

Financing the Last Mile of Electricity-for-All Programs: Experiences from China

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ABSTRACT

Financing electricity for all programs has been a main barrier to achieve universal energy access. In this paper, we investigate the financing mechanisms of China's electricity for all programs with a focus on the last mile problem, and we find that central investment, cost sharing, and public-private partnerships are essential for China's success in such programs. We also discuss the challenges to disseminate those financial mechanisms to enable successful electricity for all programs.

Keywords: Electricity for all, financing, China

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1. INTRODUCTION

Electrification is key to deliver modern energy services and other fundamental services that dependent on energy. China has achieved electricity for all by the end of 2015, and the universal access to electricity has empowered the information penetration and IT revolution to rural area, and facilitated other social economic development goals, for examples, education, public health, women rights, and civic engagement (NEA 2015; He and Victor 2017). This is an impressive achievement, given China's large population and the world still has more than 1 billion population without electricity access. Finance is one of the main barriers to deliver energy to the world poorest. While there are numerous programs to facilitate and promote electrification in developing world, there are significant finance gaps to achieve UN's Sustainable Energy for All by 2030. The current finance mechanisms for global electricity for all programs are largely driven by multilateral institutions (36%), donors and investors in developed countries (38%) and other developing countries (27%) (SEforALL 2015). About 6 billion USD a year in commitments went to increase residential electricity access for medium or high levels of electricity service, which falls well below the estimated 45 billion USD needed annually to meet the 2030 objective of universal electrification (SEforALL 2015). However, the international finance made up just over half of all commitments tracked, or an average of 11.7 billion USD per year (SEforALL 2015). There are still significant financial gaps to fill to enable global electricity for all.

China's progress in electrification has drawn academic attentions on its history and success factors. Peng and Pan (2006) conducted a historical review on the institution, investment and achievement over the three main development stages of China's rural electrification (Peng and Pan 2006). Luo and Guo (2013) reviewed the relevant policies that enabled China's ru-

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ral electrification. Other scholars discussed China's case to provide electricity access and the comparison with other developing countries (Bhattacharyya and Ohiare 2012; Pereira et al. 2011). China's efforts to accomplish full electrification in 2015 raised the interest on the last-mile problem in electrification programs. However, there is little discussion on the last push to achieve electricity for all in China. He and Victor (2017) analyzed the experiences and lessons from this last-mile problem, and showed coordination between central and local governments and other stakeholders, selection of appropriate technologies to fit local situation and demand, and embedding electrification into overall social economic development, are key to the success (He and Victor 2017). This paper is a follow up analysis of the financial mechanisms of the last mile programs and their implications for global efforts.

2. HOW CHINA FINANCED ITS ELECTRICITY FOR ALL PROGRAMS

2.1 Earlier stages paved the roads to the last-mile

China's rural electrification had experienced four main stages (Table 1) that are embedded in China's larger social economic reform. Due to an urban-rural dual economic structure which sucks rural resources to put urban development a priority, the national electrification programs had focused on urban programs. There were pilots and policies to encourage small hydro and local power stations, however, rural electrification has been largely ignored to run at its own course until 1998 (Peng and Pan 2006; Luo and Guo 2013; Zhang 2007).

1998 is marked as a milestone year for rural electrification in China, since then rural electrification become a priority in national development agenda. The State Council then launched the initiative to "Promote Reforms of Rural Power Supply Network and Management System to Achieve Unified Pricing for Urban and Rural Power Supplies", which broke the urban-rural dual systems of power investment and the rural electrification speeded up. Rural electrification was achieved by two main efforts focusing on both generation and transmission: installation of generation capacity at rural and local area; rural grid upgrade and renovation.

From 1998 to 2015, there were six rounds of rural grid innovation initiatives that targeted to upgrade the grid quality, extend the grid service, and bridge the urban-rural power gap

TABLE 1
The four stages for China to achieve electricity for all.

Period	Before 1978	1978-1997	1998-2012	2013-2015
Stage	Setting up a national management system	Transferring electricity system management to local government	Promoting market-oriented reform	Achieving electricity for all
Finance for rural electrification programs	Little support from the central government. Building small power plants, mostly hydro, during the 1960s and 1970s.	Central government poverty reduction efforts. Local government investment to encourage economic development.	Unifying rural and urban electricity pricing, specified central government fund for grid innovation and extension.	Specified central government fund, central-local governments cost sharing, PPP, and other financial mechanisms.
End of stage electrification rate	65%	95%	99.7%	100%

Note: The first three stages are adapted from *Rural Electrification in China: History and Institution* (Peng and Pan 2006).

(the prices difference, and per capita electricity consumption difference). The total investment added up to 2024 billion RMB (nominal value in its historical year, same thereafter) in the twelfth five-year plan period only (2011-2015), including a final push to achieve electricity for all in 2015. In 2012, the central government initiated its *Electricity for all three-year action plan (2013-2015)* that outlined a plan to assure electricity supply to the last 2.73 million people (NEA, 2015).

Through those programs, in 2015, China announced the achievement of electricity for all. The gap between rural and urban electricity service has significantly improved. By the end of 2015, the electricity supply reliability reached 99.9%, and the voltage compliance rate was up to 98.8% in rural area. In 2016, the National Development and Reform Commission (NDRC) initiated a new round of rural grid renovation investing more than 700 billion RMB which focuses on upgrading and improving the grid service to rural area.

2.2 The last mile is different and difficult

The term “last mile” was first used in telecommunication networks, referring to the final end of the networks which is usually the bottleneck to deliver services to end users. The term was also commonly used in retail, transport, and delivery services. In this paper, we borrow the term to describe the final utility infrastructure needed to deliver electricity to the whole population. We consider the “last-mile” to be high cost of both through grid extensions and remote mini-grids or distributed power systems.

The last mile is the most difficult part of electrification. By 2012 before the final push, China had 256 towns, 3817 villages, 936000 households, with a total of 3.87 million population without access of electricity. Most are featured as the “Lao (Old revolutionary base), Shao (Minority), Bian (Border), Qiong (Poor)” area, including some old revolutionary base area, minority area, remote and border area, and the poorest area in provinces of Xizang, Qinghai, Xinjiang, Gansu, Inner Mongolia, and partial of Sichuan, Yunnan, see Table 2.

Those areas are mostly located in high elevation mountains, and suffer from adverse natural condition, natural hazards (landslide, snow, frost, debris flow), and usually have no roads for transport. As such, the average cost to provide electricity access had increased over time as the programs move to the last-mile. Grid connection is prohibitive expensive in some of most

TABLE 2
The last mile of Electricity for all in China.

Province	Population without electricity	Projects	Total investment (Billion RMB)	Population served by grid extension	Population served by distributed systems	Average investment per capita (RMB)
Xinjiang	870,000	207	4.43	669,000	201,000	5,092
Sichuan	681,000	102	7.97	589,000	92,000	11,703
Xizang	520,000	122	9.48	201,000	302,000	18,231
Qinghai	469,000	94	5.12	197,000	272,000	10,917
Gansu	88,000	26	0.31	—	88,000	3,523
Inner Mongolia	45,000	17	0.56	—	45,000	12,444
Xinjiang Production and Construction Corps (XPCC)	56,000	15	0.41	—	56,000	73,21
Total	2729,000	583	28.28	1,656,000	1,056,000	10,363

Source: Summarized and calculated from the *Electricity for All Three-year Action Plan* (NEA 2012) and multiple sources.

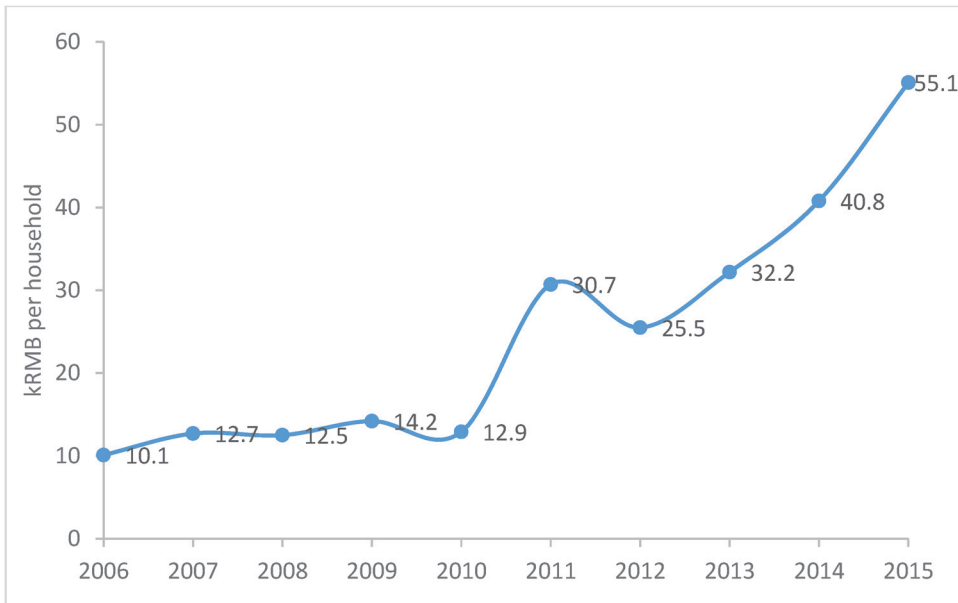


FIGURE 1

Average cost for household electricity access in State Grid service area.

Note: The average costs are calculated based on investments and households served by those new investments.

Source: State Grid.

isolated areas. The average investment cost per capita had grown from 25.5 thousand RMB per household in 2012 to 55.1 thousand RMB per household in 2015, see Figure 1.

2.3 Financial mechanisms that completed the last mile

The financial mechanisms to fund the last mile therefore must come from bold plans that could mobilize resources to stimulate multiple key stakeholders to join the push for full electrification.

Cross subsidization

Cross subsidization is a strategy of charging higher prices to one group of consumers to subsidize lower prices for another group, and in this case charging higher tariff to people already consuming electricity to provide service to those who have no electricity access or to improve the quality of service. Cross subsidization is widely used in providing service which involves large infrastructure that should be shared among wider users. Electric power grid, telecommunication, post service are typical examples of cross subsidization. There are four types of cross subsidies in China: industrial consumers subsidize urban residential consumer, high voltage subsidizes lower voltage, high load users subsidize low load users, and low-cost region subsidize high cost region. China's cross-subsidization is not unique, however, is more complicated as cross-subsidies are deeply embedded in the tariff setting and highly penetrated in the energy sector.

In China's electrification process, cross subsidization provides the fundamental financial resources for grid renovation, and PV installation and maintenance. The trillions renovation costs since 1998, and the investments of new rounds of rural electric grid renovation are col-

lected through a national electricity tariff surcharge at 2 cents per kilo-watthour (kWh) to repay the loans and interests (MoF 2001). The solar PV systems are subsidized through the “Golden Sun” Project, which could provide 70% of the investment cost for PV systems installed in the remote area. The maintenance costs of the distributed systems are covered by the “Renewable Energy Surcharge” collected in the tariff.

Central and local government cost sharing

Local governments usually have less incentive and resources to fulfill electricity access while the central government has a political mandate to provide electricity for all. Before 1978, the central government controlled the fiscal resources of the provinces and the appointment of major provincial officials. Between 1978 and 1994, China adopted a fiscal responsibility system whereby local authorities took full responsibility for their revenues and expenditures. The central government controlled the appointment of major officials in the provinces, but no longer controlled each province’s fiscal revenue. In 1994, the introduction of the Tax Sharing System (TSS) reform enabled the central government controls most of the nation’s fiscal resources and, financially, the provinces rely heavily on transfer payments. In the electrification case, those provinces rely on central government transfer to provide the investment needed for electrification projects that are economically unattractive.

Full electricity access requires central government leadership, and essentially funding support, in China, about 20% to 80% of the total cost depending on the local conditions (He and Victor 2017). The central local government share level is based on the local condition and funding capacity. The central government paid a larger share (80 percent) of the investment in Xizang (Tibet) where economic status is the poorest among those focus areas and development cost is particularly high. As comparison, the central government share in Xinjiang, Qinghai, and Gansu were at 50 percent level, and that in Inner Mongolia was 20 percent. This is consistent with Table 2 estimation of the per capita cost, with the exception of Inner Mongolia, which has a small part of the population without electricity. The investment from local governments were through the involvement of provincial-owned power companies. In total, the governments allocated 20.68 (among which 11.7 from central government, 57%) billion RMB total investment for grid extension and 4.1 (among which 2.85 from central government, 70%) billion RMB small off-grid solar photovoltaic (PV) systems during 2013-2015.

Public private partnership (PPP)

Public-private partnership (PPP) is an instrument to involve the participation of the private sector to deliver public good in order to increase the source of funding, and promote the project efficiency. The public and private players can share resources and expertise within this partnership.

The last mile grid extension projects are in charge by provincial electric power corporation. The distributed solar PV systems, and small hydro projects are through a collaboration between provincial governments, state owned power companies and private companies. In addition to the conventional Big Five, “Huaneng, Datang, Guodian, Huadian, State Power Investment Corporation (SPIC)”, and other state-owned energy enterprises (SOEs), China General Nuclear Power Group (CGN), China Energy Conservation and Environmental Protection Group (CECEP), China Three Gorges Corporation (CTG), private company such as ZONERGY Company Limited are also involved in the last-mile electrification, especially

in Xinjiang and Qinghai. Those SOEs and private company worked with the provincial governments through the service contract to execute the projects, especially the distributed PV projects. In addition to conduct resource assessment, and population investigation, they also provide maintenance service. The service contract is key for a successful PPP, which should specify the responsibility of both partners. For example, ZONERGY Company Limited signed service contracts with local government which showed government to provide the fund, information and land access, and private company to commit on the standard, area, and timeline for delivering project service.

✎ 3. KEY LESSONS FOR GLOBAL ELECTRICITY-FOR-ALL PROGRAMS ✎

While China's electricity for all programs has its unique condition to fulfill, there are a few key lessons to draw from China's experience in financing the last mile to provide electricity for all.

First, infrastructure is key to pave the road for a full electrification success. Without the foundation of 99.7 percent population already served by grid connection, the last 0.3 percent would not bump up as a priority and it would take longer for them to access modern electricity service. Through the 99.7 percent, the backbone electric network provides the base for grid extension, and the growing volume of electricity market also makes cross subsidies less burden for rate payers. The project experiences, technological and policy advancement during the process also become an asset to the last mile efforts.

Cross subsidization, often flawed in efficiency and fairness concerns, is a powerful financial tool for countries with large electricity market to collect financial resources for special projects and designated initiatives. Providing electricity for all, which is similar to the universal access to post service, telecommunication and internet service, is a need for humanity and fairness. And cross subsidization has been used in enabling and continuing those services for the population who would have no access if purely on economic basis. Cross subsidization has fulfilled its great mission in China to provide universal service, now it's time to reflect and reevaluate the impact on welfare and efficiency. The real question is how to achieve electricity for all more efficiently.

Electricity for all programs usually involves multiple stakeholders whose interests are not always aligned, if not conflicted. One challenge is the financial arrangement between the two key players, the central government and the local government. Central and local cost sharing mechanism turns out to be an effective way to mobilize the local government to act in favor of the central government's agenda. The proportion between the central and local government needs more meticulous calculation and negotiation based on local condition, cost structure, and financial capability. Public-private partnership (PPP), with careful agreement between the public and private partners, can leverage the participation of the private sector to bring together resources and deliver public good.

Lastly, China relies less on conventional international aid and emerging funding mechanisms, such as carbon financing, and multilateral development banks (MDBs) loans, for its electricity for all programs. Even though China has started the world largest carbon market nationally first within the power sector, the electricity for all programs have not used revenue from this program. It should be noted that China achieved electricity for all right before intro-

ducing the power sector reform in 2015, which demonstrated that delivering access does not depend on fully liberalized market-oriented electricity system reform.

Will all these work for other parts of the world? China is different in many aspects in the ending game of electrification. China's vast electricity market made cross subsidies seem less burdensome, and strong central government makes it possible to intervene through central financial investment. In other countries, such public interventions maybe funded by international public finance, domestic budgets and carbon finance (Glemarec 2012). For those countries lack of domestic financial resources, they would rely more on MDBs finance, international aid, or private foundations support. China's experience offers a strong case that despite mounting fiscal and resources constraints, the central and local financial arrangements, as well as public private partnership, offer opportunities to leverage and align resources to achieve universal electricity access.

✎ 4. CONCLUSION ✎

Financing energy access is a pressing challenge, especially for the global efforts to achieve sustainable energy for all by 2030. Many countries have yet to fulfill the goal of full electrification and the last mile might stock the overall commitment. China's push in the last mile of achieving electricity for all programs offers experiences on how to finance the last mile programs: these include bold financial investment through central governmental subsidization, appropriate central local cost sharing scheme, and successful public-private partnerships.

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