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Socio-technical and political economy perspectives in the Chinese energy transition

Akihisa Mori

Graduate School of Global Environmental Studies, Kyoto University, 606-8501 Kyoto, Japan

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A B S T R A C T

Electricity systems are so strongly path dependent and deeply embedded in society that vertically integrated monopolistic or oligopolistic supply are justified. However, over-incentivize for capacity investment, excess dependency on fossil fuel, inefficient supply, and lack of customized services, accountability and participation raise dissatisfaction with the prevailing system, urging system transition. Given high potential of renewable energy in breaking the lock-in and generating positive feedback effects, this paper aims to explore how niche innovators and incumbents capitalize on their resources and power to create, augment or weaken prevailing political path-dependencies and lock-in of the prevailing electricity supply system to prospect a future energy transition, taking China as a case. Main findings are: (a) renewable energy has generated feedback effects in China; (b) regime actors have capitalized on their resources and power to organize alliances to be consistent with the government policy orientation while blocking institutional reforms for energy transition; and (c) their resources and power are derived from the monopolistic or oligopolistic electricity supply system and the government price control, both of which are justified for the sake of energy security and economic stabilization.

1. Introduction

Electricity systems are featured by sunk investments, high entry barriers, long operating lifetimes and complementary capital investments [1]. They are also strongly path dependent and deeply embedded in society in terms of norms, values, laws, modes of governance, social relations and culture [2]. These features have justified vertically integrated monopolistic or oligopolistic supply system of electricity. They enable incumbent suppliers to capitalize on the excess rents to gain comparably large power and resources to pursue regulatory capture [3], to compensate opposition stakeholder groups [1], and to tame the media to propagate legitimacy of the prevailing regime widely to the population [4]. Longer reign of ruling party-incumbent supplier alliance ensures stable supply of excess rents, further reinforcing the prevailing socio-technical regime [3]. This makes the regime be prone to technological and institutional lock-in, and become so economically, institutionally and politically entrenched that is difficult to reconfigure [5].

The system also generates a number of problems that dissatisfy the society. These include: full cost pricing that over-incentivize capacity investment and fossil fuel and nuclear fuel consumption; inefficient supply and high electricity price that may harm industrial competitiveness and/or income distribution; lack of customized services; and lack of accountability and participation [6].

Given strong path dependency, deep embeddedness in society, and self-reinforcing incumbents, attempts to reconfigure the prevailing electricity system open up frictions and develop into struggles of power [7], thus are likely to take several decades [8]. Creating, maintaining and funding a long-term policy framework are indispensable to sustain momentum toward reconfiguration [9]. Nonetheless, what energy system is materialized in the future depends largely on institutional or social aspects rather than a purely technical one [10]. This is why imagining and negotiating energy futures are required [11].

Renewable energy can potentially break the lock-in and reconfigure the prevailing electricity regime [1]. First, it can increase competition and diversity into the monopolistic or oligopolistic market. It will eventually alter the prevailing market dynamics within the electricity sector as its generation cost approaches grid parity. Secondly, such competition and diversity squeeze excess rent to the incumbent suppliers, making them incapable of compensating opposition stakeholder groups and of propagating the population. Thirdly, it can foster emerging local industry poised to benefit from increased renewable energy

E-mail address: mori.akihisa.2a@kyoto-u.ac.jp.

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growth. Finally, decentralized or distributed energy technologies offer greater flexibility and can therefore more readily organize and enable distributed political and economic power, and vice versa [12].

Renewable energy in China is likely to satisfy these conditions except the last one. First, China's deployment of renewable energy outpaced the government target, which showed upward revisions.[1] The rapid deployment convinces the Energy Research Institute (ERI) of the National Reform and Development Committee (NDRC) to make a scenario analysis of a 50% renewable energy penetration in 2050 [13]. Second, it has created exporting industries in renewable energy on a greater scale [14]. Third, the government has sufficient budget to play a leading role in supporting the development of renewable energy technologies throughout from prototype to commercial viability stages [9], and in limiting the price hike to consumers. Finally, it can learn from the experiences from developed countries and acknowledge both the political opportunities and potential traps that arise from policy design [8]. In reality, non-fossil fuel has increased its proportion in total primary energy consumption from 8.6% in 2010 to 12% in 2015 and 13.3% in 2016 [15].

However, transition of energy system causes hard-fought inter- and intra-scalar contestations between old and new institutions, agents and technologies [16]. Incumbents can capitalize on power and resources to block off development of sufficient network capacity, system-balancing facilities and strong demand management that are required to stabilize a hybrid system of fossil fuel-based and renewable electricity [17]. It is by far easy to go beyond the hybrid system toward more sustainable pathway that is featured by either load balancing or region-wide supergrid, as either pathway requires changes in the basic architecture of the prevailing system, guiding principles, beliefs and practices [2,18], including baseload power and reliability [19]. This poses inherent limitations on rapid change [20].

Against this backdrop, this paper aims to explore how niche innovators and incumbents capitalize on their resources and power to create, augment or weaken prevailing political path-dependencies and lock-in of the prevailing electricity supply system to prospect a future energy transition, taking China as a case. It introduces political economic perspective in the socio-technical transition to use as analytical framework, and makes extensive review of published research papers and relevant news reports to provide evidence.

The remainder is organized in four sections. Section 2 makes a literature review to provide justification on the use of both perspectives as analytical framework. Section 3 presents results of the analysis, followed by discussion to draw out implications for transformation of electricity supply system in section 4. Section 5 offers conclusions and implications for future electricity regime in China.

2. Political economic perspective of socio-technical transition

A number of ex ante quantitative analysis of China's energy and climate change policies has been made to draw out energy implications for the long-term GHG emissions reduction targets. Earlier researches pointed out China's possibility of peaking carbon emissions around 2035 [21] or in 2050 [22] with 6–7% annual economic growth rate. However, they just listed up technological measures [23] that are required to attain the targets without regard to how and to what extent they should be operationalized. Recent scenario analysis shows the amount of coal consumption reduction that is required to attain the carbon emissions reduction target, air quality target, and water resources targets in 2020 [24]. However, their policy implications are divergent: some insist stronger efficiency improvement and structural adjustment [25], others recommend development and efficient system operations of transmission infrastructure, power trading in the market, flexible generation capacity, energy storage technology, and demand-response mechanisms [13,26].

A group of ex-post empirical analysis has been made to explore the effectiveness of energy and climate change policies. Most of them employ decomposition analysis to confirm the significant contribution of industrial structural change and efficiency improvement to the reduction in energy and carbon emission intensities [27–29]. Contrary to the estimate that anticipates larger carbon emission reduction with smaller welfare loss in carbon tax with/without revenue recycling than in energy tax [30], energy intensity target, not the carbon intensity target proves to be binding to both energy and carbon emissions intensity reduction in the 12th Five Year Plan (FYP) period [31]. While identifying the power sector's active reduction as the main factor, they do not explore how power sector addressed to the underlying mechanisms that create the technological and institutional lock-in.

The other group explores enabling factors of the emergence of wind power and solar photovoltaic (PV) manufacturing, with special focus on the role of technological transfer [32,33], government industrial fostering policies [34–36], renewable energy deployment policies [14], and technological capacity and market conditions [37]. Some go further to analyze underlying causes of renewable curtailment as a side effect of increasing renewable energy [38], proposing reform options [39]. However, they do not fully analyze political, economic, social and institutional barriers that make it difficult to move out of lock-in.

The socio-technical transition perspective provides a suitable theoretical idiom to explore change processes [18], and practical toolbox of techniques to encourage collaboration among niche innovators [40]. It views supply system of electricity as a socio-technical regime consisting of the rules and routines embedded in infrastructure, markets, technology, politics, knowledge and meanings [41]. It defines a transition as a long-term fundamental change (irreversible, nonlinear, multi-leveled and systemic) in the culture (mental maps, perceptions), structures (formal institutions and infrastructure systems) and practices (use of resources) of a societal system [42]. The multi-level perspective adds three levels of socio-technical system—the niche, the regime and the landscape—, and defines the change in the socio-technical regime as the outcome of multi-dimensional interactions between radical niche innovations, an incumbent regime and an external landscape [43]. It emphasizes a pathway whereby radical innovation emerges in niches and breaks through and overthrows the existing regime in a specific way: (a) niche innovations build up internal momentum through learning processes, price/performance improvements and support from powerful groups, (b) changes at the landscape level create pressure on the regime, revisiting the orientation of innovation and the way technologies are deployed, and (c) destabilization of the regime opens windows of opportunity for niche innovations, as well as struggles among rival commercial groups over regulation and property rights [17,43].

This framework, however, focuses too much on innovation and technologies, which results in a limited conceptualization of power and politics [44], market competitiveness [8] and governance between different scales and generations [45]. Politics and power play important roles in how pathways are shaped, which pathways win out and why, and who benefits from them [46] through changes to laws, rules and expenditures. Such changes can only be engineered through political processes, and legitimized and enforced through institutions [44]. This is why political economy perspectives should be introduced into the multi-level perspective of the socio-technical transition [47].

Net positive feedback effects that renewable energy policies are likely to generate give another reason to employ political economy perspectives in the analysis of energy transition. Feedback effects can be classified as technology and policy ones. Technology feedback effects refer to the modification of political costs and options [48], and the changes in norms, policies, regulations and prevailing institutions

[1] Chinese government announced the renewable energy target of 10% by 2010 and 15% by 2020 in total primary energy consumption in 2007 [108]. It proposed the binding targets for non-fossil fuel of 11.4% by 2015 and 15% by 2020 in the 12th Five Year Plan (FYP) in 2011. It set out the target of 20% by 2030 in its Intended Nationally Determined Commitment (INDC) to the Paris Agreement, and more than half by 2050 in 2017.

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