How to achieve full electrification:

Lessons from Latin America

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Abstract

Electricity coverage in Latin America has increased substantially in recent decades, rising from 50% of the population in 1970 to more than 95% in 2015. Growth, however, slowed in the 1990s as many countries experienced difficulties in extending their networks further, in particular to serve those living in isolated and rural areas. In spite of this, the process of electrification was not interrupted and at the beginning of the 2010s decade most countries in the region were able to provide access to electricity to almost all of their populations. In this paper, we examine the main strategies used in Latin America to increase coverage and argue that only a combination of policy efforts has made it possible to achieve the current situation. We also examine the remaining obstacles, at policy and institutional levels, to achieving full coverage.

Keywords: Electrification, Latin America, Rural Areas, Renewable Energies, Subsidies, Peru.

1. Introduction

Around 95% of the population living in Latin America (LA) by 2012 enjoyed access to electricity (Figure 1). This degree of coverage can be considered a success, given the low levels existing in some countries of the region already in 2000, when the UN Secretary-General's Advisory Group on Energy and Climate Change established the Millennium Development Goals (MDGs). Yet, the International Energy Agency (IEA) has calculated that still some 28 million people in LA remained without access to electricity in 2012, many of whom live in the rural areas of Haiti, Peru, Guatemala, Nicaragua, Argentina, Colombia, Bolivia and Honduras. Moreover, the high electrification levels throughout the region hide important differences in per capita consumption of the service. Thus, while consumption is high in Argentina, Uruguay, and Venezuela, for example, it is markedly lower in Bolivia, Nicaragua and Peru.

Most studies analyzing the factors that determine the electrification process of developing countries have focused on economic and geographic conditions. For example, Lipscomb, Mobarak and Barham (2013) study the development effects of electrification in Brazil in the period 1960-2000 based on the geographic placement of hydropower plants. They show that placement depends on factors that are exogenous to the government and which can be predicted based on topographic characteristics, such as river gradient, water flow, and distance from the Amazon. However, electrification is also determined by demand characteristics, including concentration of industrial plants and population density. Wolfram et al. (2012) examined the patterns of electrification across the developing world and found that electrification is consistently correlated with GDP per capita. Other papers have stressed the importance of political institutions. Brown and Mobarak (2009) analyzed a group of 57 countries in the period 1973-1997 and showed that in poor countries democratization has meant an increase in the proportion of residential consumption of electricity in relation to that of industrial consumption. This suggests that democratic governments better reflect the preferences of the population and dedicate more resources and efforts to electrification. Wolfram et al. (2012), in contrast, fail to find a correlation between electrification and the level of democracy, and suggest that if China has been more successful than India in electrifying the country it is because the pressure of a strong authoritarian government in China has facilitated infrastructure roll-out.

Differences in levels of electrification and consumption not only reflect disparities in geographic, economic and political conditions, but also point to the adoption of different policies and regulations aimed at reducing the electrification gap. Taking this into account, the objective of this paper is to provide an overview of the electrification policies implemented in LA in recent decades, a subject that has received very little attention in the literature. On the one hand, we examine the *universal access policies* that have been adopted in most LA countries to extend the coverage of the electricity to all national territories. These policies have mainly involved extending existing electric systems to densely populated areas and promoting renewable energies, such as solar panels and mini-grids, in areas that cannot benefit from scale economies. On the other hand, we explain the adoption of *universal service policies*, which aim to make electricity affordable and to promote its use by low-income households (living in poor rural communities or in the suburbs of large cities) that are connected to the service. Specifically, we explain the design and the effects of the subsidy schemes implemented by most LA countries to make consumption affordable, and discuss problems of territorially isolated communities.

Our paper proceeds as follows. Section 2 documents levels of electrification in LA. We show that most of the expansion of the service in the last couple of decades has taken place in urban areas, with current electrification rates rising above 95% of the population in most of the countries. However, there are also significant differences in the level of electricity consumption across countries, implying that access to the service does not guarantee its use. In Section 3, we describe the main features of the process of liberalization and privatization in LA in the 1990s. We report some of the mixed opinions held about the overall outcome of these reforms. Drawing on recent evidence in Balza et al. (2013), we also underscore the importance of the creation of regulatory frameworks and the establishment of independent agencies to supervise competition.

Sections 4 and 5 discuss the process of electrification in the rural areas of LA. We first introduce the stages in the evolution of the electrification programs of developing countries: namely, donor, market-oriented and participation paradigms (Martinot et al. 2002; Kruckenberg, 2015). We then describe the various business models adopted to promote the creation of energy markets, including the dealer, concessionary and the community-led models (Glemarec 2012). Finally, we emphasize the role of off-grid technologies, such as solar panels and micro-grid systems, as essential mechanisms for completing the electrification process in rural areas.

Section 6 reviews the universal service policies that are used in LA countries to complement policies of electrification (Pantanali and Benavides, 2006; OLADE, 2013). Specifically, most countries use subsidy schemes that help low-income users meet their connection costs and the price of the service. We also report some of the difficulties of designing social subsidies that incentivize consumption by the poor.

Section 7 presents the case of Peru to illustrate some of the electrification policies implemented in LA. Peru's case is especially interesting because it combines direct funding and regulatory innovations to stimulate private-sector participation as well as community involvement. In common with many other countries in LA, Peru's current coverage is very high in urban areas, but it has encountered many obstacles to completing the electrification of rural areas. Finally, the last section of the paper offers our main conclusions of the LA experience.

Needless to say, guaranteeing access to electricity for all is a key element of development.[1] In the rural areas of developing countries, the main application of electricity is for light and watching television, given that most households are too poor to be able to afford other appliances, such as fridges or heating (Nieuwenhout et al., 1998; Khandker et al., 2012; Khandker et al., 2013). Many studies have identified the benefits of these applications for children's education, as a result of the increase in the number of study hours, the acquisition of knowledge attributable to television, and the increase in the number of hours that parents dedicate to their children (Asaduzzaman et al., 2010; Barkat et al., 2002; Barron and Torero, 2015). Electricity also allows households to spend more time on leisure and productive activities, as women tend to work more hours outside of the home while children can attend school more frequently (van de Walle et al., 2013; Khandker et al., 2013; Dinkelman, 2011). Likewise, electricity allows beneficiary households to increase their income and welfare, and to dedicate more time to non-agricultural activities (Grogan and Sadanand, 2013; Lipscomb, Mobarak and Barham, 2013; Chakravorty et al., 2014).

Increased access to light and electricity also contributes to improving communications and the diffusion of information in remote locations, which in turn helps reduce poverty. In communities with electricity, inhabitants can spend more time talking with their neighbors at night, acquiring more knowledge – for example, on health-related issues – and they can

[1] Since the seminal work of Aschauer (1989), several studies have analyzed the impact of infrastructure on the growth of developing countries (Canning and Bennathan, 2000; Esfahani and Ramirez, 2003; Yeaple and Golub, 2007).

begin to plan the organization of collective service provisions. Electrification also has health-related benefits, reducing the use of biomass for cooking and moderating levels of household indoor pollution (Bruce et al., 2011). Indeed, pollutants emitted by solid fuels in inefficient cookstoves are a major factor in respiratory infections and infant mortality in LA.

2. Electrification rates in Latin America

Since the eighties, governments, international donors and cooperation agencies have actively worked to boost the electrification of LA. Most of the resulting increase in coverage, as experienced in countries such as Bolivia, Peru and Honduras (Figure 1), has been generated in urban areas, where per capita income is higher, and the costs of expanding the grid are low. But electrification rates have remained low in rural areas, especially in Central America and the Andes. Indeed, more than 28 million people in LA remain without access to electricity, many of whom live in Haiti, Peru, Guatemala, Nicaragua, Argentina, Colombia, Bolivia and Honduras (Figure 2). Low coverage levels can be explained by the poverty of the population and the geographic conditions of some regions, but also by delays in the introduction of electrification policies and their inappropriate designs. On the other hand, it should be stressed that service provision in many rural areas is inefficient and unreliable. This means that major investment is still needed to modernize the grid and its management (Niez, 2010).

Insert Figures 1 and 2

Another salient feature of LA electricity markets are the significant differences in the levels of consumption across countries, which suggests that access to electricity alone does not mean that all consumers can reap all the benefits of the service. Figure 3 shows that while per capita consumption is quite high in Argentina, Uruguay and Venezuela, it is significantly lower in countries like Haiti, Guatemala, Nicaragua, Bolivia, Honduras and El Salvador. Consumers in these latter countries may well not use the service due to high prices or because they cannot afford energy-using appliances.

Insert Figure 3

Among electrified households, consumption patterns might also differ significantly. Barnes et al. (2005) examined household fuel use in 45 cities from 3 continents and found that per capita total energy use is very similar across income classes, but that households with a high-income level tend to use more higher-energy-value fuels, such as electricity or gas. Moreover, middle-income households use about twice as much electricity as low-income households and rich households use about four times more. The World Bank (2008a) explains that although there are substantial variations by country, the expenditure by the poor on electricity is around one-half to two-thirds that of the non-poor. Thus, for example, the richest quintile of Uruguayan consumers uses only 1.3 times more electricity than the poorest quintile, but in Guatemala those in the richest quintile use 4.5 times more.

Among the more specific problems rural and isolated communities face, we should highlight the difficulties that many Latin American countries encounter when trying to replace traditional cookstoves that use solid fuels with gas or electric stoves. Figure 4 shows that in many countries a significant percentage of the population still uses biomass for cooking and heating, rather than clean energies. For example, this is the case of 12.5 million people in Brazil, 10.7 in Peru, 9.6 in Guatemala and 7.1 in Colombia (IEA, 2014). There is a broad consensus in the literature that households tend to replace traditional cookstoves with modern ones when their socio-economic situation improves (Hosier and Kipondya, 1993; Masera et al. 2000; Heltberg 2004; Pachauri and Spreng, 2004). However, the challenges faced are rather more complex: low-income households usually consume a portfolio of fuels that are used for different tasks. For example, while they might boil water using modern stoves because it is faster and cleaner, they continue to make tortillas using traditional stoves because they consider it to be cheaper and the tortillas to taste better (Ruiz-Mercado et al., 2011, Hanna and Oliva, 2015). Access to clean cookstoves is even more difficult in isolated communities because they may not have ready access to gas cylinders, while it is difficult to adapt off-grid technologies for cooking[2].

Insert Figures 4

3. The processes of electricity liberalization and privatization in LA

Part of the increase in the access to and consumption of electricity described in the previous section can be attributed to the reform of the electricity markets that took place in LA at the end of the last century. Until the 1990s, power sectors in LA were mostly managed by vertically integrated state-owned firms; based on the rationale that public monopolies could harness economies of scale, make an efficient use of scarce managerial skills and offer the service at an affordable price. By the mid-1990s, however, the economic situation of the region together with the inefficiencies and managerial problems of these firms led many governments to reform the sector. Many countries privatized their public monopolies and liberalized the energy market with the objective of attracting investors and promoting free-market competition (Victor, 2005; Calzada et al., 2009).

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[2] Organizations such as the Global Alliance for Clean Cookstoves (GACC), the World Bank and the Energizing Development Project fund programs to promote the use of clean kitchens in developing countries. Most of these programs target African and Asian countries, but projects are also run in Latin America, most notably the FISE in Peru (Calzada and Sanz, 2017) and the Mines Energy Policy 2013-2027 in Guatemala (http://cleancookstoves.org/resources/284.html).

These pro-competition reforms were not unique to the energy markets but part of a broader movement toward the introduction of market forces into many sectors such as telecommunications, transport and water.[3] The macroeconomic fluctuations of the 1970s and 1980s in most LA countries had a strong negative impact on public investment in the power sector. As the global economy slowed down, many countries simply could not afford to invest in their power sectors, leading to a decline in the quality of public services and multiple shortages in their provision. At the same time, consumer demand steadily rose due to the development of the region and the urbanization process, resulting in considerable dissatisfaction with public supply. Consumer prices in the state-owned power sectors were heavily subsidized, which meant state-owned power firms ran continual losses.

Against this backdrop, energy sector reforms became a means for governments to gain much needed capital through the sale of public infrastructure, and to reduce public spending on subsidized tariffs (Wamukonya, 2003). International institutions were also a large driving force behind power sector reform. At this time, the 'Washington Consensus' pro-market doctrine was being embraced by institutions such as the World Bank and the International Monetary Fund. In 1993, the World Bank made power sector loans conditional on commitments to private sector participation and liberalisation (World Bank, 1993). Many other institutions, including the Inter-American Development Bank, began similar practices shortly afterwards.

Liberalization and privatization are often presented in the literature as attempts not only to improve efficiency in the power sector, but also to bring about a wholesale change in

[3] Some scholars have criticized the market-oriented approach, suggesting that it favors the interests of the most privileged members of the society and "disempowers the state" (McCluskey, 2003). Moulian (1997) links this approach with the increase of poverty and inequality in Latin America. In the case of energy, Tironi and Barandiarán (2014) suggest that this approach was used as a rationale to end of the development of nuclear power in the 1970s in Chile.

ideology, with electricity going from a public service to a market commodity. Initially, power sector liberalization brought in much needed private sector investment to LA. By the end of the 1990s, the region had the largest share of private electricity projects among all developing regions worldwide. More than 38% of total investment in the developing world's power sector was concentrated in LA (Henisz et al., 2005). Although the promised investment did arrive, it was largely concentrated in the more profitable areas with low cost and large demands, and opinions are mixed on the overall outcome of the reforms. However, there is evidence that the power sector reforms did bring about efficiency savings, while extending coverage, increasing consumption and reducing prices in several countries (Henisz et al., 2005 and Balza et al., 2013).

The privatization process in LA countries often took place in conjunction with the vertical unbundling of the sector into its three basic business units - generation, transmission, and distribution. Most governments transferred generation, and to a lesser extent distribution and transmission, to the private sector. At the same time, they established new regulatory frameworks and market mechanisms to encourage competition. These transformations profoundly changed the institutional framework and the regulatory instruments available to supervise the sector, opening the door to new scenarios that favored the mix of public and private intervention to solve policy problems. For example, greenfield projects were auctioned off by public authorities across LA to stimulate the expansion of national grids to territories without coverage (Estache, Foster and Wodon, 2002).

Balza et al. (2013) show that in LA the intensity of private investment in the power sector was not significantly related to an increase in coverage.[4] By contrast, they do find that

[4] In spite of this, investment in electricity did increase the quality of service and the efficiency of its generation, with a reduction in electricity losses and an expansion of generation capacity.

liberalization and the creation of independent agencies had a positive impact on the expansion of the service. During the 1990s, new regulatory models were established to introduce more competition in different areas of the market, especially in generation, but also in transmission and distribution. Moreover, price regulations and subsidy schemes were established to allow fair conditions for domestic consumption, regulated users and the financial sustainability of firms (Levi-Faur and Jordana, 2006).[5] To implement these sophisticated regulations and provide some credible commitments to foreign investors, most countries created independent regulatory agencies, with highly qualified staff and with a strong organizational autonomy (Figure 5). At the same time, similar institutions were created for other basic services such as telecoms, transportation and water, as part of a large public sector reform. Expecting regulatory returns, governments delegated responsibilities to these newly created agencies in the areas of supervision, licensing, price setting and arbitrage, among other regulatory issues (Jordana and Levi-Faur, 2005; Jordana, 2012).

Insert Figure 5

In recent years, a few countries in the region have partially reversed these policies due to changes in the political ideology of their governments and a certain disenchantment with the results of the reforms. This is the case of Bolivia, which in 2010 initiated a nationalization process that reversed many of the changes introduced in the 1990s and nationalized several firms, while in Venezuela several firms have been nationalized in the last few years. In spite of this, most LA countries have consolidated a model of regulated competition and have tried to offset the unwanted effects of liberalization by implementing

[5] Murillo and Martínez-Gargallo (2007) show that even those countries that have introduced the strongest market liberalization policies and which have privatized their national incumbent operators maintain price controls and a strict regulation of the sector.

electrification policies. One obvious effect of privatization and liberalization is that private investors tend to focus their efforts on urban areas where they can exploit high-income consumers and benefit from economies of scale and density. In rural and remote areas, by contrast, the service is not profitable enough to attract the same degree of interest from investors. To compensate for this, since the nineties, national governments have implemented specific electrification programs. Some countries, such as Brazil and Peru, have passed specific rural electrification laws and many others have created rural electrification funds. In addition, most LA countries use social tariffs to boost the affordability of the service. The next sections explain the evolution of these programs and their results.

4. Rural electrification strategies

In the last decades, the complexity of electrifying the rural areas of developing countries has been recognized by domestic governments and international agencies. New programs have sought to adjust electrification strategies to the socio-economic and geographic conditions of each region, to adopt off-grid technologies in rural areas and to increase coordination between all institutions and local communities participating in the electrification process.

4.1 Evolution of electrification policies

Kruckenberg (2015a) identifies and describes three stages in the evolution of the electrification programs of developing countries. The first stage, the "donor paradigm", occurred between the 1970s and the 1990s, when international donors and cooperation agencies intervened in rural areas through the diffusion of new technologies. Typically, these programs were based in the transmission of small-scale renewable-energy technologies such as biogas, cookstoves, wind turbines and solar heaters, which were barely self-sustainable (Martinot et al., 2002). Development agencies sought to demonstrate to the local authorities and communities how these technologies could solve their energy needs. However, many of the projects suffered major shortcomings and failed: often they did not allocate resources to maintain and operate the equipment that was delivered to the communities, the beneficiaries were not trained to use or repair the systems, and there were no specific regulations or institutions available to guarantee the long-term sustainability of the projects (Martinot et al., 2002; Krukenberg, 2015a).

The second stage, the "market-oriented paradigm", was initiated after the 1992 UN Conference on Environment and Development (The Rio Earth Summit), when new forms of multilateral assistance were adopted for the diffusion of renewable energies, including solar home systems, biogas for lighting and cooking and small-scale mini-grids (Martinot et al. 2002). The new programs, designed by development agencies, aimed at promoting these technologies by creating business models for firms and cooperation agencies in which funding programs shouldered part of the costs and risks. These interventions were based on the expectation that renewable energies would be economically profitable in rural areas, but that their adoption would require giving some institutional and financial support to local firms. Many of these initiatives were adopted in the rural areas of countries such as Argentina, Brazil and Chile. However, usually they were only successful in richer communities that were already undergoing development and that had access to other public services such as water, telecommunications, health and education.

This suggests that effective methods for targeting poor communities required private sector involvement to be complemented with more active public measures. Here, it should be recalled that in many LA countries the pro-market period coincided with a process of administrative and political decentralization that transformed public policy-making in many different areas (Falleti, 2010). Faguet (2004), for example, reports that a major decentralization process in Bolivia led to greater investment in human capital and social services, as the country's poorest regions were able to choose projects according to their greatest needs. This process was also characterized by significant drawbacks: some studies of the period warned that decentralization could be related to corruption and regulatory capture, since municipal governments were often at the mercy of local power elites (Bardhan, 2002).

Finally, the third stage in electrification identified by Kruckenberg (2015a), the "participation paradigm", was introduced in the early years of the new century. Many studies of rural electrification programs in developing countries have found that the impact and sustainability of the projects is usually constrained by persistent resource, capacity and participation limitations. In this sense, and contrary to traditional electricity technologies, the introduction of off-grid renewable technologies in rural areas requires the creation of new development pathways. Electrification programs today include a large variety of stakeholders (governments, development banks, bilateral and multilateral agencies, private enterprises and non-governmental organizations, utilities, micro-finance institutions) that need to be coordinated. In this context, partnerships between these organizations can help obtain the complementary resources, skills and knowledge that are necessary to promote sustainable off-grid solutions, and promote the participation of local communities (Kruckenberg, 2015b and 2015b; Morsink et al., 2011).[6]

[6] Several recent papers provide examples of how different forms of inter-organizational relationships affect the sustainability of renewable energy partnerships. Kruckenberg (2015a) present six experiences in Central America. Ince et al. (2016) empirically analyze the role on informal institutions in Caribbean countries.

Cross-sector partnerships have become popular within formal debates on international development. Kruckenberg (2015a) explains that Target 8 of the UN's Millennium Development Goals called for a new "global partnership for development" involving various collaborations between business and development agencies. For example, the World Summit for Sustainable Development in Johannesburg in 2002 called for "type II" partnerships between actors such as governments, international organizations, companies, NGOs, and scientific organizations, as a way to accelerate development (Forsyth, 2010).

Within this new paradigm, electrification projects recognize the multi-level and cross-sector nature of socio-technical change. New projects seek to attract investment and create cost-sharing models, foster knowledge transfer and capacity building, and improve the involvement of public policy initiatives and donor organizations with local communities. The main novelty of this approach is that it recognizes the importance of strong relationships between local stakeholders and policy entrepreneurs to foster the introduction of new technologies. According to Kruckenberg (2015a), strong ties between organizations facilitate fine-grained knowledge transfer, extensive collaboration and the development of problem-solving capabilities; whereas weak ties enhance access to non-redundant information and prevent the insulation of more durable partnerships in the wider sector. In spite of this, partnerships assisting in the uptake of off-grid solutions are also likely to face multiple knowledge gaps that have to be tackled in a dynamic process (Kruckenberg, 2015b).

Sovacool (2013) explores eight case studies in Africa and Asian countries. Finally, Schaffer and Bernauer (2014) analyze the relevance of partnerships between national governments and international institutions in 26 EU countries.

4.2 Business models for rural electrification

In recent decades, various methods of intervention have been adopted in developing countries, influenced by the electrification strategies defined above.[7] We review here the main business models used (the dealer, the concessionary and the community-led model) and include a summary of this review in Table 1 of the Appendix.

The "dealer model" was introduced in the eighties and harnesses pre-existing local retailers to sell energy-generating equipment – predominantly photo-voltaic (PV) solar technologies – directly to off-grid consumers. Its objective is to expand the market by making credit and partial subsidies available from qualified dealers. Specifically, policy intervention involves offering subsidies to local dealers to reduce the per unit installation cost of electricity systems. These subsidies are expected to be passed on to the consumers to create lower retail prices, thereby increasing demand and access, while also ensuring a profit for the dealers themselves (Glemarec 2012). However, in practice, the business model is difficult to implement because of the difficulties encountered in attracting dealers and due to their resistance to extend credits and subsidies to consumers. As a result, these programs are often concentrated in affluent regions with pre-existing networks of small-scale electricity supply firms that have the skills and technology required to supply services directly to consumers. While the dealer model was initially developed in various Asian and African countries, it can be found in LA applied in combination with other business strategies.[8] For example, although the dealer model usually allows accredited dealers to sell anywhere in the country, in some World Bank projects in Honduras and Nicaragua subsidies are provided

[7] Our descriptions of these models, as well as the explanation of the community-led model we offer below, are based on Barnes and Halpern (2001). See also Rolland (2011) and ADB (2015) to see examples for other regions.

[8] Barnes and Halpern (2001) explain that in Sri Lanka and Indonesia a combination of Global Environment Facility funds and World Bank credits were to be offered to dealers to on-lend to customers.

only for sales in designated priority areas. On the other hand, in Bolivia, the Decentralized Infrastructure for Rural Transformation Program specifies that the dealers must offer operation-and-maintenance services (World Bank, 2008b).

The "concessionary model" was also introduced in the nineties in countries such as Argentina, Bolivia, Chile and Peru. It involves tendering to private firms the generation, transportation and distribution of electricity in rural and remote regions, while the government maintains the regulation and subsidization of the service. Since firms compete for the concessions, this mechanism should lead to cost reductions and better services. In spite of this, the concessionaires are responsible for running the service during the life of the contract, which means the public authorities have to monitor the quality of the services and ensure the equipment is maintained.

In the concessionary model, an essential objective is to encourage private firms to compete for the concessions and to regulate the winners. Moreover, before the tender, public authorities must identify the country's unprofitable regions in which the electricity sector needs to be expanded. Unattended regions can be split into different areas and the concessions for these regions can be tendered simultaneously or sequentially. In each region firms bid to obtain an exclusive contract to supply the service. The bids can reflect the number of households that the firm agrees to supply for a given public subsidy, or the minimum subsidy the firm requires for extending access to a given number of households. One advantage of this mechanism is that it is well targeted to meet the needs of rural communities: governments set tariffs that are affordable to the rural poor identified by the program. On the other hand, it uses market forces to select the provider in each region that is willing to offer the service at the lowest cost. Typically, the biggest hurdle is gaining sufficient competition in the tender process to keep firms' subsidies low. If there is not enough competition and subsidies are high, this model could be excessively costly (Barnes and Halpern, 2001; Calzada and Miralles, 2009). Concessionary tenders have been widely used across LA to distribute private sector concessions. For example, tenders have been used in Argentina under the Project for Renewable Energy for Rural Markets (PERMER) starting in 1999 (Best, 2011, Alazraki et al., 2007); the Rural Electrification Plan (REP) in Peru, beginning in 1993 and given new impetus in later periods, and the project *Luz Para Todos* (Light for All) launched in Brazil in 2003 (Gómez and Silveira, 2010).[9]

A third approach adopted in recent projects is the "community-led model". This could be viewed as a decentralized application of the concessionary model (bottom-up approach), typically geared toward off-grid and mini-grid electricity supply expansion. Local leaders, organizations, community members and entrepreneurs work together to produce a business plan to best serve the needs of their community.[10] The project is submitted to a national regional agency, which, if approval is given, assigns partial funding through loans or subsidies for the installation or repair of infrastructure. New projects typically involve a financial contribution from the communities themselves, which is believed to invoke an attitude of community ownership and responsibility for long-term maintenance.

One of the main criticisms of the concessionary model is that the projects developed by the concessionaires are largely disconnected from the interests of the local communities whom they serve. For example, the technology used by a concessionaire might not have

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[9] Calzada and Miralles (2009), Coelho and Goldermberg (2013) and Maurer and Barroso (2011) give a broad overview of concessionary auction mechanisms, with examples from Brazil, Colombia, Chile, Peru, Panama and Mexico from Latin America.

[10] Policymakers in developed countries are increasingly coming to view the community approach as a way to improve the results of renewable energy initiatives (Walker et al., 2010). This represents a significant shift in energy policy from focusing solely on large-scale, centralized technical systems to local, small-scale and collective approaches to sustainable energy generation, as advocated by alternative technology activists since the 1970s (Walker and Devine-Wright, 2008). The community approach, as used for example in community-owned wind farms in the UK, can reduce local opposition and promote the choice of appropriate technologies at the local level.

enough capacity to meet the (perceived) needs of the communities, or may be installed in inadequate places. This argument is similar to the one used against the development of large-scale generation projects, including hydroelectric plants and large wind farms, which benefit the country as a whole but not the local community (Libert and Cacho, 2008). The community-oriented approach tries to overcome this limitation by engaging local governments and communities in the design of the projects and by developing local skills that are essential for the operation and maintenance of the equipment.[11] In this sense, community-based and community-driven projects have been increasingly accepted by policy-makers as appropriate solutions for the provision of public services in rural and isolated areas. Local communities may have a better knowledge of the needs of the population and can be more willing to contribute financially to a project when they are entrusted with some level of decision-making. In spite of this, the biggest drawback of this model is its inability to generate economies of scale due to the small size of rural communities and the difficulty of generating diffusion effects across multiple communities. Moreover, as McGranahan (2015) points out, community-driven projects may have difficulties combining and coordinating local demand; obtaining the support of public authorities; persuading the community to develop affordable and sustainable projects; and achieving an adequate provision of all basic public services.[12]

An example of community-based interventions is the rural electrification programs developed in Chile since 1994. The National Program for Rural Electrification (PER), the National Program on Rural and Social Energy (PERYS), the Huatacondo micro-grid

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[11] For a review of the literature examining demand-driven projects see Mansuri and Rao (2004 and 2013), Bardhan and Mookherjee (2005) and Yadoo and Cruickshank (2017).

[12] Mansuri and Rao (2004) also claim that community projects may not best reflect the preferences of rural communities and that they may fail both to create the adequate infrastructure and to improve welfare outcomes. Rigon (2014) explains that the management of these projects requires offering these communities training and resources, which national and local governments may have problems financing. When this occurs, these projects can be seen as a mechanism for passing the costs of development on to the poor.

project, or the Coquimbo Project has adopted bottom-up approach which has given a relevant role to local communities. In these projects, local communities are responsible of requesting the intervention, and they participate in the design, execution and sometimes the operation of the systems. In the case of the PER, operators were selected by the central government considering a number of criteria, including a cost-benefit analysis, the operators' investment commitment, and the social impact of the project. The tender could cover only the initial installation or also the operation and maintenance of the infrastructure. On the other hand, the central government allocated subsidy funds to the regions based on the number of unelectrified households and the electrification of the region in previous years. Local consumers paid the connection costs from the distribution plant to their homes and the costs of wiring within their homes, roughly equivalent to 10% of the total project costs. Between 1995 and 1999, this model increased rural electrification in Chile by 50% (Jadresic, 2000; Tomkins, 2001; World Bank, 2008a). In the case of off-grid systems, the involvement of the community has contributed to the success of the projects, such in the case of the Coquimbo Project developed in the period 2001-2012. However, a participative approach has not been applied in other cases. For example, in 2010 a group of off-grid Photo-voltaic projects were implemented in southern Chile, with a high failure rate: harming system interventions from users occurred in 18% of the cases because of a lack of user training (Feron et al 2016).

4.3 Financing electricity equipment

A typical concern in many electrification projects is the high costs of installation. Microfinance schemes can be particularly helpful in overcoming the liquidity constraints associated with electrification projects. In regions with strong microfinance networks, consumer credit through microfinance institutions (MFIs) has been used to promote access to clean energies systems (Glemerac, 2012). In LA, however, the current capacity of MFIs is insufficient to target rural areas and to unlock the potential of the energy market for microfinance loans (IEA, 2011). MFIs in LA are highly commercialized and currently geared toward urban and middle-income regions. Most micro-loans have been supplied to established micro-enterprises in need of capital for expansion, rather than to the rural poor in isolated regions (Morris et al. 2007). Unlike MFIs in Asia and Africa, few such institutions in LA explicitly provide energy lending portfolios. This has been attributed to poor government planning, with politically motivated promises of free giveaways of electrical services stifling demand for microfinance loans and hindering the market (Allderdice et al., 2007). MFIs have been involved in a small number of donor-led electrification programs such as World Bank/UNDP sponsored programs in Bolivia, the Dominican Republic, Honduras or Nicaragua. Each of these projects has used microfinance to help individual households and communities purchase solar electrification products. In all these cases, the loans have been embedded in broader business loans, rather than being explicitly given for energy purposes (Morris et al., 2007). In Honduras, for example, the Programme for Rural Electrification with Solar Energy (PROSOL) is executed by the Honduran Fund for Social Investment (FHIS), a governmental entity, through the Rural Infrastructure Project (PIR). While the first phase (2008-2013) was financed by GEF funds, the second phase is funded by the World Bank. The objective of the program is to make solar home systems affordable to rural users with limited financial capacity. PROSOL subsidizes part of the cost of the system and has allowed for the option of micro financing through a credit line managed by 6 micro finance institutions that can issue loans to families who cannot pay their rest of the equipment's cost.

5. The use of sustainable technologies for rural electrification

The main obstacle to the electrification of rural areas is the high cost of expanding the grid into low populated regions. Many of the households that remain without electricity in LA are in highly remote areas, for example in the Andes or in Amazonia, and their extreme poverty and high connection costs prevent them from attracting the interest of electricity distributors. In the late 1990s, most LA countries implemented specific electrification programs in their rural areas. Initial programs focused on expanding the grid to the more profitable consumers of urban and peri-urban areas. Centralized governments built large hydroelectric dams and power plants, as well as lengthy distribution and transmission lines. But the electrification of rural areas required a different strategy to control the amount of investment required, and, as a consequence, a difficult learning process was initiated. At first, top-down rural electrification programs were introduced, but implementation mechanisms were far from flexible. This resulted in significant policy failures and only small advances in electricity coverage, and more often than not negative externalities with regard to their impact on isolated communities.

Today, donors, NGOs, private firms and communities collaborate with the governments to develop small-scale, localized energy generation systems.[13] In rural locations, the adoption of renewable energies has emerged as a cost-effective solution, often with the use of off-grid and small-scale systems. But success is not only technology driven: a tailor-make design of policy intervention, including well-calibrated instruments that are able to adjust to incorporate results from participatory processes in local communities, is also essential for

[13] Several papers have analyzed the design of these programs (Brass et al., 2012; Sovacool and Drupady, 2012; Kruckenberg, 2015). Other studies have found that decentralized electrification can be more cost-effective than grid extension, even for communities that lie only 5 km from the grid (Adkins et al., 2010; Contreras, 2008; Diniz et al., 2011). Palit and Chaurey (2011) analyze off-grid rural electrification in South Asia.

the success and sustainability of the projects. In particular, the way in which a new technology is socially introduced within a community, the way this technology empowers community members or, alternatively, makes them more dependent on external sources that extract revenue, are key factors in the introduction of the service in the communities and in the promotion of its use. To be successful, instrument design and the choice of particular technological options in these programs needs to move beyond a technocratic rationale, based on the logic of cost efficiency. Taking into account the existing power relations within a community, gauging if they can be placed under stress, and the way in which the representation of these power relations might be altered with the introduction of electric power have to be given careful consideration in most cases.

Renewable technologies, such as photo-voltaic panels, micro generators, hydroelectric plans and wind power have many advantages. They need less initial investment than is required by having to expand the electricity grid; they reduce the dependence on imports of fossil energies; they increase the security of provision by diversifying energy sources; they have lower environmental impacts; and their retail prices are lower than those of fossil fuels. Their main drawbacks, however, are that they might involve higher operative costs than hydroelectric or thermal plants, they are less attractive for private investors, and, in many cases, there is no operator to maintain the equipment. For this reason, renewable energies are often considered an intermediate step to the connection of households to the main grid, and a contribution to the social learning process. The idea is that they can facilitate access to the electricity service for many communities and that they can eventually be substituted should consumption increase sufficiently (ladder of investment).

Photo-voltaic (PV) panels have been widely used as a cost-effective means for expanding electricity supply and their costs have fallen significantly in recent years (Glemarec, 2012).

Some authors claim that PV panels might generate dissatisfaction among users, because the limited power provided does not allow them to develop economic activities that require electric machinery, such as retail shops, grain mills, carpentry or sewing businesses. In addition, the social economic implications for the existing community order have to be examined very carefully. Coelho and Goldemberg (2013) have analyzed electrification programs in Brazil. They report that initially 50 kWh per month was sufficient to meet a family's immediate needs, including light in the evening, the pumping of water, and television. But then electrified households started installing fridges and other electric equipment; they even began cooking with electricity. These authors argue that in this situation installing meters and charging for the electricity consumed becomes essential. Further limitations of PV panels include the fact that new businesses dependent on this technology cannot stay open late because the energy produced is insufficient to power their essential equipment (Green, 2004 and Hajat et al., 2009).

Another major problem of PV panels is that they are usually installed by dealers (decentralized dealer model) and so there is no long-term contract established between consumer and retailer. This means panel and battery maintenance are dependent on the community members, who usually do not feel especially responsible for the equipment and/or do not have the capacity to maintain it (Barnes et al., 2001). As a result, when batteries are exhausted they may not be replaced.[14] In spite of this, some new electrification projects do dedicate considerable efforts to advising household members on how to use and maintain solar panels, and they might even train local technicians to install the equipment and maintain them. This requires a political and social understanding of how the community works, and probably the establishment of participatory process that contribute

[14] Obermaier et al. (2012) explain that, in Brazil, 56% of the equipment installed by the electrification programs at the end of the nineties (PRODEEM) was not in use a few years later.

to empower the community with the use and the control of the new technologies introduced. A good example of this is the *Acciona* MicroEnergy project in Peru, which has installed more than 5,000 PV panels since 2008, as well as being responsible for battery maintenance (Arraiz and Calero, 2015).

An alternative to PV panels are micro-generators, which can be fueled by hydro, wind or thermal power, or by traditional fossil fuels. These technologies can also power mini-grid systems servicing small communities, although they are more expensive. According to Brass et al. (2012), diesel generators typically cost two to three times more per kilowatt-hour than grid electricity and are susceptible to fluctuating fuel costs. In comparison, renewable systems are often cost competitive, but require higher upfront costs per end user.[15]

Micro-generators are also limited in terms of their generation capacity, with their ultimate suitability and cost effectiveness being determined by the characteristics of the local environment. In Brazil, in 2008, there were 1,267 small, diesel-fueled, power plants (Coelho and Goldemberg, 2013). The strategy adopted by this country of extending electricity lines to slum areas and distant villages has succeeded in universalizing access to electricity. However, because of the difficulties and costs to create and maintain these plants, many new projects have adopted renewable energies.

Many LA countries use hydroelectric plants to generate electricity, but usually they produce several megawatts in order to benefit from scale economies. By contrast, the adoption of small hydroelectric plants remains quite limited. Taking into account the rainfall rates and

[15] Brass et al. (2012) review an extensive literature on distributed generated projects and offer different estimates of the costs of adopting renewable energies.

the high topographic relief of many countries, the use of small plants would be especially appropriate for many remote areas, for example in the Andean mountains.

A further solution for rural areas is the use of wind power systems that incorporate batteries within the homes to store electricity. However, it is estimated that wind turbines are only more economical than PV systems in areas with high average wind speeds (Fuente and Álvarez, 2004).

As discussed above, one limitation of off-grid systems is that they cannot be so readily adapted to an expansion in consumption. Hence, the success of electrification projects might in part depend on the firms' and on the government's ability to make accurate predictions about the future evolution of consumption in each place (Gertler et al., 2011). In the case of the rural regions connected to the grid, a potential problem is also the existence of a low generation capacity (Crousillat et al., 2010). In these instances, in order to extract the full benefits of electrification, grid expansion has to be complemented with an increase in generation equipment.

Finally, it should be stressed that the presence of renewable energies for the production of electricity in LA today is significant, although their use in rural areas is relatively recent and remains modest. According to the International Energy Agency (IEA), renewable energies currently represent around 29% of total energy production in LA, and according to OLADE they account for 25% of total production in LA and the Caribbean (Figure 6). This is a relatively high figure compared to the 5.7% share renewable energies represents in the OECD countries. In practice, however, most of the renewable production in LA is generated by the large hydroelectric plants and by biofuels.

Insert Figure 6

In recent decades, the price evolution of fossil fuels, climate change, increases in energy consumption, plus the energy crisis experienced by various countries have alerted policymakers to the need to reduce their dependency on the traditional energy supply system (Scrasse et al., 2009). Yet, despite measures aimed at reducing energy consumption and the promotion of alternative energy technologies, most LA countries remain highly dependent on fossil fuels to meet demand. As Verbong and Loobach (2012) explain, most societies have adapted to the fossil-based energy system so that changing the organization of the supply and usage of energies presents many major challenges: new technologies compete with each other, dominant technologies are placed under pressure, and different actors, authorities and institutions may have conflicting interests as to how best to implement new strategies (Grin et al., 2010). An additional barrier for the environmental groups that support renewable technologies is their limited influence on research agendas (i.e. the "undone science", as explained by Hess, 2007).[16]

Energy systems are characterized by their complexity, uncertainty and inertia, which means that we have to consider many actors when analyzing their transformation. An important challenge facing electrification projects is being able to take into account the differences in needs and preferences of local communities. In recent years, Science and Technology Studies (S&TS) have shown a willingness to seek global solutions to energy and

[16] Hess (2007) explains that when alternative technologies and practices, such as most renewables, are taken to a bigger scale, they are transformed into something that is more compatible with established mainstream options, although less adapted to the specific needs of local communities. On the other hand, Jasanoff and Martillo (2004) argue that identifying which issues require global attention is a matter of power and resources, including scientific resources.

environmental problems. However, various authors have explained that global solutions to environmental problems must be coupled with new opportunities for local solutions.[17]

6. Universal service policies and social tariffs

Most countries in LA complement their electrification policies with universal service policies that seek to make the service more affordable for electrified households. Specifically, most countries use subsidy schemes that help low-income users meet their connection costs and the price of the service.[18] This practice contrasts with the trend in OECD countries to eliminate social tariffs, where they are believed to create inefficiencies and to have little impact on the energy poor. In LA, social tariffs constitute an essential part of social policies and might have an important redistribution effect (Pantanali and Benavides, 2006). In many cases, social tariffs have been created to moderate the increase in energy prices following the introduction of renewable energies and plans to increase market efficiency or to protect the vulnerable population in periods of economic difficulties. Thus, for example, in Argentina social tariffs were introduced after the 2001 crisis.

In most countries, social tariffs are tied to energy consumption, although several countries also link them to other indicators such as the geographical location of the households or measures of household income. For example, in Argentina, Brazil, Chile, Colombia and Peru the beneficiaries of social tariffs have to be included on the census as low-income consumers. In these countries it is believed that electricity consumption is not sufficient on

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[17] Howe (2015) argues that if solutions to global climate change have to be applied, "they will require analyzing projects and policies that are touted as planet-preserving (the universal appeal) as well as those projected to benefit local populations (the particular appeal)". In the same line, Jasanoff and Martello (2004) explain that local self-sufficiency and placed-based identities continue to be important for effective environment governance.

[18] Some exceptions are Barbados, Belize, Costa Rica, Grenada and Guyana (OLADE, 2013).

its own to determine household income and other variables, such as the size and location of households, are used to determine their energy needs. In Peru, the SISFOH (*Sistema de Focalización de Hogares*) is a system that collects information about the households socioeconomic characteristics and which calculates a poverty index that allows households to be classified into seven categories or strata. This information is then used by different national agencies to determine the beneficiaries of social programs.

Some countries, including Peru, Ecuador and Nicaragua, finance social tariffs with cross-subsidies, but there are other countries in which cross-subsidies are not allowed and social tariffs are financed by the electricity companies or with a direct contribution from the State. For example, in Peru and the Dominican Republic, social tariffs are financed by those users that consume more than 100 and 500 Kwh per month, respectively. In Argentina cross-subsidies are forbidden and social tariffs are supported by public funds, while in Brazil tariffs are financed out of the Global Reversion Reserve, funded with payments from the energy providers.

OLADE (2013) has analyzed the use of social tariffs in LA and shows that in most countries, the percentage of beneficiaries of these tariffs is higher than the percentage of people living below the poverty line, and higher than the percentage living below the extreme poverty line.[19] Figure 7 shows that some exceptions are Bolivia, the Dominican Republic and Paraguay, and even in these countries the percentage of people obtaining subsidies is higher than the percentage living below the extreme poverty line. In this

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[19] CEPAL (2014, p. 64) defines the poverty line as the minimum income required to meet a person's basic needs. It is based on the value of a basket of basic food necessary to cover the nutritional needs of the population, taking into account consumer habits, the availability of food and the prices in each country. The extreme poverty line additionally includes the income required by households to meet their basic non-food needs. This measure takes different values in urban and rural areas and changes each year.

respect, there may be political and technical circumstances that make it difficult to prevent non-poor households receiving subsidies. Komives et al. (2005) warn of the complexities of designing social subsidies that only incentivize consumption by the poor. For example, they report that in Guatemala and Colombia many non-poor households figure among the low-volume customers that may benefit of social tariffs. In urban Colombia, the poorest quintile consumes more than the subsistence level. Yet, the administrative and political costs of improving the selection of the beneficiaries of these tariffs can be high.

Insert Figure 7

OLADE (2013) reports considerable differences in the maximum consumption levels established at which consumers can benefit from subsidies. These range from 70 kWh/month in Bolivia to 900 kWh/month in Mexico (this threshold applies in the summer season and in some specific regions). In spite of this, most countries adopt a limit between 200 and 300 kWh/month, and many countries offer a range of consumption levels with different discounts. Thus, for example, in Peru there is an initial range for 0-30 kWh/month and another for 30-100 kWh/month. In Ecuador, there are three thresholds: 110 kWh/month in the Sierra, 130 kWh/month on the Coast, and 120 kWh/months for the elderly. These differences are justified on the grounds that there is no single general consumption level that reflects the needs of all households. Clearly, the consumption requirement might depend on the size of the family, the geographic location of the household, the season of the year, and cultural habits.

The discounts applied to the regular tariff vary according to the country and the consumption level. Many countries apply decreasing subsidies. For example, in Peru the subsidy is 62.5% for consumption between 0 and 30 kWh/month and 49% for a consumption between 31 and 100 kWh/month. By contrast, in Ecuador the subsidy is 50%

for the three ranges used. The countries that apply the smallest subsidies are Nicaragua (15%) and Bolivia (25%), and the countries that apply the highest discounts for specific groups of consumers are Argentina and Brazil (100%) (OLADE, 2013). The use of these increasing subsidies is considered important in giving the right consumption signals to consumers. Subsidies modify the consumption patterns of households and should not stimulate unnecessary consumption and waste.

Finally, another interesting aspect of OLADE's report is that it estimates the impact of social tariffs on the budgets of beneficiary households that are below the extreme poverty line, according to the World Bank's definition (households that obtain less than 1.25 US$ per day per household member, for a family of five members, i.e., 2,281 US$/year). After making various assumptions, they found that in several LA countries, including Bolivia, Honduras and Peru, the impact of social tariff was small, since it only increased the acquisitive power of these households by less than 30 US$/year, which represented around 1% of their annual income (Figure 8). The highest impact was found in the Dominican Republic and Mexico, where households below the extreme poverty line obtained 235 and 493 US$/year, respectively, which was around 10 and 21% of the households' income. In spite of these results, there is still a shortage of information on how subsidies can change the consumption patterns of the population.

Insert Figure 8

Subsidies seek to improve opportunities to use modern energy options at affordable costs. But some authors consider that social tariffs often fail to achieve this policy objective and suggest the use of alternative measures, such as direct welfare payments or investments in social services. Komives et al. (2005) argue that the absence of any administrative selection of subsidy beneficiaries might mean that subsidies are regressive: both because many poor households do not have an electricity connection, and because those with a connection use less electricity than rich households. In this sense, the adoption of a progressive distributive policy would mean that a large part of the population do not receive any subsidy.

Another criticism of subsidy programs is that they can distort firms' long-term investments. McRae (2015) has identified an important anomaly that affects subsidy programs in Colombia. Subsidies should create sufficient demand in poor neighborhoods to encourage private operators to improve distribution networks. But he explains that, paradoxically, many Colombian regions receiving large subsidies have precarious distribution networks. This generates a vicious cycle: households with informal connections receive low quality service for which they do not pay; distribution firms tolerate nonpayment because they receive financial support from the government; and the government subsidizes these users to retain their political support and to avoid civil conflict. The explanation for this situation is that governments cannot observe real consumption levels and, as a consequence, in areas with a large number of informal connections, the fiscal transfers firms receive are higher than the cost of providing the service. Since the profits obtained are high, the incremental profit from improving the network is lower than the capital cost. As a result, operators opt not to invest in the expansion and upgrading of their networks.

Similar distortions attributable to subsidies have been described in other countries. On the one hand, Krishnaswamy and Stuggins (2007) explain that in the Dominican Republic the government paid 75% of the cost of the electricity used in informal settlements, and this policy incentivized firms to expand the number of households included in the program. On the other hand, Rehman et al. (2012) explain that in the "Big Five" countries of Asia inefficient subsidies have distorted the utilities' incentives to invest. All in all, these papers conclude that government policies aimed at maintaining services for nonpaying, unmetered households may perpetuate the existence of low-quality connections by creating a disincentive for distribution companies to invest, even when the investments result in the households paying for the service. McRae (2015) suggests addressing this problem by making the subsidies dependent on the quality of the service and shifting out household demand in order to increase the profitability of upgrading the distribution networks.

7. A case study: Peru's electrification process

Peru's experience of electrification is interesting in the sense that it has sought to combine direct funding and regulatory innovations to stimulate private participation as well as community involvement. However, electrification in Peru is still characterized by major shortcomings.[20] In 2012, although coverage in urban settings was already close to 99%, it reached just 65% of the population in rural areas. Amazonian and Andean departments were the territories with the lowest levels of electrification, owing to a highly dispersed rural population and very difficult terrain. According to the IEA, in 2014, more than 2.5 million people did not yet have access to electricity in the country.

During the 1990s, most of the Peruvian electricity sector was privatized, particularly as regards energy generation and distribution. Efforts were made to attract investment so as to increase electricity generation and to renew its distribution networks. Later, during the 2000s, transmission networks were also privatized. At that time, the country's policy priorities were focused on improving the efficiency of the electricity system as a whole, and coverage was expanded rapidly as a consequence of increasing electricity production. To attract investment, companies were under no obligation to connect users lying more than 100 meters from their networks, a measure that possibly impeded a more rapid increase in

[20] For a general analysis of the energy sector in Peru see Fontaine (2010), Leung and Jenkins (2014), Calzada, Costas and Jordana (2009) and Quintanilla (2009).

coverage. However, already in the early 2000s, two key instruments were adopted to address the electricity gap in the country and to expand universal coverage.

First, in 2001 the government created the FOSE (*Fondo de Compensación Social Eléctrica* - Electricity Social Compensation Fund), a cross-subsidy system to adjust electricity tariffs, which included a reduction in tariffs for customers with an energy consumption below 100 kWh/month using fixed and proportional discounts. This fund was managed by the electricity regulatory agency, OSINERGMIN, financed through a surcharge in the tariff paid by regulated consumers with monthly consumptions above 100 kWh, and benefited about 60% of electricity users in the country. Second, the Ministry of Energy and Mines directly invested in rural electrification, a process implemented by the National Rural Electrification Office (DGER) and other related agencies. Following the construction of these electricity systems, they were handed over either to state-owned distribution companies or to the municipalities for operation. The combined effect of all these efforts contributed to a significant increase in rural electrification, climbing from 24% in 2001 to 65% in 2012.

In 2006, a fund (*Mecanismo de Compensación para Sistemas Aislados*, MCSA) was introduced to supplement and rebalance the tariffs of off-grid systems. The objective of this fund, financed by electricity customers and complemented with government funds, was to guarantee that grid and off-grid costs are the same, from the point of view of private investors. Off-grid customers only pay 20% of the tariff and off-grid generation companies are compensated from the fund's resources. This social tariff for off-grid systems constitutes an innovative measure in LA.

However, in 2012 a broader program, the FISE (*Fondo de Inclusión Social Energético*), aimed at providing a more comprehensive solution to energy coverage shortcomings, was introduced. This fund promotes a universal energy service and is financed by the State, energy firms, and large electricity and gas users. The FISE seeks to expand energy coverage across the country, develop compensation mechanisms for residential consumers, and promote renewable technologies, including solar panels, for electricity generation in off-grid areas (Law 29852, 2012). Led by the Peruvian government and temporarily managed by OSINERGMIN, the FISE has implemented several innovative initiatives, including the distribution of vouchers to promote the use of liquid petroleum gas cookstoves and the reduction of electricity prices for final consumers in rural areas (initiated in 2016). It has also sought closer collaboration with private firms in strategic areas with the objective of reducing public investments.

Another example of the Peruvian government's efforts to complete the electrification process in the country is its organization of several universal service auctions. Their objective is to offer the lowest possible subsidies to companies investing in electricity generation in designated places, making use of renewable technologies. In 2013, the government auctioned 240 MW, which were allocated to 19 small hydroelectric systems. In 2014, it organized the first auction for the provision of off-grid systems in rural areas, and the winning firm obtained a concession for the installation, operation and maintenance of 500,000 autonomous solar panel systems. Finally, in 2016 the government auctioned 1300 GWh, the stipulation being that they have to be provided by renewable energies such as biomass, wind and solar systems, and 450 GWh to be provided by hydroelectric plants generating less than 20 MW (Quintanilla, 2016). Overall, this large-scale initiative is highly characteristic of the concessionary model, but it includes two particular innovations. First, it uses solar panels to cover almost all the territory and, second, it involves close collaboration between the Ministry and the regulatory agency in the design and management of the universal service policy (FISE, 2016).

8. Conclusions and policy implications

The electrification process in Latin America can be considered a success story. By the end of 2015, 95% of the population had access to electricity, up from just 50% in 1970. As such, the LA experience can serve as an example for many countries in Africa and Asia where coverage levels continue to be low despite many decades of electrification efforts. The main drivers of electrification in LA have been related to economic growth and democratization. Power sector reforms, characterized by privatization and regulated market competition, have also attracted investment at crucial points in the process, but more significantly, the establishment of independent regulatory agencies has provided policy stability and transparency.

However, 28 million people in LA are still without access to electricity. Many of these people live in remote, rural areas, where extending the electricity network is extremely challenging. Innovation, especially in the form of new renewable energy technologies, is proving essential in extending access to electricity without having to expand the electricity network. But the implementation of rural electricity policies is often ineffectual, resulting in policy failures. Moreover, these efforts may be subject to the vested interests of large firms and intermediaries, both local and multinational (Howe et al., 2015). To mitigate these problems and achieve the political goal of full coverage, electrification projects need to be adapted to the socio-economic and geographic conditions of the area. These projects also need to promote the close coordination of all the institutions and local communities involved in the electrification process. In this regard, a particularly relevant area for further research would be an examination of the characteristics of the community-based projects implemented in the region over the last decade.

The Peruvian case (presented in the last section of the paper) is a clear example of a new generation of public policy that can be used to attaint full electricity coverage in a more coherent and active fashion. After many years of fragmented and limited initiatives, the FISE program (2012) combines a variety of regulatory instruments and public resources with the objective of universalizing access to and the use of clean energies. This initiative has been complemented with several universal service auctions aimed at completing the electrification of rural areas with the use of off-grid technologies.

The next challenge the continent faces is to increase its overall consumption levels. Indeed, in spite of the successful expansion of electricity coverage in the region, per capita consumption is very low compared to that of developed countries, and there are huge disparities in consumption levels between and within countries. Social tariffs and subsidies are the traditional instruments used by LA governments to foster consumption, but it has probably been the economic growth of the last few years that has enabled millions of people to escape poverty and to begin to purchase electrical equipment (such as fridges and heating systems) that has induced the biggest increase in energy consumption. Increasing consumption levels in rural and isolated areas is a much more difficult objective and will require a different set of policy instruments. On the one hand, many communities in these areas live below the poverty line and lack access to other basic services, such as roads, safe water and telecommunications that might act to spur their development.[21] This means that electrification strategies there cannot rely on marker-oriented solutions. On the other hand, the electrification of these regions has been based on off-grid renewable energies, which make it possible to use basic services such as light and television, but not other appliances

[21] Electrification has a greater impact if complemented by investment in water, education, health and infrastructure. New initiatives have been adopted in recent years that seek the integrated management of environmental resources. See, for example, the Nexus Observatory project, promoted by the UN-FLORES Institute (https://nexusobservatory.flores.unu.edu/).

that consume more energy, such as fridges, clean stoves and agricultural machinery. In the coming years, the countries of LA will have to define the quality of the electricity service they want to offer their rural communities and they will need to verify whether the technological solutions they currently offer are appropriate for meeting this goal.

Appendix

Insert Table 1

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