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Rural utility to low-carbon industry: Small hydropower and the industrialization of renewable energy in China

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ABSTRACT

Small hydropower (SHP) is a renewable energy that provides electricity for many rural areas in the Global South that lack national grid access. In China, however, SHP has transformed from a community-focused rural utility into to a privatized low-carbon industry that earns revenues from the sale of electricity to the grid. This paper analyzes the policies that enabled this transformation of SHP in China, and the profit motivations and political incentives that shape plant construction and operation. I argue that privatizing and framing SHP as 'low-carbon' makes it more amenable to industrialization, because its value is based on the amount of electricity it generates, not its contribution to poverty alleviation and conservation. Data were collected from interviews with government officials, private investors, and farmers in Xinping county, located in Yunnan province in China's southwest. I find that investors and officials are incentivized to build and operate large-scale SHP systems that have a high installed capacity, are situated in multiple-plant cascades, and that attempt to operate year-round, including during the dry season. Some of these plants reduce streamflow and irrigation water access for farmers. This case thus exposes the inequalities of privatizing and deploying rural renewable energy for low-carbon industrial growth in the absence of strong local environmental and social safeguards.

1. Introduction

In the last decade, China has built renewable energy installations at a rate matched nowhere else in the world. Between 2006 and 2016, the country added 258 GW (GW) of renewable energy capacity, and now boasts 15% of all systems installed worldwide.[1] Chinese firms lead the world in renewable energy manufacturing and construction, bolstered by government subsidies and preferential policies. Large swathes of rural China have been transformed by new utility-scale solar photovoltaic (PV) and wind farms, and the government has announced a further US$360 billion investment in renewable energy by 2020 (Forsythe, 2017). Renewable energy has thus become China's most prominent 'low-carbon industry', a set of commercially-oriented firms that pursue profit through activities that are deemed to reduce greenhouse gas (GHG) emissions.

Yet while the expansion of large-scale installations is new, small-scale renewable energy has been used in rural China for decades. Indeed, when the term 'renewable energy' first entered official Chinese discourse in the 1990s, it referred to small-scale technologies deployed in remote areas for off-grid rural electrification (Zhang et al., 2009). Early government documents described these technologies as 'clean' because they were seen as replacements for 'dirty' biomass and fuelwood use in poor rural households. Government programs in the 1990s and early 2000s promoted the use of small-scale wind, solar PV, biogas, and hydropower installations in areas with poor or nonexistent grid connectivity, and many gained financing through the Clean Development Mechanism (CDM). I refer to these systems in this paper as 'rural renewable energy' because they are primarily off-grid (or feed into local grids) and serve a local, rural consumer base (Zhu, 2005, pp. 158–159). Rural renewable energy has traditionally been managed as a rural utility by local governments or communities tasked with generating electricity for local rural development.

The most widespread of these rural renewable energy systems in China is small hydropower (SHP). SHP refers to facilities ranging from tiny 'micro-hydro' turbines of a hundred kilowatts (kW) installed capacity, to large systems of tens of megawatts (MW) installed capacity (Paish, 2002).[2] Globally, SHP is generally considered a renewable energy source that can provide local electricity and reduce emissions

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[1] China had approx. 300 GW of installed renewable energy capacity (not incl. large hydro) as of Dec. 2016; global installed capacity was approx. 2000 GW as of Dec. 2016 (China Electricity Council, 2017; REN21, 2006, p. 5).

[2] Plants larger than 10 MW are defined as medium-size hydropower in many countries, including Nepal, Indonesia, the Philippines, and Pakistan. China's definition of SHP (≤50 MW) is twice that of India's definition (≤25 MW).

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without the major ecological consequences of large dams (Hicks, 2004; Li et al., 2005). SHP generates more stable electricity and has a cheaper per kilowatt-hour (kWh) construction and operating cost than solar PV or wind (HRC, 2009). For decades, local governments in China built and managed SHP plants as rural utilities to provide electricity for village lighting and industry. Beginning in the late 1990s, SHP was deployed in remote forested regions to replace peasant fuelwood and biomass use with electricity, with the aim to reduce deforestation (Zhou et al., 2009). For these reasons, SHP in China is viewed as an immense success in driving poverty alleviation and forest conservation.

In the 2000s, however, SHP came to be seen in a different light: as a technology that could help China meet national electricity production and GHG emissions reduction goals. This followed two major changes in the electricity sector in the early 2000s: the extension of grid electricity access to over 99% of households, and the partial privatization of electricity generation following the dissolution of the State Power Corporation of China (SPCC) (Luo and Guo, 2013, p. 324). Local governments were empowered to approve privately-operated SHP plants of up to 50 MW installed capacity, and grid companies were required to purchase SHP electricity (Wang et al., 2015). The result is that China's SHP installed capacity more than doubled between 2002 and 2015, driven by a vast SHP industry made up of local governments, private investors, operating companies, turbine manufacturers, design consultancies, and engineering, procurement, and construction management firms. The primary role of SHP has thus shifted from providing electricity for rural development, to generating renewable energy that can be sold to the grid and dispatched to industrial consumers for profit. In other words, SHP has transformed from a rural utility to a low-carbon industry.

This paper analyzes how the transformation of SHP into a low-carbon industry shapes the construction and operation of plants on the ground. My main argument is that privatizing and framing SHP as low-carbon makes it more amenable to industrialization, because the industry can earn profit and claim 'green' credentials simply by generating more electricity, whether or not it contributes to GHG mitigation. By 'industrialization', I mean the construction and management of large-scale SHP systems – cascaded systems with multiple plants of a high installed capacity that tend to operate throughout the year, including during the dry season. As this paper will show, SHP investors favor large-scale SHP because they generate more profit, require the same approvals as smaller plants, and can obtain financing through the CDM. Local officials approve large-scale SHP because they drive renewable energy production, taxation revenue increases, and local industrial development – all of which are targets for cadre promotion. The result of these incentives has been a boom in large-scale SHP construction in the 2000s that has reduced stream flow and farmer irrigation water access across much of southwest China. This case thus exposes the inequalities of privatizing and deploying rural renewable energy for low-carbon industrial growth in the absence of strong local environmental and social safeguards.

The remainder of this paper is structured as follows. In Section 2, I review the modernist (and eco-modernist) literature on rural renewable energy in the Global South, and trace its ongoing concern with poverty alleviation and conservation to a more recent interest in carbon offsets and private finance. I then draw on a political ecology framework to critique this literature and highlight the lack of research on the industrialization of rural renewable energy. In Section 3, I discuss how SHP plants work, provide a brief history of China's national SHP policy, and describe the main players in the SHP industry and the industrialization of SHP. Section 4 describes my research methodology and case study of Xinping county in Yunnan province. In Section 5, I detail the profit motivations and political incentives that influence private investors and local officials in Xinping to construct large-scale SHP plants and operate them throughout the year. I conclude with implications for studies of rural renewable energy and rural development in the context of low-carbon transformation, and make suggestions for improving SHP management.

2. Rural utility or low-carbon industry?

2.1. Energy access and rural development

Rural renewable energy has long been the subject of mainstream scholarship on rural development, which takes the modernist view that energy access and affordability are central to development outcomes (such as improvements to income, education, and health) (Ashworth and Neuendorffer, 1982; Gamser, 1980; Haines et al., 2007; Winkler et al., 2011). This literature focuses on rural communities in the Global South that do not have national grid access, and are hence 'energy poor'. Often implicit to this scholarship is the concept of the 'energy ladder', or a hierarchy of fuel sources corresponding with socioeconomic status in which 'traditional' biomass is at the bottom, and modern electricity is at the top (van der Kroon et al., 2013). Studies building on this concept highlight that burning traditional biomass causes exposure to indoor air pollution (Mishra, 2003), is inefficient and time-consuming to collect (G. Liu et al., 2008), and can exacerbate deforestation and land degradation (Heltberg et al., 2000). Moreover, this research suggests that without modern electricity, household income stagnates because residents cannot access modern services or devote time to employment and education due to the opportunity cost involved (Cabraal et al., 2005).

For scholarship in this vein, rural renewable energy offers a potential way out of the downward spiral of energy poverty without the high costs associated with grid extension or reliance on diesel generators. Case studies show that solar, wind, and SHP systems can provide electricity for lighting and agricultural processing for a relatively low cost (Byrne et al., 2007; Urmee et al., 2009). To improve electricity stability, separate systems can be integrated through low-voltage mini grids to supply power for more than one village (REN21, 2017, pp. 101–102). Scholars recognize that rural renewable energy access is not a 'silver bullet' solution to poverty – it must also be affordable and situated within a broader rural development framework – but that it does provide means to replace traditional fuels, improve productivity, and enable rural people to access modern services. For these reasons, and despite reservations about cost and intermittency, rural renewable energy systems have gained mainstream recognition as a poverty alleviation and forest protection tool (Haines et al., 2007; Ottinger and Williams, 2002).

Rural renewable energy is problematic, however, because systems are still relatively expensive and require regular upkeep. At the national scale, rural renewable energy is mainly reliant on government funding, such as equipment and power generation subsidies, tax exemptions or reductions, and financial support for household electricity connections (Mainali and Silveira, 2011). Households generally purchase solar, wind, or SHP systems through local dealers, or pay a fee-for-service to an operating company that collects payments and provides long-term maintenance (REN21, 2017, p. 107). In some cases, poor households can form rural cooperatives to buy a small-scale system, and then use it to generate electricity for sale to wealthier villagers and pay off the initial loan (Biswas et al., 2001). Yet scholars have found that relying on state and village-level finance is inadequate to the task of rural electrification in remote and poverty-stricken communities (Huang, 2009; Mainali and Silveira, 2011). Such findings raise questions about how small-scale renewable energy can be financed whilst remaining a rural utility that provides local social and environmental benefits. Determining models of small-scale renewable energy that are low-cost, equitable, and affordable for poor consumers has thus become a chief normative policy goal for scholars writing about this issue (Kaygusuz, 2012; Palit, 2013).