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# Smart electricity distribution networks, business models, and application for developing countries☆

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ABSTRACT

The electricity distribution industry in the developing world is dominated by public sector utilities. These utilities are technically and economically inefficient and face large financial losses that prevent further development of the networks. The reforms are introduced to unbundle the vertically integrated utilities and introduce private investment and management, but these efforts often fail due to poorly designed market and incentive models. Focusing on the electricity distribution in developing countries, we propose a business model based on organizing the utilities into distinct activities and businesses. In many developing countries political economy and weak investment conditions do not favour full privatization of utilities. However, in some activities 'competition for the market' and 'management contracts' can provide a partial role for the private actors. The model is based on the concepts of enterprise innovation, emphasizing external collaboration and partnerships and can be operationalized via specialization, where some specific tasks are outsourced. The proposed model can also be applied to developed countries as the energy sectors of both developing and developed countries are undergoing transformation due to new technologies such as communications, distributed generation (DGs), and active demand response.

## 1. Introduction

Access to modern energy services is crucial to human well-being and to a country's economic development. However, globally nearly 1.2 billion people are without access to electricity. More than 95% of this population is either in sub-Saharan African or developing Asia, and around 80% are in rural areas (IEA, 2015). In future, developing countries will account for an increasing share of total world energy consumption due to their economic growth, along with accompanying structural changes. As per the World Energy outlook 2016, Non-OECD demand for energy rises by 71% from 2012 to 2040 (WEO, 2016). On the other hand in the more mature energy consuming OECD economies, energy rises by only 18% in the same time span of 2012–2040.

The rapid increase in the share of developing countries in global energy consumption emphasis the need for new electricity sector and reform models to improve efficiency and productivity. Many developing counties are in some stage of reforming and developing new laws and regulatory framework for their electricity sectors, for transforming public utilities into market-oriented and regulated entities (Jamasb et al., 2017; Saleem, 2007). However, despite various market and regulatory reforms, the distribution sector continues to be weakest link in the electricity value chain and suffers from basic drawbacks such as high losses mainly due to lack of full-cycle measurement of electricity supplied, particularly to the subsidized categories of consumers, lack of accountability and an over-loaded and ageing network infrastructure (Scott and Seth, 2013).

Technological progress in telecoms sector brought about large benefits to many consumers in developing countries who were deprived of reliable service or lacked access altogether. However, similar progress and benefits in the electricity sectors of the developing countries are yet to be achieved. Thus, it is imperative for developing countries to explore new and smart networks and business models for the following reasons:

- To break the vicious circle of low investment, poor customer satisfaction and in turn low realization which is the source of poor financial health of various power distribution companies.
- The present emphasis towards low-carbon future makes distribution sector different than the conventional by having distributed generation, renewable penetration, demand side management and storage facilities as important segment of the system (Soares et al.,

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2012). This will make distribution grid a crucial element of sustainable electricity sector of the future. Already, the growing role of distributed resources in the electricity system is leading to a shift in the fundamental business model paradigm of the industry.

- Distribution sector is undergoing transformation due to emergence of digital innovation and its impact to monitor, observe and automation of system, ICT/smart grid application making communication as top priority etc. Thus, it is imperative to provide a regulatory framework that allows development of new business models along with emerging technologies.
- Another important driver for new business model is change in the policy perspective, including environmental regulation to century-old economic regulation, as renewable generation both as main source of generation as well as distributed generation is needed due to environmental concern.

These drivers motivate shifts in policy objective and the need for new business model in electricity distribution for a future sustainable electricity sector and to reduce the entry barriers for new private and specialist players in developing nations. The present paper aims to critically analyze the distribution sector in developing countries. It then proposes a new business model based on entrepreneurial theory and economics in the light of the emerging developments in the ICT and smart technologies. The proposed model is expected to overcome the significant challenges in this sector faced by developing countries. The model is based on developing enterprise innovation emphasizing external collaboration and partnership and can create considerable employment opportunities and also, open up new markets for other players in IT, communication, insurance, education and training, and social networking etc.

The next section outlines the context of electricity distribution sector in developing countries. Section 3 presents the basic economic principals of a new business model and then describes the constituent components of the model in some detail. Finally, Section 4 is the conclusions with some policy suggestions.

## 2. Electricity distribution challenges in developing countries

### 2.1. Background

Despite considerable reform efforts, in the form of unbundling, corporatization, and regulation of the electricity sector in many developing countries, the distribution segment is experiencing substantial financial losses undermining the critical role and financial viability of the distribution utilities. Bhattacharya and Patel (2011) and Patel (2008) discuss the prevailing systemic flaws and sector vulnerabilities. As a result, many distribution sectors in developing counties are characterized by inefficiency, low productivity, frequent supply interruptions, etc. (see, e.g., Jamasb et al., 2017; Thakur et al., 2006). The social objectives, such as electrification or cross subsidies have traditionally yielded large inefficiencies in the sector. It is generally accepted that the quality of institutions affects the economic performance of countries (Acemoglu et al., 2002). Dramani and Tewari (2014) examines performance of institutions and electricity sectors in Ghana and gave the findings that institutions influence the reserve margin, installed capacity, reliability and efficiency of distribution companies over time. Regulators are established but they are still appointed by the Government, thus shows inclination towards Government. They are still following cost plus regulation and offering no incentive for improving performance.

Such factors contribute to significant technical and financial losses in the system, and lead to erosion of creditworthiness of the government utilities.[1] For example, in India, the electricity sector's after-tax losses (excluding state government support and subsidies to the sector) stood at Rs 618 billion ($10.13 billion) in 2011. This is equivalent to nearly 17% of India's gross fiscal deficit and around 0.7% of its GDP (Pargal and Banerjee, 2014). However, when subsidies are included as revenue for the utilities, the losses fall by more than half to Rs 295 billion ($4.83 billion). Distribution companies (Discoms) had an outstanding debt of Rs 4.3 trillion ($70 billion) as on 30 September 2015 (MoP, 2016). This in turn would adversely affect the overall sustainability of the electricity sector including its ability to mobilize the much-needed capital investments to extend and modernise the networks.

Financial viability of the electricity sector is one of the key drivers of performance toward universal electricity access. In most of the developing countries electricity prices are much below the full supply cost. This is the main reasons for utilities ongoing financial distress and infrastructure decapitalization. The outcome is the inability of utilities to expand and maintain services, especially in remote, rural and poorer areas. Barriers to expanding access to electricity have been broadly categorised as financial and economic; capacity and technical; and policy and institutional (Sovacool, 2012; Watson et al., 2012; Nepal and Jamasb, 2012; Chaurey et al., 2012).

Given the poor financial performance of distribution utilities in developing countries, it is imperative to devise strategies to reduce network energy losses as part of the efforts to improve financial viability of the networks. One approach is electricity sector reform and market liberalization, of which privatization is considered a lynchpin (Dobozi, 2016). However, privatization of the sector in general and of the networks in particular without effective regulation does not provide positive results, on sector reform outcomes, other than improving the government fiscal position through privatization receipts and reduced fiscal subsidies[2] (Jamasb et al., 2015).

Revenue sustainability is imperative for operating and maintaining a distribution network, thus, ensuring sustainable growth of the distribution sector requires significant focus on private sector participation. Admittedly, the pricing methodologies and regulation of distribution network services need to accommodate the adoption of smart network technologies (see Li et al., 2015; Brunekreeft et al., 2015). This not only helps to make the Discoms financially viable but they can invest in new technologies to become smart utilities. Recognizing the need for privatization in both urban and rural areas to improve service, reduce losses and increase customer satisfaction, it is important to take up this activity in a methodical and integrated manner to ensure that the various layers of information are analyzed and understood by all stakeholders – i.e. the regulators; franchisors, distribution utilities and franchisees (private entrepreneur/company).

### 2.2. Case for smart distribution networks and business models in LDCs

The conventional electric utility business models are poorly adapted to tap the full potential value of emerging technologies such as distributed generation, energy efficiency, and demand-side response to meet the societal demands for reliable, affordable, and cleaner electricity supplies. This recognition has motivated a search for more suitable business models for distribution utilities (Perez-Ariaga et al., 2013). In addition, in order to deliver low carbon sustainable economies, emerging paradigms such as Energy Systems Integration (ESI) suggest holistic approaches that identify the potentials to integrate different energy vectors such as electricity, gas, and fuel. This integrated system will in turn exploit the synergies with other infrastructures such as transport, water, and communications systems (see

[1] Electricity generation and distribution have traditionally been with the public sector in developing countries, even with the introduction of various power sector reform measures, ownership is still predominantly with respective governments.

[2] In India, this has motivated some private actors to invest in power distribution business in the form of distribution franchise (DF) model. TERI (2010), Task Force (2012) and Chaurey et al. (2012) have reported successful involvement of DF for local power distribution in rural settings that these schemes have enhanced energy access using “pro-poor public-private partnership” model (“5Ps”).