A utility approach to accelerate universal electricity access in less developed countries: A regulatory proposal

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Working Paper IIT-18-010A

Preprint

Economics of Energy and Environmental Policy

Special Issue: Access to Electricity: Global Experience and Future Directions

In press

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Keywords: electricity, infrastructure, regulation, development

Abstract

We propose a high-level definition of a large-scale business model designed to accelerate electricity access, and attract corporate investment in electrification in developing countries. The model is based on the findings of an investigation of the factors underlying the low level of electricity access in a large number of developing countries, and an examination of practical alternative business models to replace the nearly universal government owned power company model. Our proposal – the Electricity Company of the Future, ECoF – seeks to address the existing problems that cripple the incumbent power companies and discourage further investment. The ECoF is built around the concept of an enhanced distribution utility we term the "Integrated Distribution Company" (IDC), incorporating a wide variety of additional context-dependent activities including, for example, operating and investing in generation and transmission, operating battery charging stations, and manufacturing and selling appliances. The ECoF does not necessarily have to cover the entire ensemble of activities needed for electricity supply – its fundamental role is to provide electricity services in underserved areas. The structure and scope of the company should be adapted and implemented differently in each country.

1. INTRODUCTION

According to the International Energy Agency (IEA 2017) electrification efforts have taken place too slowly to achieve universal access to electricity by 2030, an objective included in the 7th United Nations Sustainable Development Goal. 1.1 billion people live without access to electricity, spending about $27 billion annually on mobile-phone charging and lighting with kerosene lanterns, candles, and flashlights. More than another billion people nominally connected to electricity grids experience very inadequate quality of supply. The estimated volume of investment that would be needed to achieve even the modest level of universal access to electricity as defined by the IEA by 2030 is $52 billion per year. Therefore, it is imperative to "think big" in order to address this problem in its true dimension. Given the perennial scarcity of public funding in most developing countries, this necessarily means to create viable business models that can attract private investment.

It clearly appears that the incumbent power companies of many developing countries have not been able to deliver access, or an acceptable level of service (Maithani and Gupta 2015; World Bank 2014; World Bank 2017a; World Bank 2017b; World Bank 2017c; World Bank 2017d). We have looked into the factors leading to the lack of electricity access, singled out the areas where serious investment is needed and examined the incumbent business models, and identified where the core problems appear to be. We propose guidelines to establish a business model approach – the Electricity Company of the Future, ECoF – that, based on past experience, could address the existing problems that cripple the incumbent utilities and discourage further investment. The ECoF in developing country settings does not necessarily have to cover the entire ensemble of activities needed for electricity supply – its role is primarily to provide electricity services in underserved areas, so that it may be only a part of an appropriately unbundled system. Accordingly, the structure and scope of the company should be adapted and implemented differently in each country.

The paper is divided in three blocks. In the first, we briefly describe the status of electrification in developing countries from a regulatory perspective. We then review the core activities that are necessary in a comprehensive electrification plan, and the business models that suit each model best. The final block introduces the ECoF, a company centered substantially around the business of electricity distribution, combined with regulatory innovations that make it better equipped to accelerate universal access in the developing world.

2. THE PRESENT REGULATORY PERSPECTIVE

The failure of the conventional power sector to provide universal electricity access in many developing countries has a number of well-identified causes, which have to be examined in the broader context of the regulatory reforms that have taken place in the world during more than two decades. The situation in emerging economies, in sub-Saharan Africa, south-east Asia and parts of Latin America, is very different from the standard model that is prevalent in most of Europe, the Americas and Australia (Littlechild and Joskow 2006). Few developing countries have fully unbundled their utilities, private sector participation has concentrated on independent power producers (IPPs), and wholesale and retail competition is generally absent. Instead, "hybrid power markets" have developed (Gratwick and Eberhard 2008; Eberhard and Godinho 2017; World Bank 2013), where incumbent state-owned utilities have retained dominant market positions and IPPs are introduced on the margin, i.e. both state-owned enterprises (SOEs) and IPPs are involved in new generation investments. A few countries have allowed the introduction of private capital and management in the distribution business, either via outright privatization, public private partnerships (PPP), or diverse types of franchises (World Bank 2017c; World Bank 2017d).

The following main challenges in these power systems have been identified (Pérez-Arriaga 2017; World Bank 2017a; World Bank 2017b; World Bank 2017c; World Bank 2017d):

i. The performance of utilities needs serious improvement. Inefficiencies in investment and operations, poor governance and few incentives for cost reduction lead to deterioration or collapse of services.

ii. Poor quality of service results in an adversarial relationship between the utility and its customers, which engenders illegal connections and unpaid bills, as well as a permissive attitude of the utilities and authorities with this kind of behavior. Politicians make use of subsidized tariffs to gain votes, leading customers to believe that they have right to inexpensive, or even free electricity, often effectuated via lax or unenforced collection policies.

iii. Capacity expansion and electrification need financing; any existing public resources must leverage private investment under reasonably attractive conditions. In addition, in general there is no clear assignment of responsibilities for planning, procurement and contracting.

The regulatory measures that have to be applied are apparent:

- Independent regulation must be introduced to insulate tariff-setting from opportunistic political interventions, thus enabling cost-recovery and more predictable revenue streams.
- Effective planning, competitive procurement and contracting – critical for accelerating investment in large generation – must be implemented widely. Since wholesale market competition (i.e., competition *within* the market) is beyond reach in most low- and middle-income developing countries, competition to enter the wholesale market (competition *for* the market) must be encouraged. This is presently also applicable to renewable generation, which can now be procured competitively.
- The performance of state-owned enterprises (SOEs) – distribution, in particular, which is the weakest link in the supply chain – must be improved by incentive schemes, SOE governance reforms, clarification of roles and responsibilities, a more consumer-centered approach, and improved transparency and information. This would all be greatly facilitated by changes in the ownership structure of the SOEs and their management, promoting the entry of private capital.
- Transmission, a natural monopoly, can attract private investment in a cost-efficient manner via auctions, but this requires legal security, a competent entity in charge of regional network planning – plus enforcement of the plan – and sound regulation, particularly with regards to the allocation of costs of new investments.

There is no single approach to electrification. Despite numerous attempts to develop integrated

electrification models leveraging a range of energy access technologies, until now the dominant pathway for providing electricity access has been through grid extension, which has been the source of the vast majority (97%) of new electricity connections since 2000 (IEA 2017). This requires coordinated developments of the complete chain of distribution, transmission and generation. However, rapidly declining costs of solar PV, battery technologies and energy efficient appliances are making decentralized renewable energy systems increasingly affordable, and often competitive with grid extension in rural and dispersed communities. Decentralized systems can also be attractive in areas with grid access but unreliable power supply. The opportunity to combine the three dominant modes of electrification – grid extension, mini-grid, and standalone solutions – increases the number of pathways available to attain electricity access.

The differentiation between the three electrification modes is becoming smaller, as the experience in several countries shows. Any of the three could be adopted depending on multiple circumstances, two or more modes may coexist for some consumers (typically one as a back-up for the poor reliability of other), and in some cases off-grid solutions may be a transitory bridge between total lack of access to electricity and the connection to a reliable central grid. Several electrification planning studies, performed with our Reference Electrification Model (REM) computer software, show how the mix of electrification modes in the lowest cost plan strongly depends on some critical factors, such as the layout, capacity and reliability of the existing grid, the expected demand level, the topography, the cost of the components, the target reliability for off-grid solutions, and the local price of diesel[2].

Needless to say, the regulatory designs must be tailored to the specific country circumstances. Further, countries must have certain characteristics to be able to attract substantial private investment, including: i) adequate governance, which includes both sound policy and regulation, legal security and functioning institutions; ii) some level of development in information and communication technologies (ICT); iii) significant market potential – i.e., scale – for any of the business models related to electrification activities; and iv) social and political receptiveness to the presence of private actors in electricity supply.

3. INVESTMENT OPPORTUNITIES AND CHALLENGES IN THE ELECTRICITY SUPPLY CHAIN

The supply of electricity requires the contribution of several activities of very different nature from a regulatory, financial and organizational perspective. They also relate differently with the several electrification modes. In this paper, we have focused on the activities that we have deemed as having the best chances for large investments for electrification purposes in developing countries: independent power production (IPP) with large generation, independent power transmission (IPT), electricity distribution and retail, mini/micro grids, and stand-alone home systems. Other activities, like manufacturing, distributing and financing home appliances, battery charging and appliances for productive uses, can also attain very substantial dimensions. However, they are considered here as ancillary to the electrification processes via grid extension and decentralized solutions.

Some activities require a minimum level of good governance so that the country risk is tolerable; this kind of risk is less important when selling solar home systems directly to end users, for instance[3], than when investing in a regulated distribution company, whose remuneration directly depends on a regulatory decision. Similarly, IPP generation does not need sophisticated ICT infrastructure and know how in a country, which is a critical factor for an off-grid pay-as-you-go (PAYG) business. The market potential or market size of a country may be very different for distribution privatization, IPP generation or PAYG solar home systems, since some countries may be favorable to the entry of IPP generators, but reluctant to release the control of publicly owned distribution companies and they may or may not have adequate conditions

[2] See the MIT / IIT-Comillas Universal Energy Access Lab website: http://universalaccess.mit.edu/#/main

[3] The PAYG model for SHSs is exposed to the currency exchange rate risk, as well as to import taxes for components, which also depend on regulatory measures.

for deployment of PAYG solar home systems (SHSs). The market potential for distribution privatization depends on the size of the distribution company to be privatized, which may not be directly related to the size of the country where it is located.

3.1. Large centralized generation

Providing universal access to electricity in countries with low levels of electrification will need massive investment in generation and transmission infrastructure (IEA 2017)[4], given that the generation capacity and kilometers of lines per capita in these countries are much lower than in the rest of the world (World Bank 2017a).

The current approach to large generation investment is quite standard, but for the fact that a substantial amount of new investment opportunities will be on renewable technologies. IPPs are generally contracted under long-term power purchase agreements (PPA), with two-part contracts: fixed payments for availability (per MW) and variable payments for energy (per MWh).

This model has worked so far, and it will continue to do so under the standard practices of risk management that have become common during the last two decades. However, as typically implemented, it has several shortcomings (Africa GREENCO 2017). With the exception of a handful of cross-border projects, IPPs within SSA are currently structured on a bilateral basis, i.e., with a single buyer and seller, and they are negotiated on an ad hoc project-by-project basis. Negotiations of project documents for individual IPPs are usually very lengthy, often lasting many years. To reduce risk to all parties and to increase liquidity, it has been proposed (although not yet tested) to interpose a single creditworthy counterparty between buyers and sellers on multiple independent power projects (Africa GREENCO 2017).

The advantages of power pooling and the subsequent need for cross border transmission reinforcements cannot be overemphasized, given the small electrical size of many of the countries we have analyzed. Some large generation investments are only economically justified if there is enough transmission capacity shared under sound trading rules among countries within a geographical region. Progress has been made in establishing large power pools in sub-Saharan Africa: The Southern, East, West and Central African Power Pools. However, the lack of institutional strength and flaws in the market rules and transmission regulation under which they operate continue to hamper investment in generation and, most significantly, in the transmission networks (Rose 2017).

3.2. Large transmission network assets

The Independent Power Transmission (IPT) model is considered to be well-suited to the conditions of developing countries, and can be attractive to private investors (World Bank 2017a). IPTs have already performed well in several developing countries, and are relatively straightforward to accommodate within the legal framework. Among other things, legislation, licenses, and other legal instruments can be made to provide for multiple transmission providers. Also, concessional finance, in wide use for generation IPPs, can be adapted to the IPT case.

Further, IPTs may require a lower need for investor confidence in a country's regulatory capacity. Under a project finance structure, a government guarantee on payment can be linked to a small increase in electricity tariffs designed to provide for cost recovery, irrespective of the government's other debt servicing burdens, and expenditures. This protects the return on investment for private investors, and can be used both for national internal transmission and interconnectors.

International experience with regional electricity markets suggests that necessary investments will not take place without regional rules for network planning, cost sharing and management. Coordinated planning is needed to identify investments that satisfy regional needs rather than the needs of each country alone. For transmission projects of regional scope, the costs of designing and implementing a project tend to be high

[4] South Africa will need close to 300 GW of new additional generation before 2040, which will require about US$20 billions of investment a year.

and the benefits are often distributed among multiple agents spread across multiple countries. Some sound cost-allocation method that is agreed upon at a regional level is needed to guarantee cost recovery for network investments. Project sponsors could negotiate payments among potential beneficiaries, but this is not ideal as it would tend to limit the types of projects being developed to only those with a small number of easily identified beneficiaries.

3.3. Electricity distribution

Electricity distribution is considered to be the weakest link in the entire value chain of the power sector in developing countries. In most, "distribution companies" are simultaneously the network company that connects the consumers to the main grid from which most of the power is drawn (i.e. the strict distribution activity), and also the retail company that purchases the power at wholesale level so that it can sell it to the end consumers at regulated retail tariffs. In virtually all developing countries, the collected revenues from the tariffs fall short of recovering supply costs (World Bank 2017b).

Since it is the distribution company that collects the revenues from the end customer and pays the wholesale energy costs as well as transmission and regulatory charges (taxes, diverse subsidies, etc.) to the corresponding parties, it is the distribution company that absorbs any (usually substantial) deficit. This leaves many distribution companies in the developing world chronically unprofitable, and even insolvent. Consequently, without periodic state bailouts most publicly owned distribution companies would be unable to function. Likewise, in such an environment, privately owned distribution companies would require ongoing subsidies to be viable. Financial viability has been achieved only in a few cases, in mostly urban areas, with private ownership or public-private partnerships (World Bank 2017c; World Bank 2017d).

Electricity distribution in rural areas with low and dispersed demand is much more expensive (up to several times more) than distribution in densely populated urban areas and with higher demand per household. In countries with low levels of electrification, attempting to cover the electrification cost of the many (without access) by a surcharge on the few connected to the grid places an unacceptable burden on viable urban ratepayers, and potentially on commercial and industrial customers[5]. Since the available direct and cross subsidies are usually insufficient to cover the cost of providing rural service, distribution companies typically drag their feet in extending rural service. The term "viability gap" denotes the difference between the actual cost of providing the service and the revenues that are actually collected from existing tariffs or estimated from the willingness of potential customers to pay.

As indicated previously, there are several formats for potential private participation in the management and ownership of (mainly) publicly-owned distribution companies. In the franchise model the incumbent distributor retains ownership of the existing assets, and the privately-owned firm takes full managerial responsibility for a prescribed period of time, is strongly incentivized to improve reliability, efficiency and revenue collection –including theft reduction – and makes any necessary associated investments (which will be transferred to the incumbent distributor at the end of the license period). The franchise model has been successful in a few instances, almost exclusively in urban environments; however, it is not meant to enable substantial new electrification investments, and therefore is not the best approach for situations in which greatly expanded electricity access is desired. Privatization, or better, the public-private partnership approach, is more suitable for such situations (Indian Secretariat for Infrastructure 2012), but private investors would require that the viability gap issue be satisfactorily addressed.

In developing countries, on- and off-grid solutions coexist and compete, with the incumbent distributor solely responsible for grid extension, and a multiplicity of generally unregulated developers offering off-grid electricity services in areas where grid-service is either unavailable or unreliable. One might well anticipate that in many cases this will result in duplication and waste in the long term.

[5] This is the method that has been used in most developed countries to achieve full electrification, when only a minority of households remained unelectrified.

3.4. Mini/micro grids

Here we shall use the term "mini-grids", regardless of system size. Mini-grids are most common in areas without access to grid electricity, but they can also be found in areas with unreliable grid electrification. Mini-grids may connect to the central grid at a future date if they are built according to the established grid code.

Mini-grids are typically owned and operated by private developers, in most cases without any formal agreement with the local distribution company, and they are subject to little or no regulation, at least until they reach a significant size as measured by generation (e.g. 100-500 kW). In order to secure long-term revenue streams, many mini-grid operators seek contracts with large (anchor) customers such as industrial/commercial business, large buildings such as hospitals, or telecommunication towers.

All other things being equal, the cost per kWh of the mini-grid service in an isolated rural area is in general higher than the typically-subsidized tariff of the incumbent utility, but lower than the per kWh cost of power obtained by grid extension. The financial resources of rural households will frequently be too low to enable them pay for either scheme. Subsidized tariffs for grid-connected customers present a risk for the mini-grid entrepreneur if the regional distribution utility decides to electrify the area in which they are operating, since customers would opt to switch to the lower cost supplier – typically the regional utility. Without some form of assurance from the government or utility, such as an exclusive license, cost-reflective tariffs, guaranteed subsidies, or at least a secured payment for the residual value of the network assets and the power injected into the grid, mini-grid developers are typically hesitant to invest in areas likely to be connected to the grid within a foreseeable time horizon. Regulation must provide a stable and reliable framework to compensate mini-grid owners in the event of grid arrival.

In most rural areas, low ability-to-pay strongly limits expected financial returns, therefore deterring large-scale private investments in the sector. This situation could obviously be mitigated by government assistance in the form of up-front grants or on-going subsidies; however, laws and regulations that would ensure the payment of such subsidies are typically not present. Where they are, mini-grid developers face the considerable risk that the subsidies will not be honored for the lifetime of a project, which may be decades. To limit risks, profitability expectations are defined in the short/middle term, forcing mini-grid developers to quickly recover their costs, thereby limiting the affordability of the service.

Community engagement remains a crucial aspect for mini-grid operators to ensure that customers see the value of the system, and are willing to pay for the service it provides, and trust the mini-grid operator.

3.5. Stand-alone home systems

Individual solar home systems (SHS), including solar kits, presently have a large rate of expansion, based on innovative business models and recent improvements in the price and efficiency of solar panels, the emergence of smart metering technologies, and the widespread use of mobile phones and mobile payment facilities in operations and collections (Sotiriou et al. 2018).

The new business models provide financing for solar kits using the so-called "pay-as-you-go" (PAYG) system. Customers receive the solar product after making a small down payment, and then prepay (usually) monthly to use the solar product via mobile money for a period of 12 to 36 months, whereupon they own the asset. The consumer is denied energy service if his or her prepaid balance has been used or expires, and is given access again when the consumer adds prepaid credit to his or her account. Some PAYG companies track information on product performance (i.e. solar panel and battery voltage) and customer usage, sending data back to the central software hub on regular intervals.

To satisfy their investors, PAYG companies primarily have focused their activities on wealthier customers in the most densely populated urban and rural regions of some of the most populated sub-Saharan African countries (e.g. Kenya, Rwanda, Tanzania). Thus, solar kits remain, in practice, out of reach for nearly half

of the rural populations of these countries. Innovative and inclusive financing schemes involving public funding could largely increase the effective addressable market of the PAYG solar sector.

This sector is in the hands of private companies that generally operate independent of the incumbent distribution companies, regulatory authorities or government planners. Some of these companies are fully integrated, with in-house design, manufacturing, distribution, customer management and training; while others procure systems from third parties, and focus on distribution and consumer services. These companies raise funds on international debt and equity markets and are subject to strong profitability constraints.

Local regulations (e.g. taxes and stability and predictability of import tariffs for components) on SHSs have been shown to have a dramatic impact on the feasibility and financial viability of PAYG solar business models. PAYG solar companies preferentially emerge in countries where local regulations are favorable.

After years of spectacular growth, a number of the larger PAYG companies operating in sub-Saharan Africa are now facing unprecedented operational and financial challenges as they expand their activities to complex markets; a consolidation of the industry into a smaller number of efficiently managed firms with strong business models seems likely.

4. THE ENERGY COMPANY OF THE FUTURE

The many experts consulted concur that the heart of the electrification deficit is in the distribution activity. Incumbent distributors devote most of their efforts to grid extension, struggling with deteriorating assets and quality of service, theft and unpaid bills, poor reputation among consumers, and financial survival, while paying little attention to actual consumer needs. There is typically no overall strategy to move consumers from the lower access tiers to full access, either on or off-grid, nor to coordinate electrification planning with overall economic planning to ensure an economic return on electrification investments, with associated growth in demand.

Despite the many difficulties experienced today, distribution – in its broadest rendering, including network assets and commercial activities, encompassing all forms of electricity supply (i.e. grid connection, mini-grids and stand-alone systems), and because of its present weaknesses – offers multiple possibilities for innovation in management, technology, regulation and consumer engagement. This is particularly the case for the last mile, where the direct interaction with the end consumers takes place.

We propose here an approach (the ECoF), that tries to overcome the major limitations of the model that is present in most developing countries and pursues some key societal objectives: i) acceleration of the electrification process while guaranteeing that it will reach everybody with a planned incremental strategy; this will require the growth of connections to the main grid or to mini-grids, and the provision of microfinance for the purchase of solar home systems when this is the most cost-effective option; ii) efficient use of resources, minimizing duplication and waste; iii) reduction of the financial risk – and the cost of capital, as a consequence – for the expensive investment in and operation of network assets; iv) creation of a positive relationship of collaboration with the customers, making use of local expertise, in order to enable reduction in the level of theft and unpaid bills; v) improvement in the technical and commercial quality of service; vi) leverage electrification to promote productive uses of electricity, and vii) make use of customer relationships to enter adjacent markets, such as ICT, agro-marketing, retailing of non-electrical goods, or banking.

4.1. Characterization of the ECoF

The ECoF is built around the concept of an enhanced distribution utility that we shall term the “Integrated Distribution Company” (IDC). The ECoF is the IDC, plus other activities that might be added depending on the circumstances, and that will be described later. The key elements of the IDC are:

- *The distribution activity is defined here as a zonal concession* (World Bank 2017d)*, i.e. a company with the obligation of electricity supply to all existing and potential customers in the assigned territory, by any electrification mode*. Rather than caring only for the grid-connected consumers, the new distribution company would be responsible for the supply to all consumers in some assigned territory via any technical means – grid connection, mini-grids or stand-alone systems, and even battery charging – where the off-grid solutions could either be provided by the distribution company, outsourced to franchised developers or left to independent developers under the supervision of the regulatory agency and the distribution company. Cooperatives and mini-grids interacting with the distribution company through a connection point can be accommodated. The scarcity of funding may impede the investments that would make possible an immediate implementation of universal electrification. However, an integral plan that "leaves no customer behind" – although with diverse electrification modes and timing, as needed – must exist, and its implementation must commence from the outset.
- *Substantial private participation in the ownership and management of the incumbent distribution utility.* In general, the necessary managerial, financial and operational changes would be made possible by the ownership participation and management responsibilities of a large private energy firm with sufficient financial muscle in the incumbent (typically publicly-owned) distribution company. This private firm, by itself or in consortium with one or more local companies, must have the technical expertise to deal with last mile distribution issues and the capability of effective consumer engagement.
- *Recognition of the different capability requirements and risk profile of the mostly-infrastructure and mostly-consumer centered business models*. The classical distinction between the activities of *distribution* (i.e. installation and operation of network assets) and *retail or commercialization* (i.e. purchasing wholesale electricity and selling it to end consumers, serving as the only interface with them) is magnified in the context of rural electrification[6]. While the former should be treated as a regulated monopoly – an activity of low financial risk and mostly related to physical assets – the latter has several important sources of risk and its success mostly depends on its relationship with the consumers, and how it is perceived by them. The "infrastructure" side of the distribution company would be accountable for the quality of the physical service provided to the end consumers and the technical losses in its networks. The retail firm would be responsible for metering[7], billing, the reduction of electricity theft, and all activities related to commercialization of the electricity product and consumer engagement, including the search for anchor loads, the development of productive uses of electricity and the design and utilization of an adequate system of tariffs that could facilitate the viability of the company. Proper regulation of the IDC will require some sort of "regulatory separation" of these activities (accounting separation at least; legal separation is cleaner, but it increases the transaction costs between the two companies).
- *Focus on a more integrated and consumer-centered approach.* The presently deteriorated relationship between the consumers and the distribution utility has to be radically changed. To achieve this

[6] Distribution and retail are activities generally carried out by the same company in developing (and also in many developed) countries, and their unbundling has been always proposed and implemented with the purpose of making possible retail competition and business models based on distributed energy resources. For instance, in the member states of the European Union is mandatory to separate (at least, legally) the activities of distribution and retail. This separation, under the denomination of "carriage and content", is a major topic of debate presently in India. Here the purpose of this unbundling is different: better allocation of financial risk and utilization of the specific skills for each business.

[7] In power systems in developed countries, all metering-related activities usually fall under "distribution", in the case of unbundling of distribution and retail. In developing countries with a significant lack of access, where the type of metering is an essential component of the relationship with consumers, ownership, installation and maintenance of meters can reside with the distribution company, while data collection and treatment, plus billing, can be the responsibility of the retail company. This arrangement can more easily converge in the long term to the normal worldwide practice.

objective, it is necessary to focus on the human factors that are most relevant to an integrated distribution company and that are amenable to be influenced in a positive way. Relevant strategies are: i) before any other measure is adopted, the physical quality of service has to improve significantly to a level perceived as acceptable, so that customers notice that a change has taken place; ii) provide the means for more effective and immediate communication channels between the service provider and the consumers, with a well-staffed and around the clock call center, plus consumer attention offices – both fixed and mobile – for direct interaction with the customers and ample schedule of attention to the public; iii) technology-based interventions (e.g. additional sensing and control technologies applied to individual consumption and the power infrastructure, which may enable better management of the power system, as well as prediction, prevention, detection and reduction of electricity theft); iv) ground-level consumer engagement activities; e.g. develop a network of trusted local individuals who know the communities well and can serve as "brand ambassadors" for the company, and build women literacy centers or professional education and training centers; v) "connection camps", whereby the company sends some staff to neighborhoods to help potential customers without connection with the logistics of the process and financial support, so that they can immediately have access.

In addition to and reinforcing these essential reforms, there are other measures of a more conventional nature, but equally necessary to achieve the desired objective of accelerating the universal electrification process with a viable ECoF:

- *The Integrated Distribution Company (IDC) may be enhanced by integrating into the same business model other major electricity supply activities, such as generation or transmission*. Owning generation in sufficient volume can guarantee the physical supply of electricity and provide price hedging. Owning transmission can also increase the firmness of the supply to the IDC. Investments in generation and transmission can also help in establishing or reinforcing the presence of the new private company in any selected country.

- *Exploit the several existing opportunities to reduce the viability gap by improving the efficiency of the distribution company and increasing its revenues.* As a private company takes over the property or the responsibility for managing a troubled distribution company, the opportunities for cost reduction and increasing revenue collection are multiple, and can jointly significantly reduce the difference between costs and revenues (the "viability gap"), which unquestionably is the major roadblock to achieving economic viability. Possible measures include: advanced digitization –with implications on theft control and payment of bills; better consumer interaction and company perception; cost reduction by mass production and standardization or massive purchases of equipment; microfinance loans and further consumer involvement, for instance facilitating purchase of appliances and bankability; and promotion of productive and community uses of electricity that can spur economic development.

- *Focus on and give priority to electrification projects associated with productive uses of electricity*. The classic "two lights and phone charger" must be only the beginning, not the end, of the electrification process. The connection between electrification and productive and community uses of electricity cannot be overemphasized, since it is the most promising option for reducing the viability gap once the low hanging fruit has been collected.

- *Engage in additional activities that may improve the economic viability of the company*. The integrated distribution company could engage into additional activities to improve its economic viability, such as battery charging or selling and installing solar pumps to improve agricultural productivity. Design and manufacturing of solar kits and appliances is another possibility. It may also venture into other sectors where synergies with electricity exist, such as information and cultural or entertainment services, retailing of diverse goods, banking or health.

4.2. Regulatory design of the Integrated Distribution Company

The corporate structure

The first step in the design of the IDC is to define a structure of ownership and management of the new distribution company that is acceptable socially and politically in a given country, while preserving the autonomy of the private company to operate and invest in the manner that it considers is most appropriate for its viability, and ability to ensure consumer satisfaction. As indicated before, the distribution franchise model (DF) – which has succeeded in dramatically reducing aggregated technical and commercial losses and in improving quality of service in several countries – may not be adequate when significant new investment in electrification is necessary. Acceptable options would range from complete privatization to partial ownership of the company –under some PPP format – but with complete responsibility in its operation and any new investments by the new private component.

Both privatization and PPP arrangements will require a large volume of investment for distribution companies with one million customers or more. The private company must combine a large financial capability with technical experience in distribution and consumer engagement skills in the specific local context. If this combination does not exist in a given country, a consortium of companies can be created for the purpose. The regulatory guidelines that follow assume at least an "accounting unbundling" of the distribution and retail sides of the IDC, so the regulatory design for each side can be done separately.

The distribution side of the IDC

The distribution side of the IDC is responsible for the system operation at a distribution level in the franchised area, and for making the electrification plan, i.e., the specification of the electrification mode (grid extension, mini-grid or stand-alone system) corresponding to each customer, compliant with the quality of service target prescribed by the regulatory authority. The plan must account for the possible transition from one electrification mode to another (e.g. moving from being supplied by a mini-grid to being connected to the main grid). Because of budgetary constraints and the low and unequal financial capacity of the customer base, the electrification plan will include all customers but may not give to all of them the final desired level of access within the considered time span.

The distribution company also builds, maintains and operates the main grid and the mini-grids specified in the electrification plan under regulated conditions of grid compatibility, quality of service, tariffs and subsidization. The distribution company must make sure that the mini-grids that are included in the electrification plan – either for isolated rural communities on a permanent basis, or as a bridge to a grid-connection in the future – are implemented. This may require the participation of local mini-grid developers as IDC franchisees, or the creation of a separate company within the IDC holding fully devoted to mini-grid activities. External developers may work directly with communities to settle the provision of electricity from mini-grids in areas where the electrification plan will still take some time to materialize, with mutually agreed upon tariffs in the temporary absence of subsidies. These operations should moreover be subject to grid compatibility requirements, to be inspected and enforced by the distribution company and supervised by the relevant regulatory authority.

The regulation of the distribution network is similar to what is being applied to many distribution companies worldwide. A differentiator is the typically high losses – both technical and resulting from theft. The reduction of technical losses must be the objective of *ad hoc* performance-based regulatory incentives. Dealing with illegal connection and non-paid bills should be left to the retail side of the company, with the technical support of the distribution company. The resulting regulated remuneration of the distribution network should be guaranteed and recovered from the tariffs paid by the customers (preferably) or other ring-fenced funds.

The retail side of the IDC

The innovation in the proposed creation of the IDC mostly resides in this "enhanced retail side", which is responsible for an ensemble of tasks, most of which require direct interactions with all customers connected to the main grid: i) collect the metering data and bill the customers connected to the main grid and to the mini-grids under the control of the distribution company; ii) perform activities necessary for reducing theft

and unpaid bills according to any time schedule established by the regulatory authorities; iii) facilitate that those consumers that are supposed to be supplied with solar home systems within the concession territory of the IDC can get them; this can be facilitated via microfinancing, and/or directly selling the equipment; ICT, commercial and maintenance activities may help in establishing a relationship with these consumers, equivalent – or even closer – to that existing with grid-connected consumers.

The regulation of the retailing side of the IDC is not trivial because it must cover several activities, some of which should be regulated very lightly, if at all, while others have to be supervised more carefully.

- Collection of metering data and billing can be a regulated activity under cost-of-service regulation. However, given the special conditions in many developing countries, strong performance incentives should be added to reduce theft and unpaid bills according to time trajectories specified by the regulatory authority. The estimated efficient costs incurred in consumer engagement and social activities necessary to establish a solid consumer-centric approach must be acknowledged in the regulated remuneration. Activities beyond what is necessary for this purpose may be incurred by the retail company to further other commercial businesses, and this part should not be subject to regulated remuneration. The boundary between the two is fuzzy.
- On the other hand, the default provision of stand-alone systems (solar kits, typically) is usually a non-regulated commercial activity operating in a competitive market, to be performed by an outsourced company, which we propose must be mandated to comply with a minimum set of requirements to incentivize its physical presence and business activity throughout the concession territory[8].

The participation of the governments

The presence of the IDC, with new investment capacities and efficiency improvements, will lessen the financial burden of the corresponding government, which today has to subsidize the publicly-owned distribution company heavily, and will also provide fresh funds because of the entry of the new investor in the capital of the distribution company. In exchange, the government might commit to provide subsidies targeted to facilitate basic access to the most vulnerable consumers, thus contributing to getting closer to the "universal access" objective. It is further expected that the presence of public ownership in the IDC will facilitate that this objective will not be ignored.

4.3. Implementation challenges

From a regulatory standpoint, the most obvious implementation challenge is the adaptation of the IDC approach to the existing regulatory framework in each country. From a legal and regulatory perspective, the proposed corporate structure, the concept of a territorial concession with supply obligation and the minimum requirement of accounting unbundling should not be a major problem in most jurisdictions, but legal security requires strict adherence to the regulatory approach that has been outlined above.

From the political and social perspective, the adoption of the most adequate approach is very country dependent[9]. There are two acceptability-related dimensions to be concerned about: on the one hand the compatibility with existing public policy regarding privatization or private involvement in the power sector, in particular taking into account any past or current experiences; and, on the other, negative public

[8] For instance, this company may be required to show some minimum level of activity in specific areas of the concession zone. A system of subsidies and incentives can be established whereby this outsourced company would receive a regulated payment per stand-alone system or appliance that is sold to customers that are not connected to the main grid or any of the regulated mini-grids. Alternatively, customers that are not connected to the main grid or any of the regulated mini-grids could receive a subsidy when they purchase a stand-alone system or appliance (this incentive may decrease with the capacity of the device or apply only to devices below a certain capacity, always avoiding or minimizing discontinuities in the specific regulation).

[9] For instance, in India at this moment straight privatization and PPPs appear to not be politically viable, while franchises with their several possible formats seem to be easier to accept, with variability depending on the specific state.

perceptions – and this includes trade unions, consumer associations, or environmental groups, among others – of the private sector in electricity supply.

Another potential issue is the social perception of a distribution utility that offers different kinds of electricity services (i.e., different electrification modes, each with its specific tariff and quality of service requirement) to households located in a given territory, and the ways in which this may create social unrest or perceptions of unfairness with regards to differentiated services. It may be the optimal techno-economic solution, but it has to pass muster in acceptability and consumer understanding.

The ultimate test of the proposed approach is economic viability. The IDC business model will not be viable unless a solution can be found in general to any existing structural viability gap. The gap should be substantially reduced under the proposed approach, if the measures that have been proposed are implemented.

However, after all the efforts above have been made, it may happen that some amount of viability gap still exists. This is to be expected, since almost in every country – either developed or developing – the electricity tariffs in rural areas are cross-subsidized by the electricity tariffs in urban areas when the residential tariffs are set to the same level in the entire country, regardless of the location. Unfortunately, this measure has to be applied with restraint in developing countries where the number of rural customers to be subsidized amply exceeds the number of those that will have to pay more. One undesired implication of excessive cross-subsidization is grid defection by the wealthier customers to avoid being subject to overly high electricity tariffs.

The uncomfortable truth is that some viability gap may remain, which could be substantial, given the size of the unelectrified population in some countries. If this issue is not addressed explicitly and clearly, the economic viability of any large electrification project will be seriously compromised and no large investment will take place, since even the largest private donors will lack the necessary financial muscle. How can this potentially critical problem be addressed?

- In the first place, the volume of the viability gap has to be quantified, as an essential component of any electrification plan. This can be addressed with the help of specialized computer software.[10]
- Unless public funds exist to fill the gap, which does not seem to be the case in most developing countries, the only reasonable approach is to proceed gradually in time, addressing the least costly electrification targets first (the low hanging fruit), but within a comprehensive approach that includes all of the population in the plan (nobody left behind), making progress in all electrification modes simultaneously.
- This gradual approach will require: i) the identification of those communities where electrification could more effectively promote economic development and, consequently, affordability; and ii) access to concessional loans to enable the initial investment, with a grace period long enough to allow the electrified community to start repaying. Similarly, additional loans would be required to reach the next layer of the population to be electrified.

This high-level approach to the design of a company that could help to accelerate electrification in developing countries has been discussed and has received positive comments and suggestions from a number of experts in regulation and electrification. The next, and more important part in the implementation of this concept, is the parallel discussion with, on the one hand, the governments, regulatory authorities and diverse stakeholders in a few selected countries and, on the other hand, large energy companies that might be interested in being principal actors in the ongoing electrification process in middle and low-income developing countries.

[10] See, for instance, the capabilities of the Reference Electrification Model (REM), http://universalaccess.mit.edu/#/main

5. ACKNOWLEDGEMENTS

The research work that has allowed our team, at the MIT/Comillas Universal Energy Access Lab, to write this paper has been made possible by support from the MIT-Tata Center for Technology and Design, the Shell Foundation, the Spanish National Plan for Research, Development and Innovation of the Ministry of Economy and Competitiveness, Iberdrola Foundation, Enel Foundation, and the World Bank. We explicitly want to thank a number of experts for comments and discussions: Pradeep Pursnani from the Shell Foundation, Praveer Sinha and collaborators from Tata Power Delhi DL, Debajit Palit from The Energy and Resources Institute (TERI), Amit Bhargawa from the Uttar Pradesh Electricity Regulatory Commission (UPERC), Sushanta Chatterjee from the Central Electricity Regulatory Commission (CERC), Anton Eberhard from the University of Cape Town, P.C. Maithani from the Ministry of New and Renewable Energy (MNRE), David Jankofsky from Deloitte, and David Ehrhardt from Castalia. Only the authors of the paper are responsible for its content.

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