018), for example, has conceptualised transformative capacity at the city level. However, such complex dynamics in stakeholder interactions at the community level remain under-conceptualised in urban transition studies.

2.4. The knowledge gaps

Whereas a socio-technical transition perspective can contribute to a better understanding of community energy, the community energy literature has generally lacked a systemic perspective from which to analyse community energy. In the broader field of energy technological transitions, work by OECD (2017), for example, argues that in response to the complex nature of the transition process, a systemic perspective is needed in order to build links between key components. However, such a systemic perspective has been underdeveloped in the community energy literature, and attempts to fill that gap have been made by studies that framed energy systems as social-ecological systems. On the basis of insights developed by Ostrom and her collaborators, scholars have framed energy systems as social-ecological systems. Bauwens et al. (2016) and Acosta et al. (2018) have developed variants of socio-ecological systems (SES) frameworks for integrated community energy systems. Although these SES frameworks shed important light on “action situations”, in which multiple actors interact under the influence of contextual variables (Bauwens et al., 2016), they are less effective in examining some of the most important processes in socio-technical transitions – such as incumbent/newcomer relationships (Mah et al., 2017) and the complex dynamics that span governance levels (see, for example, Späth & Rohracher, 2012).

Another theme of the community energy literature draws an important distinction between external contextual conditions (such as governmental support and guiding visions), and internal contextual conditions (such as community spirit and sense of responsibility) as being critical factors for the success of community energy initiatives (Kim, 2017; Sperling, 2017). These frameworks provide a better understanding of the structural context of community energy transition, but they are rather static and are not effective in explaining the dynamics of the processes of energy transition.

The importance of systemic perspectives to local energy initiatives has also been increasingly recognised by scholars in socio-technical transitions studies. Wolfram (2018), for example, developed a framework of transformative capacity focusing on the process of social learning, while Hasanov & Zuidema (2018)'s framework focuses on the process of self-organisation. These frameworks have contributed to a better understanding of the transformative capacity of city-level initiatives, with a focus on particular processes, but they lack a holistic view of the key processes involved.

In addition to the absence of a systemic perspective, a second knowledge gap is a lack of comparative studies of urban sustainability transitions in the Asian context. Noticeable differences exist between cities in developed countries and those in developing countries (Berkhout et al., 2009; Rock et al., 2009). This study will not only investigate concepts developed in the West and determine their relevance in the Asian context, but it also will provide Asian-specific insights to help refine the Western literature.

2.5. Towards an integrated framework of community energy in urban energy transitions

This study is based on insights from the community energy literature and from the multi-level perspective literature, and it develops an integrated framework for understanding community energy from a systemic perspective. This integrated framework is novel in that it conceptualises the interconnected elements among the processes, contexts, and outcomes of community-level energy initiatives (Figure 1).

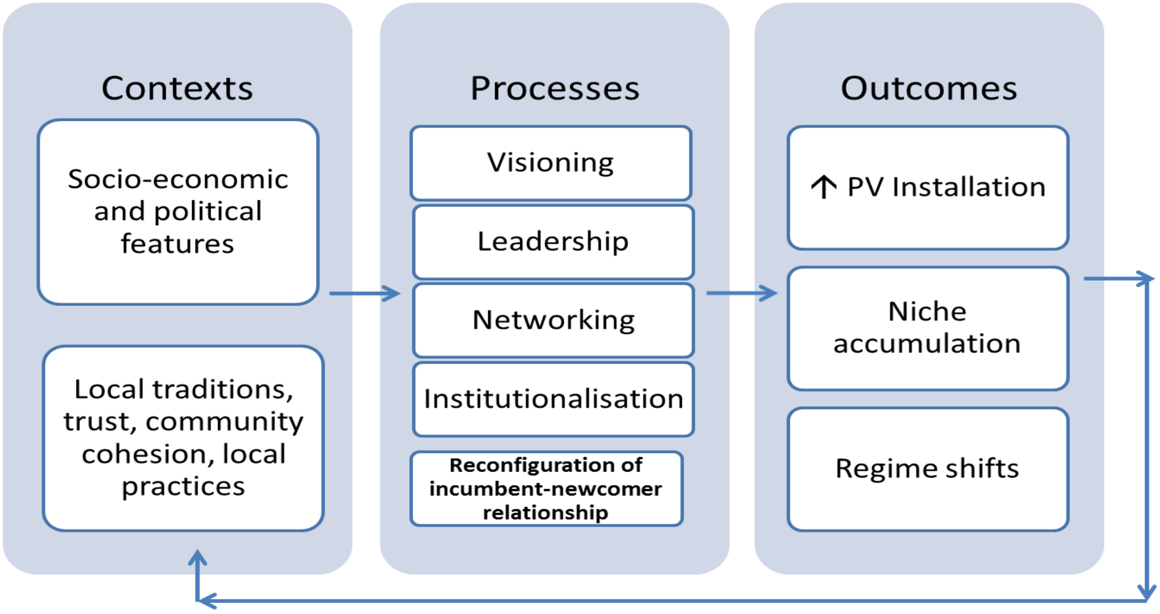

Figure 1. Understanding community energy from a systemic perspective: An integrated framework.

Our integrated framework has three dimensions. Central to that framework is the first dimension: the five processes that are critical to community-level energy initiatives. Those processes include visioning, leadership, networking, institutionalisation, and reconfiguration of incumbent-newcomer relationships. The second dimension of our integrated framework relates to contexts. Key contextual factors that underpin such processes include socio-economic and political features, as well as local traditions, trust, community cohesion, and local practices. The third dimension relates to outcomes and refers to the actual increase in solar PV installations, niche accumulations, and regime shifts.

On the basis of our integrated framework, the propositions behind this study are: (1) community stakeholders interact in the five critical processes as solar PV systems diffuse, in this case in Luonan and Sungdaegol; (2) these five processes foster solar PV diffusion, but solar diffusion may meet with barriers to niche accumulation; and (3) contextual factors create opportunities as well as constraints to the processes. Thus, this framework guided us in a systemic cross-case comparison of the contexts, processes, and outcomes of the interplay of stakeholders in our case cities.

In this paper, we are primarily interested in the five critical processes that influence the pathway and pace of community energy developments. **Visioning, the first critical process,** relates to the establishment of the guiding vision for the concerned communities and aligns short-term actions with a long-term vision (Hodson & Marvin, 2010). Central to visioning is the existence of a shared understanding amongst a wide range of social interests that produce territorial priorities (Hodson & Marvin, 2010). Visioning is critical to energy transitions because it offers an understanding of the possible changes envisioned in the context of territorial priorities. Visioning is regarded as a critical participatory process through which stakeholders can be engaged, inspired, and mobilised (Hodson & Marvin, 2010). Visioning is also a critical process for gaining policy legitimacy, enhancing public acceptance, and strengthening stakeholders' commitments to participate and sustain their efforts (Hodson & Marvin, 2010).

The second process relates to leadership. In essence, leadership is the ability to "articulate a vision, inspire people to act, and focus on concrete problems and results" (Ryan, 2001): 230). The literature specifies different approaches to leadership that have various foci, ranging from administrative leadership (Martiskainen, 2017), to collaborative leadership (Ryan, 2001), to enabling leadership (Martiskainen, 2017). A growing body of the leadership literature, such as the work of Martiskainen (2017), sheds light on the significance of community leadership in niche building through embedding into social networks, vision sharing, and decision-making. Community leadership is also different from the classical notion of leadership, in that it focuses more on the geographical dimension of leadership and of grassroots initiatives (Martiskainen, 2017).

The third critical process relates to networking. Networking is another key element that the energy transition literature highlights. In their work on sustainability studies, Clarke and Roome (1999) understood a network to be a set of "relationships" that link stakeholders together by the flow of knowledge, information, and ideas that are embedded in the social context comprising the complex of organisational and social relationships and management structures and processes. Whereas the concept of a network is deeply rooted in actor-network theory (see, for example, Warf (2015)), energy transition studies emphasise that networking among actors is a key to enhancing the capacity to sustain the long-term interactions of sharing information, understanding problems, appreciating different perspectives, and developing practices to reinforce and sustain local experiments from regime disturbance (Mah & Hills, 2012; Meadowcroft, 2009; Seyfang & Haxeltine, 2012). Community energy intermediaries are also found to have the capacity to connect with actors outside the community, through brokering and partnerships (Hargreaves et al., 2013).

The fourth critical process relates to institutionalisation. A theme of the literature focuses on the impacts of institutionalisation of the energy transition processes. Defining an institution as any form of functional body, ranging from formal regions, rules, agreements, political bodies, regimes, and organisations, to informal practices, norms, and habits, Aalto (2014) pointed out that these institutions have the capacity to function in energy markets by resisting and enabling energy transition processes. Polzin (2017) defined an institution as the pattern of behaviours, social rules, and norms associated with the existing regime. He argued that policy-makers have to align with different energy transition stakeholders in order to gain momentum and earn the public's acceptance of energy technological innovations.

The fifth process relates to reconfiguration of incumbent–newcomer relationships. Such reconfigurations are brought about by, for example, the regulatory changes that are introduced into electricity markets to accommodate niche innovations in energy transitions. This process leads to market restructuring in which (1) vertically integrated systems are liberalised with the entrance of new market players, and (2) market competition is promoted among incumbent and formerly monopolised utilities, and newcomers (niche energy suppliers) (Markard & Truffer, 2006). In liberalising markets, intermediaries such as incubator and accelerator centres, and green champions, tend to play a much more significant role in creating favourable conditions for upscaling niche experiments and subsequently for reconfiguring the relationships among existing energy regimes and niche actors (Gliedt, Hoicka, & Jackson, 2018). Incumbents, on the other hand, are found to be key enablers to energy transitions, but they can also act as blocks (Mah et al., 2017). Investor-owned incumbent utilities can provide more financing options to community distributed solar initiatives, but they are found to be reluctant to partner with communities (Hess, 2013).

Each of these five critical processes is associated with a set of indicators (Table 2). Admittedly, taken together, this set of five processes is not the only combination possible. Based on the literature, however, these processes are commonly identified as being key critical processes that can affect the success of energy transitions or define their constraints.

Table 2. The five critical socio-technical transition processes and their associated indicators

Socio-technical transition processes	Indicators
Visioning	(i) An existence of shared understanding amongst a wide range of social interests that produce territorial priorities (ii) Alignment of short-term actions with a long-term vision (iii) Alignment of interests across actors
Leadership	(i) The ability of leaders to articulate a vision, inspire people to act, and focus on concrete problems and results
Networking	(i) Access and mobilisation of human, financial, information and knowledge resources inside and outside the geographical community (ii) Establishment of linkage of stakeholders by the flow of resources to comprehend problems and develop solutions
Institutionalisation	(i) Access to organisational structure which enables local energy initiatives to have direct influence on energy policy-making through a policy platform (ii) Engagement of local energy initiatives to formal regulations, rules and agreements, political bodies, regimes or organisations which form structure in constraining and enabling actions
Reconfiguration of incumbent-newcomer relationships	(i) Market restructuring with entrance of new market players (ii) Promoting market competition among market players

3. Methodology

3.1. Research questions

This study aims to address the following research questions: (1) How do stakeholders in community-level solar initiatives interact in their solar diffusion trajectories? (2) How do the observed interactions create conditions that are conducive for key transition processes at the community level? (3) What are the similarities and differences in the key processes of socio-technical transitions in our two case communities, and what *contextual* factors can explain these similarities and differences?

By answering those questions, this paper aims to provide a better understanding of the diversity of and mechanisms for urban energy transitions that are undertaken through community engagement in solar development. We develop a conceptual framework for systemically examining, evaluating, and explaining the diversity, processes, mechanisms, achievements, and limitations relating to how urban solar energy development can be facilitated through community engagement. We test and apply our framework in two cities in Asia: Foshan in China and Seoul in South Korea.

3.2. Data collection and analysis

This study drew on data and information obtained from three sources: semi-structured interviews, desktop research, and field observations. A main source of data came from semi-structured interviews with 19 interviewees, conducted between January 2015 and September 2018, and involving three field trips in Foshan, Guangzhou (the capital city of Guangdong Province and one in Seoul. The interviewees were carefully selected informants who were knowledgeable about the subject issues being studied (Johnson, 1990). They were drawn from a range of stakeholder groups, including community representatives, solar households, utilities, solar installers, management companies, universities, and research institutes. These selected informants were identified through desk-top research, followed by a snowball sampling process. Government officials in Foshan and Seoul were invited to be interviewed, but no interviews could be arranged. A community leader of Luonan, the then Chairman Runyao Guan of the Villagers' Committee, was invited to be interviewed. But he was not available on the date of the fieldwork. Guan retired in October 2017 and was not accessible to this research since then. This study thus relied on data derived from an interview with a village leader of a neighbouring village who is knowledgeable about the solar developments in Luonan, and on a desktop study to examine the roles of Guan in the case community. A list of interviewees is provided in Appendix 1. All but one of the interviews were face-to-face. The remaining interview was by telephone, because a face-to-face interview could not be arranged. One interview, conducted in January 2015, served as exploratory work for the current study.

Whereas face-to-face interviews have the advantage of generating fruitful information for revealing the complexity of critical interactions, the "limitations of interpretivism" in which a "person-specific, artistic, private/interpretive act that no one else can viably verify or replicate" are well noted in this sort of qualitative approach (Miles & Huberman, 1994). Interviewer bias, for example, may undermine the validity of findings (Watson et al., 2007). Thus, we employed various measures to address those limitations. First, all the interviews were recorded and transcribed. Second, secondary information, such as government documents, academic publications, and news articles, were used to triangulate the interview information and provide supplementary references. In relation to data analysis, our integrated model provided a framework for cross-case comparison, providing an analytical focus on the five critical processes and their associated contexts and outcomes.

3.3. Case contexts

Both China and South Korea are characterised by their major developments in renewable energy in recent decades. China's remarkable efforts in boosting the renewable industry originated with the enactment of the Renewable Energy Law in 2005, and since then supplementary renewable energy policies at national and sub-national levels, including subsidies and feed-in tariffs, have been implemented. In 2012, renewable energy constituted 9% of total energy consumption, and the Chinese government aims to increase the percentage to 15% by 2020 (EIA, 2015). South Korea introduced a national feed-in tariff to scale up renewable energy in 2001 but abolished the policy in 2011 to ease the resulting financial burden. Instead, renewable portfolio standards were introduced in 2012 (Korea Energy Agency, 2015b). In 2015, South Korea had an installed capacity of approximately 362 megawatts (MW) and required power generation companies to generate 10% of electricity from renewables by 2023 (International Trade Administration, 2017).

China and South Korea have been undergoing electricity market reforms since the late 1980s and late 1990s, respectively. Those reforms have led to a marked commonality of their own sectors – the existence of state-owned monopolies (the State Grid Corporation of China (SGCC) and the China Southern Power Grid (CSG) in China, and the Korea Electric Power Corporation (KEPCO) in South Korea).

The two case cities, Foshan and Seoul, possess favourable conditions for urban solar energy. Foshan is a prefecture-level city in Guangdong province, where many green industries including hi-tech and renewable industries are based (Yi & Liu, 2015). The locational proximity to the renewable production chains has fostered the diffusion of solar PV systems into the city (Interviewee 7). Foshan had an installed PV capacity of approximately 270 MW in 2016 (Interviewee 10). Seoul, on the other hand, has been leading the anti-nuclear movement of South Korea since the 2012 Fukushima nuclear accident. With an installed PV capacity of approximately 135 MW in 2017 (Lee, 2017), solar energy has been adopted and promoted by the Seoul Metropolitan Government in an effort to gradually phase out new development of nuclear power plants.

This study focuses on two solar communities, Luonan in Foshan and Sungdaegol in Seoul. Luonan and Sungdaegol share similarities in their potential for solar energy use (see Table 3), but they exhibit unique environmental settings. Luonan is located in Nanzhuang Town, the periphery of the city centre district of Chencheng. It retains an urban village residential area with a mix of industrial and commercial land. Indigenous villagers reside mostly in low-rise village houses of similar heights, and that configuration contributes to a favourable physical setting for solar PV installations. Sungdaegol is an old suburban neighbourhood in the southern part of Seoul. Comprising some 56,000 residents in 2017, the community has mainly low-rise buildings with closely packed houses, apartments, street shops, and narrow alleys. Unlike Luonan, Sungdaegol has both house owners and apartment tenants, such that small solar PV panels that can be installed on balconies have also been promoted as a viable option (Interviewees 16, 17, 18). A summary of the demographic and solar power conditions of the two case study locations is provided in Table 3.

Table 3: An overview of Luonan, Foshan & Sungdaegol, Seoul

Indicators	Luonan Village, Nanzhuang Town, Foshan	Sungdaegol, Seoul
Area	Foshan: 3,797.72 km^2 (2016) Nanzhuang Town: 76.03 km^2 (2016)	Seoul: 605.2 km^2 (2016) Sungdaegol: 1.35 km^2 (2016)
Population	Foshan: 7,462,700 (2016) Nanzhuang Town: 160,145 (by permanent residents, 2016)	Seoul: 10,158,411 (2017) Sungdaegol: 56,663 (2017)
Per capita regional GDP	USD 18,340.91 (Foshan, 2016) (at 1 RMB: 0.16 USD)	USD 34,069.55 (Seoul, 2016) (at 1 KRW: 0.00094 USD)
Solar energy potential	Solar PV can generate 1,000 to 1,500 hours of electricity (Foshan)	93 clear days in 2016 (Seoul) Duration of sunshine hours (Seoul): 2,497.8
Solar PV Installed capacity (in MW)	Foshan: 270 MW (with a production of about 190,000 MWh), including 825 non-residential projects and 763 residential projects (Foshan, 2016)	Seoul: 135 MW (50.4 MW at public buildings; 18.0 MW at schools; 33.8 MW at private buildings; 32.7 MW of micro PV) (Seoul, 2017)

Sources: Interviewee 10; Dongjak-gu Office (2017); Foshan City Bureau of Statistics (2018); Korea Energy Economics Institute (2017); Lee (2017); Nanhai People's Government of Foshan (2017); Organization of Rural Socio-Economic Survey in National Bureau of Statistics of China (2017a, 2017b); Seoul Metropolitan Government (2017); Statistics Bureau of Guangdong Province (2017)

4. Socio-technical transitions in Luonan and Sungdaegol

4.1. Visioning for community solar energy

Luonan and Sungdaegol's solar initiatives are characterised by an alignment of interests among the local community and the upper-level governments. Luonan has a top-down alignment of renewable energy policies, from the national level down to the local levels. At the national level, the Renewable Energy Law enacted in 2005 marked the beginning of renewable energy development in China. Envisioning a major uptake of solar energy, the national government has also set a solar PV installation target of 100 GW by 2020 (General Office of the State Council, 2014), and a national solar feed-in tariff (National Development and Reform Commission, 2017). At the village level, the then chairman of the Luonan

Villagers' Committee, Runyao Guan, was a community leader who played a key role in driving solar developments in Luonan. Before his retirement in October 2017, he spearheaded a number of solar initiatives in Luonan (Interviewees 3 and 11). He adjusted the village redevelopment strategy to envision Luonan as the "first solar PV village in China", with plans to sustain village economic growth through green developments (Interviewees 5 and 11; Liu & Su, 2016). The vertical top-down alignment of the local energy policy framework provided favourable conditions for solar development at the Luonan community level.

In contrast to Luonan, Sungdaegol exhibits a bottom-up convergence of interests in advocating solar energy for community benefits and energy-self-reliant grassroots movements. Sungdaegol's community cohesion was first nurtured by a campaign associated with a local children library to promote a reading culture between 2009 and 2011. That successful experience aroused community members' concerns about the well-being of the next generation and reinforced community actions in a later energy-saving campaign to reduce nuclear dependence in Seoul (Interviewee 19; Byun, 2013; Lu, 2017). A subsequent series of energy incidents in 2011, including the Fukushima nuclear accident in March, Korea's nationwide power outage in September, and the discovery of radioactive asphalt in a residential area in Nowon District, Seoul, in November, triggered public concerns over energy security and nuclear risks (Interviewees 12 and 16; Kim, 2011; Yim, 2011). In search of a means to reduce reliance on nuclear energy, Sungdaegol residents self-initiated an energy-saving campaign and extended the grassroots movements to the installation of solar PV cells on rooftops. Even though the national feed-in tariff was destined to be abolished by the end of 2011 (Interviewee 16, Korea Energy Agency, 2015a), the vision for Sungdaegol to become energy self-reliant aligned with incumbent Mayor Park Won-soon's development of the One Less Nuclear Power Plant (OLNPP) policy in 2012 (Interviewee 16; Climate Reality, 2016; Lee et al., 2014).

4.2 The role of leadership in community solar diffusion

The city governments of Foshan and Seoul, as well as community leaders in Luonan and Sungdaegol demonstrated their leadership by articulating their visions and by mobilising resources to realise those visions. Foshan and Seoul governments showed their leadership by proactively rolling out additional feed-in tariffs and subsidies to reinforce national renewable strategies. For instance, the Guangdong Government announced the Guangdong Solar PV Power Generational Development Plan in 2014, setting a solar target of 4 GW by 2020 (Guangdong DRC, 2014). The Foshan City Government offered a municipal-level feed-in tariff of RMB 0.15/kilowatt-hour (kWh) for three years (in addition to the national feed-in tariff of RMB 0.37/kWh) and a subsidy of RMB 1/watt for the first-time installation of solar PV cells to households (Interviewee 10; General Office of Foshan's People Government, 2016). An installation subsidy of RMB 200,000/MW for solar investment was also provided by the Chancheng District Government, to correspond to the policies at the higher levels (Chancheng Development Planning and Bureau of Statistics, 2017). These multiple sources of subsidies from various administrative levels have driven a rapid market expansion of residential solar PV systems in Foshan since 2016 (Interviewee 10).

At the local level, the then Chairman Guan of Luonan village was recognised for his leadership in enabling the villagers to cultivate entrepreneurship and social values among themselves. As a production team leader from the 1970s to the 1980s, Guan inspired the village to invest in crafting industries at an early stage of China's economic reforms (Interviewees 3 and 11; Zeng & Wang, 2009). Villagers' efforts were inspired by Guan's leadership over decades and have transformed Luonan into a village with several large-scale private enterprises. Guan also invested in civic education to cultivate entrepreneurship among the villagers (Fu, 2006). By identifying new investment opportunities through their sensitivity to solar PV systems' high financial payback, and by Guan's popularity among villagers, Luonan's leadership has enabled villagers to adopt solar PV systems (Sun & Shen, 2016; Interviewees 3 and 11). The Luonan Villagers' Committee also showed its leadership by using the Committee Building as a demonstration site for installation of solar PV cells, so that villagers can visualise the benefits of solar energy (Interviewees: 2 and 3; site observation). Luonan's adoption of solar PV systems thus depended on the crucial role of the government and a particular village leader in promoting the value of renewable energy.

[Figure2: Solar energy information display in the Luonan Villagers' Committee Building]

Leaders at the Sungdaegol community level and city level together were able to inspire community members to participate in energy self-reliant campaigns. Sungdaegol's community leadership was promoted by the efforts of community representative Soyoung Kim, who inspired the values of self-reliance among residents. Kim was proactively involved in using the Children's Library as an educational venue to instill the values of saving energy and that grassroot movement later extended to renewable energy campaigns (Sun, 2016; Interviewee 19). In Sungdaegol, an Energy Supermarket (which sold energy-saving and solar PV products and provided energy consulting) and an energy café (which engaged in teaching energy-saving values to children) (Figures 3 and 4) were established and were used as places for demonstrations to encourage community residents to participate in energy-saving campaigns and to install household solar systems (Interviewee 19; Byun, 2013; Yeung, 2016). Those activities influenced community behaviour by serving as role models for energy self-reliance, and they inspired and motivated social learning in adapting to new socio-technical practices (Kim, 2017).

[Figures 3 and 4: Energy Supermarket and energy café]

At the city level, Seoul's Mayor Park showed collaborative leadership through proactively meeting with energy communities and incorporating grassroots values into energy policy-making (Interviewees 16, 19; Climate Reality, 2016; Park, 2018). Partly inspired by Sungdaegol's energy movement, Park introduced the OLNPP policy and the Energy Self-Reliant Village program in 2012, in a response against the national wave of nuclear developments (Interviewees 16, 19; Kim, 2017; Sun, 2016). Park introduced a feed-in tariff in Seoul in 2013, even though the national government had already abolished the national feed-in tariff in 2011 (Interviewee 16; Korea Energy Agency, 2015a). He also launched the Solarcity Plan to provide KRW 1.7 trillion for one-third of households in Seoul to install solar panels by 2022 (Chung, 2017). Under the mayor's advocacy, the energy self-reliant civil movement was able to spread to some 80 communities in Seoul and other parts of South Korea (Lu, 2017). The Sungdaegol case shows that an initiative in self-reliance, led by a community leader and reinforced by leadership at a higher level, was able to scale up local energy transition initiatives and spread the momentum to other parts of Seoul.

4.3 Networking with other stakeholders

Luonan and Sungdaegol exhibited different approaches for networking with stakeholders and exchanging resources, knowledge, and ideas. Whereas Sanshui Industrial Park served as a networking platform for industrial actors and solar PV systems (Interviewees 7 and 11; National Energy Administration, 2014), the Luonan Villagers' Committee Building served as a local marketplace for information sharing and networking. Market information was made accessible through promotional banners placed in the Villagers' Committee Building (site observation; Interviewees 2 and 3) (Figure 5).

On the other hand, the district and town governments played a key role in facilitating matches of business interests between villages and external stakeholders. Borrowing insights from the business models developed in Sanshui Industrial Park, Chancheng District launched the "Chinese household solar PV demonstration village" program in 2016 to introduce a one-stop approval service for promoting distributed solar PV systems (Han, 2016). With assistance from the Nanzhuang Town Government, the Luonan Villagers' Committee entered into a strategic cooperation agreement with Foshan Yingke Zhiwang New Energy Technology Company (a solar service provider), the Bank of China, and the People's Insurance Company of China (PICC), in which the solar company would provide a one-stop service to villagers (Han, 2016; Li & Luo, 2017; Interviewees 2 and 3). That networking, supported by the district and town governments, not only enhanced the availability of solar PV systems to villagers, it also enabled the emergence of new business models and offered first-hand market information to the solar company that was investing in the village (Interviewee 5).

[Figure 5: A promotional banner of a solar company, placed in the Villagers' Committee Building]

In Sungdaegol, the Energy Supermarket served as the core element for the community's networking with external actors. The Supermarket, together with the Children's Library and the energy café, were the meeting places for Sungdaegol's energy movements (Interviewee 19). Sungdaegol's reputation as an eco-community enabled networking with external resources. Through networking with a university, a public institute, and a solar panel company, the "Living Lab for Micro Solar Power in Urban Community" program was established. The Living Lab strengthened the network between the Sungdaegol energy movement and the various stakeholders beyond the community and enabled the solar community to gain access to a wider range of human, financial, social and even research resources (Interviewee 19; Lee, 2017). Workshops were held, inviting volunteers to discuss the difficulties associated with solar panel installation in Sungdaegol, and they subsequently facilitated the organisation of three focus groups. Each group focused on one of these areas: technical, financial, and educational and promotional issues. These locally grown networks subsequently provided resources for the development of "DIY mini solar panels", "flat cables", and solar loans (Interviewee 19; Energy & Climate Policy Institute et al., 2017).

Regionally, the Seoul energy transition experiences coincided with those in other regions in South Korea. A regional network was formed under The Joint Declaration of "Regional Energy Conversion", uniting Seoul, Gyeonggi Province, South Chungcheong Province, and Jeju Province to promote the distribution of renewable energy and to foster green industries (Seoul Metropolitan Government, 2015). Networking by different regional institutions further facilitated the exchange and mobilisation of resources in the region's socio-technical transitions, such as technical inputs into addressing problems associated with solar PV installation and the introduction of new financial models (Seoul Metropolitan Government, 2015).

4.4 Institutionalisation of community leadership

Community leaders in Foshan and Seoul were granted different degrees of access to energy policy-making institutions. The Luonan village leadership was institutionalised through the appointment of the then Chairman Guan into the institutional framework of the People's Congress (PC) and the People's Political Consultative Conference (PPCC) (Interviewees 2 and 11). Guan had served in multiple government positions at different levels, such as in the

National PC (2003 – 2008), the 13th and 14th Foshan PC, and currently in the Chenzheng District PPCC. In one instance, Guan experienced the joint petition by the Guangdong Provincial PC to replace the Deputy Director-general of the Department of Environmental Protection of Guangdong Province in 2000 (Cheng & Cui, 2004). Institutionalisation of the Village Chairman within higher levels of government thus safeguarded the continuity of policies for solar PV development, and the Village Chairman then could closely monitor changes in government policies through communications with government officials within this institutional framework (Interviewee 2).

The institutionalisation of Sungdaegol's leadership, on the other hand, was facilitated through the government appointments of community representative Kim to two important committees: The OLNPP Implementation Committee and the Citizens' Committee of the Seoul Energy Corporation. These two committees were established to engage the local energy movement leaders in formulating and implementing the capital's energy policies. In recognition of the Sungdaegol energy movement, Kim was appointed to these two committees and was empowered to suggest policy recommendation for transferring good practice of Sungdaegol to other cities in Seoul.

4.5 Reconfiguration of relationships between incumbents and newcomers

As monopolies in the transmission, distribution, and retail markets in the power sector, the CSG and KEPCO continued to play respective dominant roles in the solar diffusion processes in Foshan and Seoul. In both cities, new market players have since emerged, and interactions have occurred between newcomers and incumbents. The forces of change have been weak, however, and have not contributed to regime change.

In Foshan, the state-owned CSG has remained as a key state-affiliated market actor for solar development in the city. The CSG was responsible for connecting the grid of distributed energy sources, including residential solar PV systems. It also provided service advice for prospective solar installers in its customer centres (Interviewee 6 and site observation). On the other hand, new market players also have emerged (Interviewees 2 and 3). A solar service provider, Foshan Yingke Zhiwang New Energy Technology Company, was formed under a public-private partnership between a state-owned enterprise in Foshan, the Foshan Chancheng City Infrastructure Development and Construction Co., Ltd. and a private renewable company, Hunan Corun New Energy Co., Ltd.. The partnership company constituted the major one-stop solar service provider and solar installer in Luonan, alongside some other small solar installers that emerged in the market (Interviewee 3; Han, 2016; Sun & Shen, 2016).

During solarisation in South Korea, KEPCO's position as the national monopoly provider of electricity has not changed, even while new market actors have emerged in Sungdaegol (Interviewees 12-15). Three social enterprises, including Maeul dot Salim (Village. Living), which operated the Energy Supermarket, were established to conduct solar businesses in Sungdaegol. Their services ranged from providing solar installation consultative services to selling energy-saving products (Interviewee 19; Yun, 2017). At the city level, the Seoul Energy Corporation was established by the Seoul Metropolitan Government to take charge of the capital's solar projects. Major projects undertaken by the corporation included the Seoul Solar Centres, which provided support for solar PV installations and maintenance services, and the Seoul Grand Park's solar power generation project (10,000 kW) (Seoul Metropolitan Government, 2018). Banks offering loans for solar installations (e.g., Dongjak Credit Union) and solar installers (e.g. Microps Inc.) have also emerged (Interviewee 19).

5. Discussion from a comparative perspective

Luonan and Sungdaegol each exhibited similarities and also differences in their solar diffusion trajectories, and those similarities and differences can be understood within our framework of socio-technical transition processes. This comparative study arrived at several key findings.

First, the conceptualisation of the five key processes of socio-technical transitions through community engagement could be applied to the contexts of solar diffusion in both of these Asian case communities. As is shown in Table 4 and Figures 6 and 7, Luonan and Sundaegol had in common that the five critical processes were critical in diffusing solar power in their communities. Those key processes were: a visioning process aligned the interests at different levels in order to incorporate solar energy into sustainability transitions goals; leadership cultivated by community development over the years played a critical role in motivating community stakeholders to collaborate and make an impact; networking occurred that enhanced the capacity of resource mobilisation both within and beyond the communities; institutionalisation of the community leadership took place as community leaders were granted access to energy policy-making systems; and, when these two case communities experienced socio-technical transitions, a favourable environment was provided within which new business models could emerge that might gradually reconfigure the relationships with incumbent utilities.

It is also evident that these processes were highly interactive with each other. Visioning and community leadership, for example, were very interactive in our case communities. Community leaders, the then Chairman Guan in Luonan and Soyoung Kim in Sungdaegol, on the other hand, needed networks and institutions in order to deliver their visions and influence policy-making. These observations reinforce the Western literature on socio-technical transitions, which suggests that interactions between community and external stakeholders are critical in creating the key processes that can be conducive to niche innovations and regime shifts.

Table 4: Socio-technical transition processes of solar communities in Luonan and Sungdaegol

Socio-technical transition processes	**Illustrative examples**
Visioning	L: Top-down alignment of interest as to develop Luonan into the "first solar PV village in China" to echo the national vision in renewable development and sustain future economic growth in the village S: Bottom-up visioning of energy self-reliance emerged at grassroots level that inspired the Mayor and then spread to other parts of Seoul
Leadership	L: Foshan governments proactively introduced subsidies and feed-in tariff policies to echo national visions; village chairman cultivated entrepreneurship values among villages and utilises Villagers' Committee Building as demonstration sites for solar energy S: Community leader spread values of self-reliance among residents; Mayor of Seoul's and community leadership enhanced each other and strengthened niche developments
Networking	L: Municipal district governments and the industries have developed networks along the supply and value chains. The Sanshui industrial cluster provided a guiding model for solar diffusion and governments spearheaded facilitation of the collaboration between state-owned banks and insurance companies with private renewable enterprises and Luonan S: Reputation of Sungdaegol movement enabled the collaboration between academia, public institute, solar panel company and the community and participation of volunteers
Institutionalisation	L: Village Chairman was appointed into People's Congresses and People's Political Consultative Conferences at different levels to participate in energy policy-making S: Community leader was appointed to the Implementation committee of OLNPPP and Citizen's Committee of Seoul Energy Corporation to monitor energy policy implementation and solar projects in Seoul
Reconfiguration of incumbent-newcomer relationships	L: Emerging forces of change but minimal impacts. New energy suppliers (solar installers) and new business models emerged through partnership between the private renewable enterprise and Luonan to provide one-stop solar services to villagers S: Emerging forces of change but minimal impacts. New public enterprise of Seoul Energy Corporation established by the capital government to oversee policy implementation, solar projects and solar service provisions

L denotes Luonan; S denotes Sungdaegol

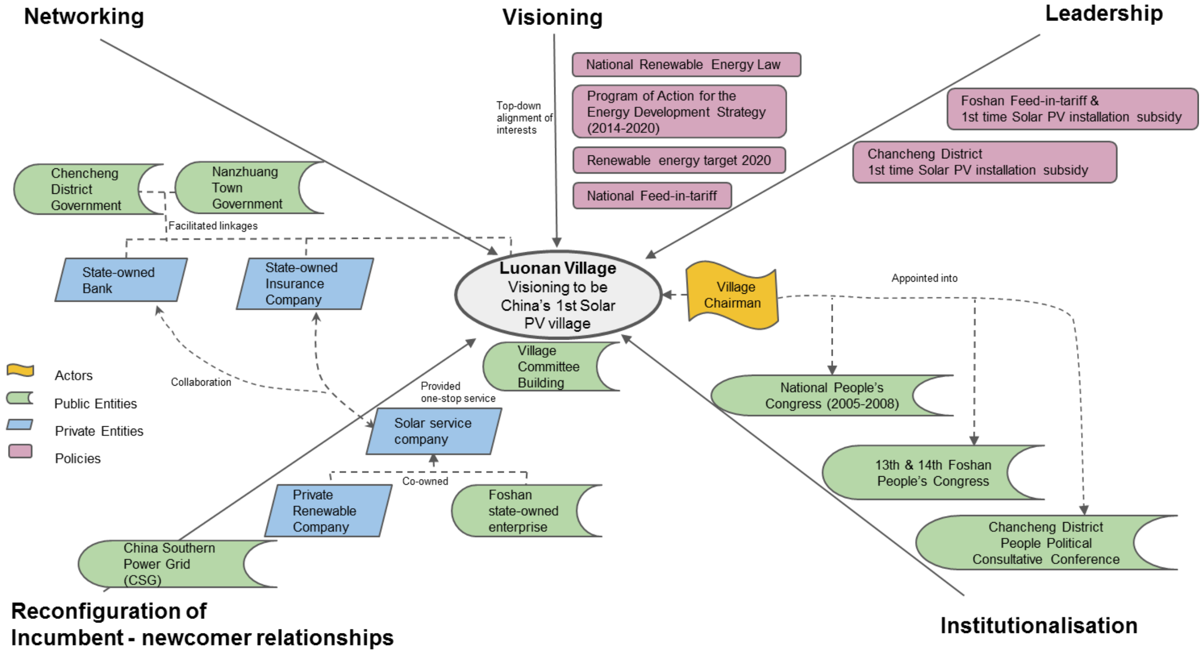

Figure 6. Key actors and their interplay in the socio-technical transition processes of solar communities in *Luonan*.

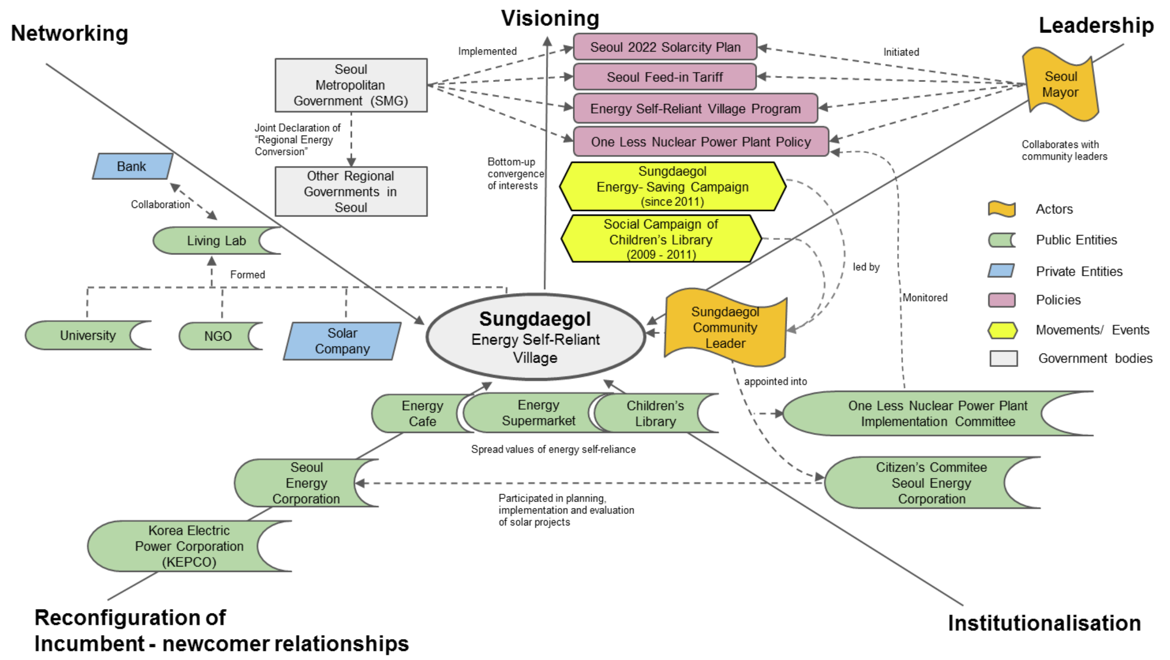

Figure 7. Key actors and their interplay in the socio-technical transition processes of solar communities in *Sungdaegol*.

Our second finding relates to the distinctive modes of community solar initiatives and the differing interactional processes in Luonan and Sungdaegol. Foshan can be characterised as a top-down, state-led, and entrepreneur-driven mode. As a prefecture-level city, it is not a surprising finding itself that Foshan's solar initiatives were strongly influenced by the national and provincial renewable energy policies. It is, however, an interesting observation that the state plays an important role through the Luonan Villagers' Committee. The then Chairman Guan of Luonan Villagers' Committee was a member of the Communist Party, the ruling party of the country. Although villagers' committees are relatively autonomous entities in the Chinese context (Zhu & Guo, 2015), the close connection between the head of Luonan Villagers' Committee and the Communist Party suggests that there was state influence on energy policy priorities in this village. This state-led approach in Luonan was complicated by the co-existence of a considerable number of private solar installers and their entrepreneurial activities, which were underpinned by a locally grown entrepreneurship that originated in the 1970s.

In contrast, Seoul developed a bottom-up approach in its community solar initiatives. Seoul, as the capital city, retained a level of autonomy that was comparable to that in other provinces in South Korea (KOCIS, 2018). That administrative autonomy enabled Seoul to initiate and formulate its own energy strategy, such as the OLNPP (Interviewee 16). Also, because of that autonomy, the Seoul Metropolitan Government introduced its own city-level REFIT in 2013, after the national government had abolished REFIT in 2011.

The third finding relates to the complexity of the interactional *outcomes* of the key processes. With regard to the impacts of community solar initiatives on regime shifts, it is evident that there was little structural change in the energy markets and that the forces of regime shift were weak in both cases (Interviewees 12-15). Despite the recent successful breakthroughs at the niche levels and the fact that new renewable market players have emerged, solar PV installations have remained a minor energy source in both Foshan and Seoul (Interviewees 5, 14, 19). A major upscaling in renewable energy will have to be in place to shift the incumbent regimes (Interviewees 12 and 13).

The institutionalisation process in the case of Sungdaegol also gives rise to a question: If a niche actor were to become institutionalised, what would the impacts be on energy transitions? The community leader in Sungdaegol, Soyoung Kim, was appointed by the mayor to the OLNPP Implementation Committee. That appointment could have been an opportunity for Kim to facilitate replicating Sungdaegol's model in other Korean cities and scaling up the niches. However, the forces of change that Kim brought may be subsumed once she has become a member of the institutions. The extent to which such institutionalisation processes would facilitate solar diffusion in communities thus requires further studies.

Despite the limited impacts that occurred towards regime shifts, this study found that critical reinforcing effects existed in the community-level transitional processes. The reinforcing effect between leadership and some local contextual factors is a good illustrative example. In the case of Foshan, local leadership from the Villagers' Committee combined with the pre-existing entrepreneurships to drive the diffusion of solar houses and the associated industrial developments. In the case of Seoul, leadership by the city mayor combined with a pre-existing community cohesion and a shared sense of responsibility in Sungdaegol to transform this suburban community into an energy self-reliant village (Kim, 2017). Work by Wolfram (2018), for example, sheds light on the interactions between local leadership and empowered communities. However, such interactions and their effects on transformative capacity have remained underconceptualised. This study thus contributes to a further understanding of such complex interactions among transitional processes, by shedding light on the reinforcing effects between local leadership and commuity contexts.

6. Conclusions

This paper contributes to socio-technical transition and energy governance literature by specifying processes for community energy initiatives from a systemic perspective. Two case studies, of Foshan, China and Seoul, South Korea, illustrate the applicability of the study's framework to conceptualising community-level energy initiatives from a systemic perspective. We argue communities can be an important source of niche innovations, and it identifies the five processes that are critical to fostering community-driven energy transition pathways.

This paper contributes several new insights to the literature. By comparing the two cases, our empirical analysis demonstrates the variety of interactional relationships among stakeholders associated with solar communities. While the solar communities in both Foshan and Seoul engaged in the five critical processes, the modes of community engagement differed. This study made a distinction between a top-down, state-led and entrepreneur-driven approach and a bottom-up grassroots-driven approach to community initiatives in energy transitions. The state-led approach in Luonan and the bottom-up approach in Sungdaegol, indicate that differing stakeholder interactions and forces of changes can contribute to the scaling up processes of niche innovations in different ways. This study thus sheds light on the multiplicity nature of deep transition pathways (Balta-Ozkan et al., 2014).

Furthermore, our study offers valuable insights into energy transitions, beyond the current focus on Western countries. This study demonstrated that the normative mechanisms of community engagement can travel across to the Asian context. Although it is beyond the scope of this study to specify a set of Asian-specific contextual factors that influenced community solar developments, the dominating role of monopolised utilities in partially liberalised electricity markets is clearly at least one of the key factors in limiting energy regime shifts in these two Asian cities. This study therefore also makes an important contribution to the transitions studies by providing a better understanding of Asian sustainability transitions as alternative transition pathways (see, for example, Berkhout et al., 2009).

This study has several policy implications. Whereas the study's findings and the information in Table 1 confirm that communities can serve as key sites of arenas for transition (Hammer, 2008; Hodson & Marvin, 2010), the analytical focus on the processes of community engagement sheds light on two important questions: (1) What are the roles of governments in engaging society in the context of energy transitions? and (2) How can governments release the potential governing capacity that is embedded in communities? This study suggests that national and local governments need to pay sufficient attention to the enhancement effects that may be realised across multiple levels in energy transitions. Special attention must be given, first, to policy coherence across national and sub-national levels, in order to maximise the effects of multi-level solar policies, and second, to leadership across national, city, and community levels in order to build up and sustain the forces of change. In addition, although electricity market reforms are often a long-term, ongoing process, governments need to pay attention to the limitations of partial electricity reforms and the negative consequences of constraining the growth of new market entrants and niche innovations in energy regimes.

Foshan and Seoul are atypical cities in some important aspects. However, the framework that we have tested in these two case cities can be applied elsewhere, and the findings can be generalised beyond Foshan and Seoul. The framework of community engagement in socio-technical transitions could be applied to examine other community initiatives in both the Asian and Western literature under similar contextual situations, such as the selected case communities in Table 1. Specifically, communities that (1) are located within a major Asian economy, (2) experience partial electricity market reforms, and (3) face urban challenges in deep carbon reduction, would share similar contexts with our case communities and could be examined by using our framework. As is shown in our two case communities, having similar contexts could give rise to diversity in transition trajectories. Such diversity is attributable to a variety of factors, which include, but are not limited to, the governance modes, the degree of administrative power, the level of electricity market reform, and the trust towards incumbent institutions and utilities, to name a few. It would therefore be interesting to apply the framework to, for example, Tokyo, Taipei, and Bangkok.

This study also had limitations. First, it lacked informants among government officials who were not accessible at the time. Although data from published materials and interviews with informants from other stakeholder groups have been used to triangulate data, future research would benefit from access to primary data from the government sector. Second, it should be noted that our framework is not an evaluative framework. The empirical data utilised in explaining the transition processes were for illustrative purposes and did not provide a comprehensive account of all the major events that have taken place around the communities, nor was the evidence presented in a strictly longitudinal manner. Whereas the evidence presented is useful in generating a critical understanding of socio-technical transition processes, sufficient caution should be paid when the empirical data are interpreted from an evaluative perspective.

Further research could be conducted in at least two directions. First, additional Asian case communities should be investigated with the current framework, in an effort to examine the applicability and transferability of the framework's concepts of socio-technical transitions in the Asian context. It is also hypothesised that a community's level of economic development might influence its socio-technical transition trajectories, and thus further investigation should be conducted to generalise the concepts into a broader context. Second, how niche innovations in community settings could be scaled up to exert a larger impact in society is currently under-researched. To what extent the relationships between communities and existing regimes can influence socio-technical transition processes requires further study.

Appendix 1. List of Interviewees

All the interviewees agreed to be interviewed anonymously. This study indicates interviews by number. All interviews were conducted in a face-to-face format, except one which was a telephone interview. Some of the interview information was used to inform authors about the case communities and has not been referenced in the main text.

	Interviewees background	Date of interview	Duration of interview (approximately)
1.	An officer of the Guangzhou Institute of Energy Conversion	7 January, 2015	1hr 30 mins
2.	Representative of solar installer A in Foshan	24 March, 2017	1hr 30 mins (for the 2017 Interview); 30 mins (for the 2018 interview)
3.	Representative of solar installer B in Foshan	24 March, 2017	1hr 30 mins
4.	Solar household in Foshan	24 March, 2017	30 mins
5.	Representative A of Foshan Power Supply Bureau, Guangdong Power Grid Group	24 March, 2017	1hr 30 mins
6.	Representative B of Foshan Power Supply Bureau, Guangdong Power Grid Group	24 March, 2017	1hr 30 mins
7.	Representative C of Foshan Power Supply Bureau, Guangdong Power Grid Group	24 March, 2017	1hr 30 mins
8.	Representative D of Foshan Power Supply Bureau, Guangdong Power Grid Group	24 March, 2017	1hr 30 mins
9.	Representative E of Foshan Power Supply Bureau, Guangdong Power Grid Group	24 March, 2017	1hr 30 mins
10.	Representative F of Foshan Power Supply Bureau, Guangdong Power Grid Group	24 March, 2017	1hr 30 mins
11.	A Chairman of a villagers' committee in Dali Town, Foshan	20th September, 2018	30 mins
12.	A research fellow of Oxford Institute for Energy Studies	22 November, 2017	1 hr
13.	An associate research fellow of Korea Energy Economics Institute	22 November, 2017	1 hr 30 mins
14.	A senior researcher of Economy & Management Research Institute, Korea Electric Power Corporation	23 November, 2017	1 hr
15.	A senior manager of Economy & Management Research Institute, Korea Electric Power Corporation	23 November, 2017	1 hr

16.	An assistant professor of the Department of Urban Administration, University of Seoul	23 November, 2017	2 hrs
17.	A chairman of resident representatives of a residential property in Dongjak-gu, Seoul	24 November, 2017	30 mins
18.	An administration manager of a residential property in Dongjak-gu, Seoul	24 November, 2017	30 mins
19.	A Sungdaegol community representative in Dongjak-gu, Seoul	25 November, 2017	2 hrs

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